APPENDIX A

Species Profiles

Part Five: Birds

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SPECIES PROFILE

American Bittern

Botaurus lentiginosus

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G4
State Rank: S3B
Author: Pamela D. Hunt, New Hampshire Audubon

Element 1: Distribution and Habitat

1.1 Habitat Description

American bitterns occupy a range of freshwater wetlands that contain tall emergent vegetation. Suitable habitats thus include cattail (*Typha* sp.) marshes associated with lakeshores, beaver ponds, fens, and impoundments (Gibbs and Melvin 1992, Gibbs et al. 1992, Foss 1994), although nests are occasionally found in hayfields at some distance from water (Foss 1994, R. Andrews personal communication). Because of the species' diet and foraging behavior, it avoids the deeper parts of occupied wetlands (Gibbs et al. 1992). In many parts of the Northeast, bitterns also occur in wetlands dominated by ericaceous or other water-tolerant shrubs (e.g., *Alnus* spp., *Cephalanthus* spp., *Viburnum* spp.) (Gibbs et al. 1991).

Some evidence suggests that bitterns only breed in wetlands above a certain minimum size. In New York and Wisconsin, these minima were 4 and 10 ha (10 and 25 acres) respectively (*in* Gibbs et al. 1992). However, during the New Hampshire Breeding Bird Atlas (BBA) survey, workers reported territorial bitterns from wetlands as small as 1.2 ha (3 ac) (Foss 1994). Such smaller wetlands may serve primarily as alternate foraging sites rather than breeding areas (Gibbs and Melvin 1992).

Bitterns generally use similar freshwater habitats during migration in New Hampshire, although at this time they also occur in salt marshes along the coast (New Hampshire Bird Records). The species has also been recorded in such habitats during the winter months, but is not known to breed in them anywhere in its range (Gibbs et al. 1992).

1.2 Justification

Although bitterns are widespread across the state (see below), there is anecdotal evidence suggesting population decline. This decline is likely a result of wetland loss through draining, filling, and other means. The decline shown by bittern populations in New Hampshire has also been seen on the regional and continental scale, although the pattern of decline is unclear. Statewide atlas accounts in New York (Andrle and Carroll 1988), Vermont (Laughlin and Kibbe 1985), and Massachusetts (Petersen and Meservey 2003) all report on the species' decline since the mid 1990s. It disappeared from Long Island between 1985 and 2000 (New York State Department of Environmental Conservation) and has declined to the point of being listed as Endangered in Connecticut (Gibbs and Melvin 1992). Breeding Bird Survey (BBS) data show a mix of decreases and stable trends in the northeastern portion of the species' range. However, given the patchy nature of bittern habitat and the species' crepuscular behavior, the ability of the BBS to detect real population trends for bitterns is moderate at best, and any trends should be interpreted with caution.

In general, the species is far more common in the northern part of its range, including Canada and perhaps the northernmost portions of New England (Gibbs et al. 1992, Sauer et al. 2004). Data from the Christmas Bird Count (CBC) (National Audubon Society 2002) show a decline in bittern populations in the southeastern United States from the mid 1960s to the early 1990s, after which point numbers have been increasing. It should be noted that bitterns are rarely detected during the CBC, and that these trends in wintering populations may be biased by variation

in observer effort or other non-controllable factors.

1.3 Protection and Regulatory Status

See pied-billed grebe.

1.4 Population and Habitat Distribution

American bitterns have probably always been widely distributed throughout New Hampshire. During the BBA, they were reported from 60 blocks (43 priority blocks) (Foss 1994), and the species was present in most of the state except the seacoast and the higher elevations and extensive forests of the White Mountains (figure 1a). More recent data from the breeding season (late April through August, NHBR) indicate that this distribution remains largely unchanged (figure 1b).

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

An American bittern habitat model for New Hampshire was modified from a model developed by the USFWS, Gulf of Maine Project (Banner and Schaller 2001). The base map for analysis was a composite wetland map developed at the NHNHB, and NHFG, in which contiguous wetlands were grouped into complexes and given attributes related to wetland size, proportions of different wetland types, and a number of additional variables related to threat and condition (see Marsh and Shrub Wetland habitat profile). Potential bittern habitat was selected from the larger wetland data set using the following criteria ("wetlands" refers to "wetland complexes" as defined in the wetland habitat profile):

- Add +0.5 for wetlands between 1 and 10 hectares (2.5-25 acres)
- Add +1 for wetlands greater than 10 hectares (25 acres)
- Add +1 if emergent vegetation occupies greater than 30% of wetland
- Subtract –0.5 if open water constitutes greater than 50% of wetland (Gibbs et al. 1991)

This model was not tested against known bittern locations in the state, since it is known that the latter data are not comprehensive. There are certainly bittern locations that might not be captured by this model, and many modeled wetlands may not be used by the species. However, the subset of wetlands selected by this model is probably a reasonable representation of the distribution of potential habitat across the state. Exceptions are most likely to occur in the White Mountains and Coastal Lowlands subsections, where bitterns are known to be rare or absent as breeders.

1.7 Sources of Information

Basic natural history information in this profile was largely gathered from the literature cited in element 6. Habitat modeling was informed by the Gulf of Maine Program (Banner and Schaller 2001) and wetland mapping conducted by the NHNHB. Identification of threats, research needs, and conservation strategies was informed by the literature and by regional bird conservation planning (Bird Conservation Region (BCR) 14 and 30 step-downs).

1.8 Extent and Quality of Data

Although bitterns are secretive and thus not as frequently detected as other birds, evidence indicates that the available data do reflect their distribution across the state. However, data on population size and trend are largely non-existent, and the limited available data are acknowledged poor indicators of population status (Sauer et al. 2004).

1.9 Distribution Research

Although the need for distribution information is less critical than for some other wetland birds, accurate population trend data is needed. Given that American bitterns occur with many other wetland birds, any inventory or monitoring program for those species should include American bittern. Surveys should target known or high-potential sites as identified by habitat mapping and should use methods consistent with other efforts in the region. Marsh bird monitoring has been identified as a priority project in BCR 30, and a coordinated regional effort would be invaluable in understanding trends in demographics throughout the northeast.

Element 2: Species/Habitat Condition

2.1 Scale

Given the widespread distribution and varied habitats of the American bittern in New Hampshire, it is difficult to identify an appropriate conservation scale below that of the entire state. In addition, any smaller scale for planning specifically for this species will be severely compromised by a lack of data. It is likely that bitterns occur in numerous wetlands from which we lack verified reports, and as a result it is essentially impossible to accurately evaluate either population or habitat condition at smaller scales. Although the state could be broken into regions based on ecoregions, watersheds, or even counties, wetlands in any such subdivision would not be subject to the same threats or amenable to the same conservation actions. As a result, this profile will consider threats and actions relevant to the American bittern at a statewide scale. Note that individual wetland complexes are being treated by the wetland habitat profile, and much of the information therein will be relevant to bitterns.

2.2 Relative Health of Populations

At the statewide scale, this item has already been addressed in section 1.2 above. Available data do not indicate any local variation of population trends within the state.

2.3 Population Management Status

In the absence of detailed information on management activity at most places where bitterns occur, or on the local effects of management on bittern populations, it is impossible to evaluate management efforts for this species.

2.4 Relative Quality of Habitat Patches

There are no data available with which habitat quality could be evaluated for this species, though the habitat model, which generates scores from 0.5 to 2.0, could be used as a rough approximation of habitat quality on a statewide scale.

2.5 Habitat Patch Protection Status

American bitterns use a variety of wetlands. See Marsh and Shrub Wetland habitat profile for protection status of various wetlands.

2.6 Habitat Management Status

No management specific to American bitterns is in place anywhere in New Hampshire.

2.7 Sources of Information

Data on site occupancy were compiled from NHBR and the New Hampshire BBA (Foss 1994). Information pertaining to management at some bittern sites (state wildlife management areas) was obtained from the NHFG.

2.8 Extent and Quality of Data

In the absence of comprehensive statewide surveys of this species or its habitat, the available data should be viewed as little more than a snapshot of bittern distribution in the state. The available data probably accurately reflect the species range (element 1), but should not be used to evaluate habitat.

2.9 Condition Assessment Research

Little is known about how bittern productivity varies across habitat types, including the effects of patch size and extent of invasive species infestation. Such demographic studies, if conducted in conjunction with distribution and abundance assessments as discussed above, would be valuable in determining the types of wetlands that are most valuable to this species.

Element 3: Species and Habitat Threat Assessment

Key threats identified in form 2 are loss of wetlands to development and the potential for habitat alteration by invasive plants. To the extent that these threats are common to a number of wetland species, they will not be treated in detail here. See the Marsh and Shrub Wetlands habitat profile for more information.

Element 4: Conservation Actions

There are no specific actions for American bittern conservation beyond those identified in the Marsh and Shrub Wetlands profile.

Element 5: References

5.1 Literature

Andrle, R.F., and J.R. Carroll. 1988. The atlas of breeding birds in New York State. Cornell University Press, Ithaca, New York, USA.

Banner, A., and S. Schaller. 2001. U.S. Fish and Wildlife Service Gulf of Maine Watershed Habitat Analysis. USFWS Gulf of Maine Program, Falmouth, Maine, USA. http://r5gomp.fws.gov/gom/habitatstudy/Gulf_of_Maine_Watershed_Habitat_Analysis.htm Accessed 14 January 2005.

Foss, C.R. 1994. Atlas of breeding birds of New Hampshire. New Hampshire Audubon. Concord, New Hampshire.

Gibbs, J.P., J.R. Longcore, D.G. McAuley, and J.K. Ringleman. 1991. Use of wetland habitats by selected nongame water birds in Maine.United States Fish and Wildlife Service, Fish and Wildlife Research Published 9. 57 pp. Washington D.C., USA.

Gibbs, J.P., and S.M. Melvin. 1992. American bittern, *Botaurus lentiginosus*. Pages 49-69 *in* Migratory nongame birds of management concern in the Northeast, K.J. Schnieder and D.M. Pence, editors. U.S. Department of the Interior, Fish and Wildlife Service, Newton Corner, Massachusetts, USA.

Gibbs, J.P., S. Melvin, and F.A. Reid. 1992. American bittern (*Botaurus lentiginosus*). *In* The Birds of North America, No. 18, A. Poole and F. Gill, editors. The Birds of North America, Inc., Philadelphia, Pennsylvania, USA.

Laughlin, S.B., and D.P. Kibbe. 1985. The atlas of breeding birds of Vermont. University Press of New England, Hanover, New Hampshire, USA.

New York State Department of Environmental Conservation. 2004. New York State breeding bird atlas website. www.dec.state.ny.us/apps/bba/results. Accessed 7 April 2005.

Petersen, W.R., and W.R. Meservey. 2003. Massachusetts breeding bird atlas. Massachusetts Audubon Society, Lincoln, Massachusetts, USA.

Sauer, J.R., J.E. Hines, and J. Fallon. 2004. The North American Breeding Bird Survey, Results and Analysis 1966-2003. Version 2004.1, U.S. Geological Survey Patuxent Wildlife Research Center, Laurel, Maryland, USA.

5.2 Data Sources

National Audubon Society 2002. The Christmas Bird Count Historical Results [Online]. http://www.audubon.org/bird/cbc. Accessed 2005 February 8.

New Hampshire Bird Records, New Hampshire Audubon, Concord, New Hampshire, USA.

Element 6: List of Figures

Figure 1. Distribution of breeding season (mid-April through August) records of American bittern in New Hampshire during a) the Breeding Bird Atlas and b) a similar period 20 years later.

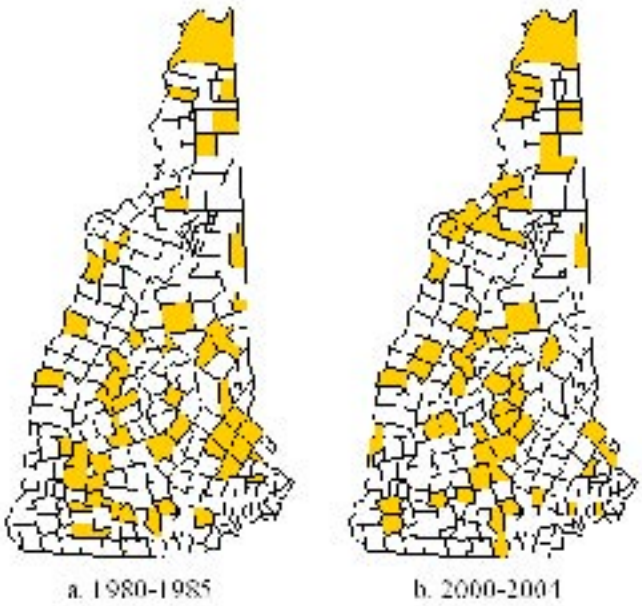

Figure 1. Distribution of breeding season (mid-April through August) records of American bittern in New Hampshire during a) the Breeding Bird Atlas and b) a similar period 20 years later.

SPECIES PROFILE

American Pipit

Anthus rubescens

Federal Listing: Not listed
State Listing: Species of Special Concern
Global Rank: G5
State Rank: S1B
Authors: Celine T. Goulet and Steven G. Fuller, New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

American pipit is a ground-dwelling passerine that uses a broad suite of open terrestrial and estuarine habitats (NatureServe 2004). Of these, American pipit breeds in alpine sedge meadow communities dominated by *Carex*, dwarf *Salix*, and *Deschampsia*, and fell fields associated with cushion plants such as *Silene, Trifolium, Phlox,* and *Arenaria* (Verbeek and Hendricks 1994). Eroded turf, tussocks, or tilted rocks are necessary features of nesting habitat, as they provide snow-free nest sites early in the season (DeGraaf and Yamasaki 2001). During the breeding season, American pipit forages in open areas including sedge meadows, felsenmeer, streamsides, and pond margins on south-facing slopes, feeding almost entirely on arthropods, primarily insects (Verbeek and Hendricks 1994).

As weather conditions deteriorate in autumn, American pipit migrates southward throughout the United States and Mexico (Verbeek and Hendricks 1994). Habitats utilized during non-breeding periods include coastal beaches, marshes, mudflats, wet meadows, sandy areas, and cultivated fields, with a preference for mud flats and river courses (Verbeek and Hendricks 1994, DeGraaf and Yamasaki 2001). During migration and the winter, they eat terrestrial and freshwater invertebrates as well as seeds in the fall (Verbeek and Hendricks 1994).

1.2 Justification

American pipit is one of a few species of ground-inhabiting songbirds that breed in alpine habitat (Verbeek and Hendricks 1994). Alpine communities are rare throughout the Northeast, occurring primarily as isolated islands on high peaks. Fragmentation and degradation of these breeding habitats due to recreation, as well as loss of migratory habitat to wetland drainage and farmland reversion, negatively impact American pipit populations (Camfield 2005). In alpine habitats, climate change will induce interdependent changes in the composition, distribution, and phenology of natural communities. In turn, this will increase habitat fragmentation and disrupt migratory patterns, reproduction, and food availability (Halloy and Mark 2003, Lesica and McCune 2004). In response, American pipit populations may become locally extinct (Lesica and McCune 2004, Camfield 2005).

1.3 Protection and Regulatory Status

Protected under the Migratory Bird Act.

1.4 Population and Habitat Distribution

American pipit occurs throughout North America and south to El Salvador (Verbeek and Hendricks 1994). Regionally, its breeding range includes alpine and arctic tundra occurring above treeline between 33° to 78°N at an elevation range of sea level in the north to 4,300 m in the mountains of western United States. The range extends across North America from Alaska to Newfoundland and south in western mountains to California and New Mexico. During the non-breeding season, American pipit migrates to lower altitudes and latitudes, generally avoiding regions with persistent snow cover (Verbeek and Hendricks 1994).

In New Hampshire, this species is rare and irregular during the winter and breeding season, with a small breeding population occurring on Mt. Washington at elevations of 1,650 m to 1,680 m (DeGraaf and Yamasaki 2001). However, during fall and spring migration, American pipit is locally common to very common, especially in major river valleys and along the coast (DeGraaf and Yamasaki 2001). Although the distribution of American pipit sightings have recently expanded in New Hampshire, Christmas Bird Count data indicate a statistically significant decline in populations in all regions (Verbeek and Hendricks 1994, NatureServe 2004). This long-term trend could be related to global warming, urbanization, or habitat loss (Verbeek and Hendricks 1994).

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

See Alpine Habitat profile.

1.7 Sources of Information

Published literature and New Hampshire Natural Heritage Bureau's (NHB) database.

1.8 Extent and Quality of Data

The New Hampshire distribution of American pipit is well documented.

1.9 Distribution Research

Winter ecology of American pipit is poorly understood (NatureServe 2004). More detailed information on winter habitat selection in southern United States and Mexico would be useful in determining areas of high concentration and detecting biologically significant population trends (Verbeek and Hendricks 1994).

Element 5: References

5.1 Literature

National Park Service. 1981. Comprehensive Plan for the Protection, Management, Development and Use of the Appalachian National Scenic Trail. National Park Service, Appalachian Trail Project Office, Harpers Ferry, West Virginia, USA.

Borror, A.C. 1994. American pipit. Pages 383-384 in C.R. Foss, editor. Breeding bird atlas of New Hampshire. Arcadia, Dover, New Hampshire, USA.

Camfield, A. 2004. "Motacillidae" (On-line), Animal Diversity Web. <http://animaldiversity.unmz.umich.edu/site/accounts/information/Motacillidae.html>. Accessed 2005 March 1.

DeGraaf, R.M., and M. Yamasaki. 2001. New England wildlife habitat, natural history, and distribution. University Press of New England.

Halloy, S.R., and A.F. Mark. 2003. Climate-change effects on alpine plant biodiversity: A New Zealand perspective on quantifying the threat. Arctic, Antarctic, and Alpine Research 35:248-254.

Hendricks, P. 2003. Spring snow conditions, laying date, and clutch size in an alpine population of American pipits. Journal of Field Ornithology 74: 423-429.

Kimball, K.D., and D.M. Weihrauch. 2000. Alpine vegetation communities and the alpine-treeline ecotone boundary in New England as biomonitors for climate change. USDA Forest Service Proceedings 15(3):93-101.

Lesica, P., and B. McCune. 2004. Decline of arctic-alpine plants at the southern margin of their range following a decade of climatic warming. Journal of Vegetation Science 15:679-690.

New England Regional Assessment (NERA). 2001. Preparing for a changing climate: the potential consequences of climate variability and change. New England Regional Overview, U.S. Global Change Research Program, University of New Hampshire, Durham, New Hampshire, USA.

NatureServe. 2004. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.1. NatureServe, Arlington, Virginia. <http://www.natureserve.org/explorer>. Accessed 2004 Nov 23.

Roland J., N. Keyghobadi, and S. Matter. 2002. Effects of rising treeline on connectivity of alpine meadows for butterfly populations. University of Alberta, Edmonton, Alberta, Canada.

Rudolph, S.G., P. Ketner, and H.O. Arjan. 1995. Selection and use of bio-indicators to assess the possible effects of climate change in Europe. Journal of Biogeography 22:935-943.

Sperduto, D.D., and W.F. Nichols. 2004. Natural communities of New Hampshire. New Hampshire Natural Heritage Bureau, Concord, New Hampshire, USA.

Verbeek, N.A., and P. Hendricks. 1994. American Pipit (Anthus rubescens). Pages 1-24 in A. Poole, and F. Gill, editors. The Birds of North America. Volume 95. The Academy of a Natural Sciences, Philadelphia, and The American Ornithologist's Union, Washington, D.C., USA.

Walker, M.D., R.C. Ingersoll, and P.J. Webber. 1995. Effects of interannual climate variation on phenology and growth of two alpine forbs. Ecology 76: 1067-1083.

Walther, G.R., E. Post, P. Convey, A. Menzel, C. Parmesan, T.J. Beebee, J.M. Fromentin, O. Hoegh-Guldberg, and F. Bairlein. 2002. Ecological responses to recent climate change. Nature 416: 389-395.

SPECIES PROFILE

Arctic Tern

Sterna paradisaea

Federal Listing: Not listed
State Listing: Threatened
Global Rank: G5
State Rank: SNA
Author: Alina J. Pyzikiewicz, New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

Arctic terns inhabit rocky coastal islands, coastal beaches, and marshes with ample supplies of fish and crustaceans (Gavutis 1994, Kress and Hall 2004). They breed in rocky, gravelly islands, barrier beaches, gravel bars, and occasionally in marshes and bogs (Hatch 2002). When nesting among other tern species, Arctic terns nest in open ground with little or no vegetation and when nesting with members of the same species, Arctic terns nest in low vegetation (Hatch 2002, Kress and Hall 2004). Arctic terns forage in waters up to 20 km away from breeding colonies where their prey is driven to the surface by predatory marine mammals and fishes, as well as in rocky shores, bays, and tidal flats (Hatch 2002). In winter, Arctic terns inhabit pack ice in open water and near-shore icebergs in the Antarctic Region, feeding in the channels between ice floes and along the edges of pack ice (Hatch 2002).

1.2 Justification

Arctic terns were once frequent nesters on the Isles of Shoals, but the species drastically declined due to an increased demand for tern feathers for the millinery trade in the 1900s and the displacement from preferred nesting habitats by gulls (Kress and Hall 2004). The primary threats to Arctic terns are competition for nesting sites and predation and displacement by gulls (Hatch 2002). This species is of high conservation concern under the North American Waterbird Conservation Plan and Bird Conservation Region 14 (Kushlan et al. 2002).

3.3 Protection and Regulatory Status

The Arctic tern is listed as threatened in New Hampshire and is protected under RSA 212 and the Migratory Bird Treaty Act.

1.4 Population and Habitat Distribution

In North America, the breeding range of Arctic terns extends from the Canadian Arctic down the eastern coastline to Massachusetts. The Gulf of Maine, Nova Scotia, Newfoundland, and the Gulf of St. Lawrence are significant breeding areas (Kress and Hall 2004). Populations of Arctic terns in Bird Conservation Region 14 are estimated at 19,000. In New Hampshire, Arctic terns historically nested on the Isles of Shoals, Seabrook Beach, and several islands in Portsmouth Harbor and Little and Great Bays (Gavutis 1994, Kress and Hall 2004, New Hampshire Bird Records). Since intense gull control was initiated in 1997 on Seavey Island in the Isles of Shoals, Arctic terns have increased. The first pair returned and nested in 2002 and 14 pairs have now nested on the island (New Hampshire Fish and Game (NHFG), unpublished data).

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

1.7 Sources of Information

Sources of information include the Breeding Bird Atlas of New Hampshire, Birds of North America, Tern Restoration Handbook, New Hampshire Bird Records, and NHFG and New Hampshire Audubon annual field surveys and reports.

1.8 Extent and Quality of Data

Arctic tern distribution and habitat use are well known in New Hampshire through annual surveys and historical reports. Little is known regarding wintering habitat.

1.9 Distribution Research

Continue to restore Arctic tern populations and monitor productivity on Seavey Island. Continue studying foraging, researching migration routes, and identifying winter habitats and their use.

Element 5: References

5.1 Literature

Gavutis, G. W. 1994. Arctic tern. Pages 378-379 *in* C. R Foss, editor. Breeding bird atlas of New Hampshire. Arcadia, Dover, New Hampshire, USA.

Hatch, J. J. 2002. Arctic tern (Sterna paradisaea). *In* A. Poole and F. Gill, editors. The Birds of North America, No 707. The Birds of North America, Philadelphia, Pennsylvania, USA.

Kress, S. W. and C. S. Hall. 2004. Tern management handbook: Coastal Northeastern United States and Atlantic Canada. National Audubon Society. Ithaca, New York, USA.

5.2 Data Sources

New Hampshire Bird Records. New Hampshire Audubon, Concord, New Hampshire, USA.

SPECIES PROFILE

Bald Eagle

Haliaeetus leucophalus

Federal Listing: Threatened
State Listing: Endangered
Global Rank: G4
State Rank: S1
Author: Christian J. Martin, New Hampshire Audubon

Element 1: Distribution and Habitat

1.1 Habitat Description

Endemic to North America, bald eagles occur widely across the continent in association with aquatic habitats such as lakes, rivers, reservoirs, and coastal estuaries (Buehler 2000). Bald eagles presently have established nests in all of the contiguous United States and in Alaska, as well as in all of the Canadian provinces, and in Mexico's Baja Peninsula. Except for coastal Alaska and parts of northern Canada, where they nest on cliffs or on the ground, eagles nest primarily in forested areas, typically near large water bodies, in mature trees near forest edges, or in super-canopy trees within more uniform forest cover. Distances between nests and water bodies are variable, but are often less than 2 km. Proximity to foraging areas that harbor abundant, diverse, accessible prey may be a more important factor than actual distance from water. Most of the 13 bald eagle nest structures documented in New Hampshire from 1988 to 2004 have been in white pines (77%), although cottonwoods (15%) or red oaks (8%) have also been used.

Populations in different parts of their continent-wide range exhibit variable migratory behaviors, depending on age, breeding status, geographic location of breeding area, and year-round availability of food sources. While territorial on their breeding sites, eagles frequently assemble in higher densities on preferred wintering areas. Such places offer a combination of readily available food and roost sites with good thermal cover and protection from disturbance. Breeding adults from territories in interior Canada typically leave breeding areas for the winter months, while adults breeding in the northern United States often remain on or near breeding territories year-round. Adults breeding in the southern United States raise young during the winter when local weather conditions are more moderate.

1.2 Justification

Bald eagle populations have been closely monitored in the United States since they experienced severe population declines beginning around 1950 (Broley 1958, Buehler 2000). Historical evidence from before European settlement suggests that eagles were abundant across the continent; however, by 1963 only 417 breeding pairs were estimated to remain in the lower 48 states. Some regional breeding populations, especially in eastern and southern states, became locally extirpated. This serious decline led to the designation of the bald eagle as Endangered under the Endangered Species Act. Subsequent research clearly demonstrated that population losses during that period resulted primarily from reproductive failure associated with the presence of high levels of DDT and other persistent organochlorine pesticides in the aquatic food web, which caused severe eggshell thinning and extremely poor hatching success (Wiemeyer et al. 1972, Grier 1982).

Biologists and natural resource managers now recognize that bald eagles can function as useful living barometers or bio-indicators of general environmental quality in aquatic systems because they rapidly accumulate chemical contaminants, such as the organochlorine pesticide DDT and its metabolite DDE, contained in fish.

In New Hampshire, historical records (Allen 1902, Brewster 1925, Dearborn 1898, Scott 1921) from the

early 1900s suggest a minimum of about 10 breeding, including some near the following lakes and coastal areas: Connecticut, Newfound, Squam, Umbagog, Wentworth, Winnipesaukee, as well as Great Bay and Hampton Harbor state (Smith 1984). Before eagles were extirpated as a breeding species in the state, New Hampshire's last documented active nest occurred on Umbagog Lake in 1949 (T. Richards, unpublished data). Eagles ceased to breed successfully in New Hampshire by 1950 but continued to occur thereafter in reduced numbers on the state's major rivers and lakes as migrants and during the winter months (Evans 1994). Since 1980, NHA and NHFG have partnered to conduct extensive annual field monitoring of the state's breeding and overwintering eagle population.

1.3 Protection and Regulatory Status

Bald eagles are protected in the United States under the Migratory Bird Treaty Act of 1918, which prohibits the possession or killing of most non-game birds and the collection of their eggs or nests. They are also protected under the Bald Eagle Protection Act of 1940 (now the Bald and Golden Eagle Protection Act), which prohibits the take, possession, or commerce involving eagles, their body parts, or their eggs. United States populations south of the fortieth parallel were first listed as Endangered by the federal government in 1967 under the Endangered Species Preservation Act of 1966 (Federal Register 32:4001), and this authority was later transferred to the Endangered Species Act (ESA) of 1973 (16 U.S.C. 1531 et seq.). Bald eagles in states north of the fortieth parallel were first protected as federally Endangered in 1978, except in Minnesota, Wisconsin, Michigan, Washington, and Oregon, where they were listed as Threatened (Federal Register 43:6230-6233). The species was first listed as Endangered by the State of New Hampshire in 1979 (R.S.A. 212-A:1 et seq.), and it currently remains classified as Endangered in the state.

Because of significant population recovery throughout much of the United States during the 1980s and 1990s, the species was reclassified in 1995 to Threatened status in all 48 contiguous states (Federal Register 60:35999-36110). In 1999, as a result of continued progress and attainment of regional recovery goals, the United States Fish and Wildlife Service (USFWS) formally proposed delisting the bald eagle throughout the lower 48 states (Federal Register 64: 36454-36464). At the start of 2005, a rule that formally removes the bald eagle from the Endangered Species list has yet to be enacted. As required for any de-listing under the ESA, the USFWS, in cooperation with state wildlife agencies, must develop and implement a post de-listing monitoring plan to track the status of bald eagle populations in the United States for a period of at least 5 years after de-listing.

Other indirect federal protective measures for eagles include those offered by the Federal Insecticide, Fungicide, and Rodenticide Act (7 U.S.C. 136) for new and existing pesticide registration and use, the National Forest Management Act (16 U.S.C. 1600), and the Federal Land Management and Policy Act (43 U.S.C. 1701). Bald eagles are also protected from unregulated international trade by an agreement of the 1975 Convention on International Trade in Endangered Species of Wild Flora and Fauna.

1.4 Population and Habitat Distribution

Following a low point of only 417 breeding pairs estimated present in the lower 48 states in 1963, and subsequent to the banning of DDT in the early 1970s, bald eagle breeding populations have recovered substantially. There were an estimated 1,500 breeding pairs in the contiguous 48 states in 1982 and an estimated 5,300 pairs in the same area in 1997 (derived from data in Buehler 2000). Wintering populations in the continental United States, which include thousands of individuals that breed in Canada, have shown similarly dramatic increases, from an estimated 13,800 individuals in 1982 to an estimated 26,100 individuals in 1997 (Buehler 2000). In the northeastern states, breeding bald eagle population recovery has been led by the states of Maine and New York, which supported 94% of the 459 territorial bald eagle pairs documented in the northeast in 2004 (table 1).

In New Hampshire in 2004, there were 8 breeding territories distributed widely across the state (figure 1), including in the Androscoggin, Connecticut, and Merrimack River watersheds. New Hampshire supported only 1 documented breeding territory from 1988 to 1997, but over the past decade the number of territorial pairs has risen to 8 pairs in 2004 (table 2). From 1988 through 2004, there were 37 active

nesting attempts documented in the state, 24 (65%) attempts were successful, resulting in 39 fledglings (1.05 young per active nest). The detailed status of the state's eagle breeding territories is described in table 3.

New Hampshire has participated in the national midwinter survey since 1981 (Steenhof 2002), surveying major wintering areas along the Androscoggin, Connecticut, and Merrimack rivers, as well as the state's Lakes Region and Great Bay/Seacoast area, and other portions of the state where eagles winter in lesser numbers. As shown in table 3, the number of individual eagles documented in the midwinter survey has risen from an average of 8 individuals detected during the 1981 through 1984 surveys, to an average of greater than 43 individuals detected during the 2001 through 2004 surveys. Minimum estimates for the overall number of eagles wintering in New Hampshire during portions of the December-March wintering season have grown from fewer than 20 individuals annually from 1980 to 1983, to greater than 90 individuals from 2001 to 2003 (table 5).

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

1.7 Sources of Information

General natural history information and some sources of original research discussed in this document were obtained primarily from The Birds of North America, No. 506: Bald Eagle (Buehler 2000)). Unless otherwise noted, the source for New Hampshire specific data is field monitoring and management activities conducted by NHA from 1983 to 2004 under annual contracts and/or grants received from the NHFG and/or the USFWS (see Martin 2004a, Martin 2004b, and prior annual reports).

1.8 Extent and Quality of Data

Since the early 1980s, the bald eagle has been one of the most intensively monitored and managed species in New Hampshire. Breeding site data are derived from field monitoring conducted for nearly 2 decades by NHA staff and trained volunteer observers, who employed standardized monitoring techniques to determine nest occupancy and productivity, as well as locations and numbers of individuals present within the state's 5 major wintering areas (Deming 2004, Deming and Martin 2004, Martin 2004b).

1.9 Distribution Research

Future distribution and abundance of bald eagles in New Hampshire should be monitored by conducting spring breeding surveys of known and potential breeding habitat, by participating in the mid-winter counts in the state's 5 major wintering areas, and by site-specific monitoring at important overnight roost sites. Active breeding territories should be checked annually to determine occupancy status and reproductive outcome, and surveys of potential breeding territories should be conducted on a rotating basis, with annual survey intensity determined by funding and human resources available. For example, sites could be checked on a biennial or triennial rotating basis, covering 50% or 33% of potential sites annually. New Hampshire should continue to participate in the national mid-winter bald eagle survey (Steenhof, K., L. et al. 2002). When bald eagles are formally removed from the federal List of Threatened and Endangered Wildlife, New Hampshire should actively participate in the required federal post de-listing monitoring program that will be established by the USFWS.

Element 2: Species Condition

2.1 Scale

Major watersheds will be used as conservation planning units for bald eagle breeding and wintering habitat due to differences in the physical characteristics, human population density, and human land use patterns associated with each major watershed.

2.2 Relative Health of Populations

All of New Hampshire's 11 recently documented occupied breeding territories through 2004 are listed in table 3. All sites listed are associated with a large lake, reservoir, or major river. Of the 11 territories documented, 8 (73%) have been occupied for more than one year, and 7 (64%) have produced fledglings.

Bioaccumulation of chemical contaminants is a major concern in high trophic-level predators, such as bald eagles (Dominguez et al. 2003, Evers 2005,

Welch 1994). Although preliminary and with minimal sample size to date, cooperative studies have begun to assess mercury levels in New Hampshire bald eagle nestlings. Although 2004 data is not included here, sampling was expanded in 2004 to include 1 additional study site (Nubanusit Lake) and 7 additional individuals.

2.3 Population Management Status

Ongoing management strategies for bald eagles in New Hampshire fall into 4 main categories:

(1) Locate territorial pairs
From 1988 to 2004, NHA biologists solicited and evaluated public reports of bald eagles in areas of potential breeding habitat and followed up with field surveys to identify occupied territories. Over the past decade, this survey activity has resulted in detection of 1 new breeding pair roughly every 1 to 2 years.

(2) Monitor and manage nesting attempts and wintering areas
Nesting attempts were monitored by trained volunteers observers and NHA staff biologists from 1988 to 2004, which resulted in the documentation of 56 occupied territory-years, 37 nesting attempt-years, 39 young fledged (1.05 young/nesting attempt), and 13 nest failures (35% failure rate). Monitoring also facilitated efforts by the USFWS, NHA, and BioDiversity Research Institute to examine and color band 56% (22 out of 39) of all fledglings produced in the state from 1988 to 2004. The NHA staff installed sheet metal predator guards around the bases of nest trees to deter tree-climbing mammalian nest predators, and NHA staff and trained volunteers also monitor numbers and distribution of bald eagles in winter foraging and roosting areas.

(3) Manage human activity at breeding and wintering sites
Acting under the guidance of NHFG and the USFWS, NHA biologists evaluated potential negative impacts of human recreation on nesting sites and implemented temporary closures when appropriate. In situations where the volume of boating or pedestrian activity threatens to jeopardize the nesting attempt, land-based or floating signs have been placed to create a buffer zone around the nest area. The NHA staff assists NHFG personnel with implementation of appropriate closures and landowner outreach strategies at important winter roost sites.

(4) Public outreach and education
Disseminating information on the goals, objectives, and status of bald eagle conservation efforts in New Hampshire has occurred in a variety of ways and has involved many different target audiences. Extensive efforts have been made to educate the public on accurate identification and reporting of bald eagles. Articles and media news releases on the state's bald eagle recovery efforts and opportunities for direct public volunteer involvement appear annually in newspapers, on radio, and in newsletters of various natural resource agencies and conservation groups. The NHA staff offers public lectures and conduct volunteer training sessions annually to encourage effective public participation in bald eagle conservation. Outreach to landowners, developers, and others concerning bald eagle habitat needs are ongoing and essential.

2.4 Relative Quality of Habitat Patches

Currently occupied breeding habitat appears to provide the key ecological attributes required to support a healthy, expanding breeding population. Large lakes, reservoirs, and ice-free areas below dams will likely provide habitat for additional breeding pairs over the coming decade. Bald eagles are generalist feeders; in addition to fish, they feed on aquatic mammals, waterfowl and gulls, and often carrion. Suitable nesting substrate does not appear to be a limiting factor, except perhaps in the Connecticut Lakes area where there are very few super-canopy pines available. The greatest ongoing habitat quality concerns include the following:

- Additional shoreline development on rivers and large lakes, especially in the Merrimack River watershed and Lakes Region areas
- Increasing use of powerful motorized watercraft and growing popularity of kayaks and canoes, especially in the lakes Region and in the Androscoggin River watershed
- Growing pedestrian use in the winter months near wintering sites along the Merrimack River and in the Lakes Region

- Increasing concerns about mercury and other contaminants, especially in the Merrimack River watershed and in the Great Bay/Seacoast area

2.5 Habitat Patch Protection Status

Of the 8 bald eagle nest sites active in 2004, 4 (50%) were located on public lands (2 federal, 1 state, 1 municipal), while the other 4 (50%) were located on private lands. One of the 4 sites on private land was subject to a conservation easement. Only a few of the state's winter roost sites are on protected land.

2.6 Habitat Management Status

Nest sites on public land are managed in a manner that promotes "no activity" buffer zones around nest trees. Nest sites on private land are subject to landowner decisions, but outreach and education with landowners has usually resulted in land use practices that benefit eagles. Formal management of winter roost areas has been a great challenge because so few sites are on protected land.

2.7 Sources of Information

Information on the state's bald eagle population and habitat is derived directly from summary reports and field data on monitoring and management activities conducted by NHA from 1983 to 2004 under annual contracts and grants received from the NHFG and the USFWS (Deming 2004, Martin 2004a, Martin 2004b).

2.8 Extent and Quality of Data

Because bald eagles have been listed as endangered or threatened on both federal and state lists for much of the past 4 decades, few New Hampshire wildlife species have a more complete data set on occurrence, productivity, and habitat condition. Annual summaries of this information are on file at NHFG.

2.9 Condition Ranking

2.10 Condition Assessment Research

Long-term baseline monitoring of bald eagle breeding and overwintering sites in New Hampshire remains an important task in order to detect any future threats to a stable or growing population. Creation and formal adoption of a state recovery plan that includes specific targets for reclassification to threatened status and for de-listing should be a priority. Analyses of the contaminant loads present in New Hampshire bald eagle chicks should be encouraged and facilitated by NHFG in order to determine the potential effect on statewide productivity and population recovery. Fieldwork, conducted by NHA and others, designed to detect and identify banded individuals should be directly supported by NHFG because the existence of an individually marked population in northern New England offers a unique opportunity to obtain critically important and hard-to-acquire data on dispersal patterns and population demography, individual longevity, and nest site fidelity.

Element 3: Species and Habitat Threat Assessment

3.1.1 Non-Point Source Pollution (Heavy Metals)

(A) Exposure Pathway
Bald eagles are subject to lead poisoning by consuming lead shot or lead sinkers contained within prey or carrion that they consume (Kramer and Redig 1997). Continued use of lead shot or fishing tackle (in violation of state laws) would threaten eagles in these areas. Physical or biological mechanisms in lakes and reservoirs that would bring long-buried lead back to the surface would also threaten eagles.

(B) Evidence
Lead poisoning of bald eagles has been reported from at least 34 states (Buehler 2000). In New Hampshire, a 10-year old founding member of the first breeding pair to become established in the state in the post-DDT era was killed when it consumed lead shot during its 1994 breeding attempt.

3.1.2 Development (Habitat Loss and Conversion)

(A) Exposure Pathway
Shoreline development affects nesting, perching, roosting, and foraging by eagles, with direct and indirect effects on reproductive success and suitability of overwintering areas (Buehler 2000). Development

can limit the future expansion of a recovering population and act to reduce future carrying capacity of areas that currently support eagles (Fraser et al. 1996). New Hampshire is among the fastest growing states in the northeastern United States, and shoreline real estate is under intense development pressure in a relatively lightly regulated environment.

(B) Evidence
Many studies over the past 3 decades have demonstrated that bald eagles prefer to avoid human-developed areas for nesting, perching and roosting. Development brings the secondary problems of increased pollution, pedestrian use, and water-based recreational activities that deter eagle use of otherwise suitable habitat.

3.1.3 Recreation (Boats)

(A) Exposure Pathway
Many studies have found that recreational boating activities can modify foraging patterns of bald eagles by reducing or precluding use of foraging areas, potentially with long-term effects on productivity (McGarigal et al. 1991).

(B) Evidence
Motorized boat traffic on New Hampshire water bodies is increasing, as are the size of vessels and their top speed. Creation of additional access points to public waters in the form of boat ramps, while desirable to the public, has the potential to add to the disturbance problem by increasing the number of boats on the water. The growing popularity of small personal watercraft (motorized jet skis as well as self-propelled canoes and kayaks) has the added effect of bringing increased human traffic into shallow coves and other areas where eagles perch, feed, and rest.

3.1.4 Non-Point Source Pollution (Chemical Contaminants)

(A) Exposure Pathway
Many types of pollutants bioaccumulate in animal tissue and to biomagnify as they reach higher trophic levels, such as bald eagles. While only infrequently resulting in direct mortalities, these pollutants have a range of more common sub-lethal effects, especially in long-lived predators such as eagles that accumulate toxins over a long period. These various neurotoxins produce reproductive, behavioral, neurological, and physiological changes that can result in reduced vigor and breeding success (Dominguez et al 2003, Evers 2005).

(B) Evidence
Brominated fire retardants, commonly known as PBDEs, are similar in chemical structure to PCBs. They are used in a wide range of synthetic household and consumer products. PBDEs have recently been shown to accumulate in wildlife populations worldwide, including in raptors.

3.1.5 Mercury

(A)Exposure Pathway
Mercury bioaccumulates in animal tissues and can reach high levels in piscivorous birds. At low doses, sub-lethal effects on birds include reproductive and developmental abnormalities; at higher doses, adults suffer broader behavioral deterioration.

(B)Evidence
Mercury levels are high and pervasive in northeastern North America, not only in aquatic food webs, but in terrestrial systems as well (Wiemeyer et al. 1972, Welch 1994, Evers 2005). Major sources of atmospheric mercury include coal-fired power plants and medical, industrial, and municipal incinerators. Mercury that makes its way into water can combine with carbon, forming compounds such as methylmercury that are more readily taken up by animals.

3.2 Sources of Information

Information on various threats to bald eagles was obtained from literature review, from NHA field data, and from consultation with specialists employed by the USFWS, NHFG, and NHA, all located in Concord, New Hampshire, and from BioDiversity Research Institute located in Gorham, Maine.

3.3 Extent and Quality of Data

Most of the threats described above have been examined carefully be researchers working outside of

New Hampshire. There are sufficient data on the lead threat in New Hampshire that legislation has recently been passed that prohibits the use of certain size lead sinkers and jigs. Other state legislation is pending. On the threat posed by shoreline development, there is sufficient concern about habitat loss to justify strengthening land use policies and investing in more land protection efforts by federal and state agencies, and by non-profit conservation groups. The negative effects of mercury, PBDEs, and PCBs on aquatic species are well known and well document by researchers nationwide. The effect of increased boating activity is poorly understood for New Hampshire.

3.4 Threat Assessment Research

There are several areas where additional threat assessment research is warranted, including the following:

- Investigation of the tolerance thresholds of bald eagles for recreational boating activity in the vicinity of nest sites and foraging areas
- Additional investigation on current levels of mercury, PCBEs, DDE, and other bio-accumulative pollutants in New Hampshire eagles
- Investigation into the likely future extent of shoreline development on water bodies in New Hampshire, its potential impact of bald eagle breeding and wintering areas, and development of a pro-active plan that would better protect wildlife values associated with shorelines.

Element 4: Conservation Actions

4.1.1 Document breeding status and wintering distribution, Restoration and Management

Distribution and abundance of breeding bald eagles should be monitored by spring surveys at active and potential breeding sites to determine occupancy status and reproductive outcome. Monitoring of wintering areas and roost sites is especially important in areas with high development pressure. Direct threats addressed under this conservation action include shoreline development and increased watercraft use.

4.1.2 Develop state recovery plan for bald eagles, Regulation and Policy

Develop a formal state recovery plan for bald eagles that includes specific targets for reclassification to threatened status and for de-listing. This conservation action builds on more than 20 years of ongoing management activities to insure population viability and establish clear targets for population recovery and reclassification. Direct threats addressed under this conservation action include lead pollution, shoreline development, increased watercraft use, and mercury, PBDEs, and PCBs contamination.

4.1.3 Determine contaminant loads, Restoration and Management

Conduct more extensive monitoring of contaminant loads present in New Hampshire bald eagle chicks to determine the potential effect of toxics on statewide productivity and population recovery. This conservation action builds on more than 20 years of ongoing management activities to insure population viability and understand the effects of environmental contaminants. Direct threats addressed under this conservation action include mercury, PBDEs, and PCBs contamination.

4.1.4 Manage human activity around breeding and wintering sites, Restoration and Management

Manage the potentially conflicting public values of viable bald eagle habitat and outdoor recreational opportunities in a manner that addresses the reality of increasing recreational use of New Hampshire's lakes and rivers. Minimize effects of frequent boating activity on bald eagle breeding success. This conservation action builds on more than 20 years of ongoing management activities. Direct threats addressed under this conservation action include increased watercraft use.

4.1.5 Develop clearer guidelines and stronger regulations to protect shoreline habitat from habitat conversion through development, and pursue ways to protect such areas directly through acquisition in fee or easement, Regulation and Policy.

Work with state regulatory agencies to determine the likely future extent of shoreline development in New Hampshire, identify areas of high habitat value for

bald eagles and their prey, and develop guidelines, regulations, and land conservation mechanisms to protect these key areas. Direct threats addressed under this conservation action include shoreline development.

Element 5: References

5.1 Literature

Allen, G.M. 1902. A list of the birds of New Hampshire. Proceedings of the Manchester Institute of Arts and Sciences 4. Manchester, New Hampshire, USA.

Brewster, W. 1925. The birds of Lake Umbagog region of Maine, Pt. 2. Bull. Comp. Zool. 66. Harvard College, Cambridge, Massachusetts, USA.

Broley, C.L. 1958. Plight of the American bald eagle. Audubon 60:162-163, 171.

Buehler, D.A. 2000. Bald eagle (*Haliaeetus leucocephalus*). *In* The Birds of North America, No. 683 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, Pennsylvania, USA.

Dearborn, N. 1898. A preliminary list of the birds of Belknap and Merrimack counties, New Hampshire, with notes. M.S. thesis, New Hampshire College of Agricultural and Mechanical Arts, Durham, New Hampshire.

Deming, L. 2004. Winter eagle habitat on the Merrimack River, New Hampshire, field verification. Report submitted by New Hampshire Audubon and New Hampshire Fish and Game. 7 pp., plus maps and appendices.

Deming, L., and C. Martin. 2004. Wintering bald eagle roost sites in New Hampshire. Report submitted by New Hampshire Audubon and New Hampshire Fish and Game. 3 pp., plus 26 maps.

DeSorbo, C., and D. Evers. 2004. Summary of BioDiversity Research Institute bald eagle banding and mercury sampling efforts in Maine and New Hampshire, 2001-2003. Unpublished report from BioDiversity Research Institute, Gorham, Maine, USA. 5 pp.

Dominguez, L., W.A. Montevecchi, N.M. Burgess, J. Brazil, and K.A. Hobson. 2003. Reproductive success, environmental contaminants, and trophic status of nesting bald eagles in eastern Newfoundland, Canada. Journal of Raptor Research 37:209-218.

Evans, D. 1994. Bald eagle. Pp. 373-374 *in* Atlas of breeding birds in New Hampshire. (C. R. Foss (ed.). Arcadia Press, Dover, New Hampshire, USA.

Evers, D.C. 2005. Mercury connections: The extent and effects of mercury pollution in northeastern North America. BioDiversity Research Institute. Gorham, Maine, USA. 28 pp.

Fraser, J.D., S.K. Chandler, D.A. Buehler, and J.K.D. Seegar. 1996. The decline, recovery, and future of the bald eagle population of the Chesepeake Bay, U.S.A. Pp. 181-187 *in* Eagle Studies (B. U. Meyburg and R. D. Chancellor, eds.). World Working Group for Birds of Prey, Berlin, Germany.

Grier, J.W. 1982. Ban on DDT and subsequent recovery of reproduction in bald eagles. Science 218: 1232-1235.

Kramer, J.L. and P.T. Redig. 1997. Sixteen years of lead poisoning in eagles, 1980-1995: an epizootiologic view. Journal of Raptor Research 31: 327-332.

Martin, C.J. 2004a. New Hampshire Nongame and Endangered Wildlife Program Status and Management Report, July 1, 2003-June 30, 2004. New Hampshire Fish and Game Department Federal Aid Project EW-1-22. 24 pp.

Martin, C.J. 2004b. Wintering bald eagles in New Hampshire, 2003-2004 Season. T-2 Progress Report submitted to New Hampshire Fish and Game Department. 10 pp.

McGarigal, K., R.G. Anthony, and F.B. Isaacs. 1991. Interactions of humans and bald eagles on the Columbia River estuary. Wildlife Monographs 115: 1-47.

Scott, C.F. 1921. Notes on land birds of southern New Hampshire. M.S. thesis, University of New Hampshire, Durham, New Hampshire, USA.

Smith, C.F. 1984. Assessment of historical and potential bald eagle breeding areas in New Hampshire. Unpublished report to New Hampshire Fish and Game Department Federal Aid Project EW-1-3. 15 pp.

Smith, C.F. and C. Ricardi. 1983. Ospreys and bald eagles in New Hampshire: status, habitat, and nest site characteristics. Pp. 149-156, *in* Biology and management of bald eagles and ospreys (D. M. Bird, ed.). Harpell Press. Ste. Anne de Bellevue, Quebec. 325 pp.

Steenhof, K., L. Bond, K.K. Bates, and L.L. Leppert. 2002. Trends in midwinter counts of bald eagles in the contiguous United States, 19886-2000. Bird

Populations 6:21-32.
United States Fish and Wildlife Service. 1983. Northern states bald eagle recovery plan. United States Fish and Wildlife Service, Washington, D.C.
Welch, L. 1994. Contaminant burdens and reproductive rates of bald eagles breeding in Maine. M.S. Thesis, Univ. Maine, Orono. 86pp.
Wiemeyer, S.N., B.M. Mulhern, F.J. Ligas, R.J. Hensel, J.E. Mathisen, F.C. Robards, and S. Postupalsky. 1972. Residues of organochlorine pesticides, polychlorinated biphenyls, and mercury in bald eagle eggs and changes in shell thickness – 1969 and 1970. Pesticide Monitoring Journal 6:50-55.

5.2 Data Sources

Bald eagle wintering area surveys, winter roost counts, breeding site surveys, and productivity data from 1980-2004, New Hampshire Audubon, Concord, New Hampshire, USA.

Element 6: List of Figures

Figure 1. Distribution of bald eagle breeding territories in New Hampshire in 2004.
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Table 3. New Hampshire bald eagle breeding territories: 1988-2004.
Table 4. New Hampshire mid-winter bald eagle survey results, 1981-2004.
Table 5. New Hampshire bald eagle wintering estimates, 1980-1981 through 2003-2004.

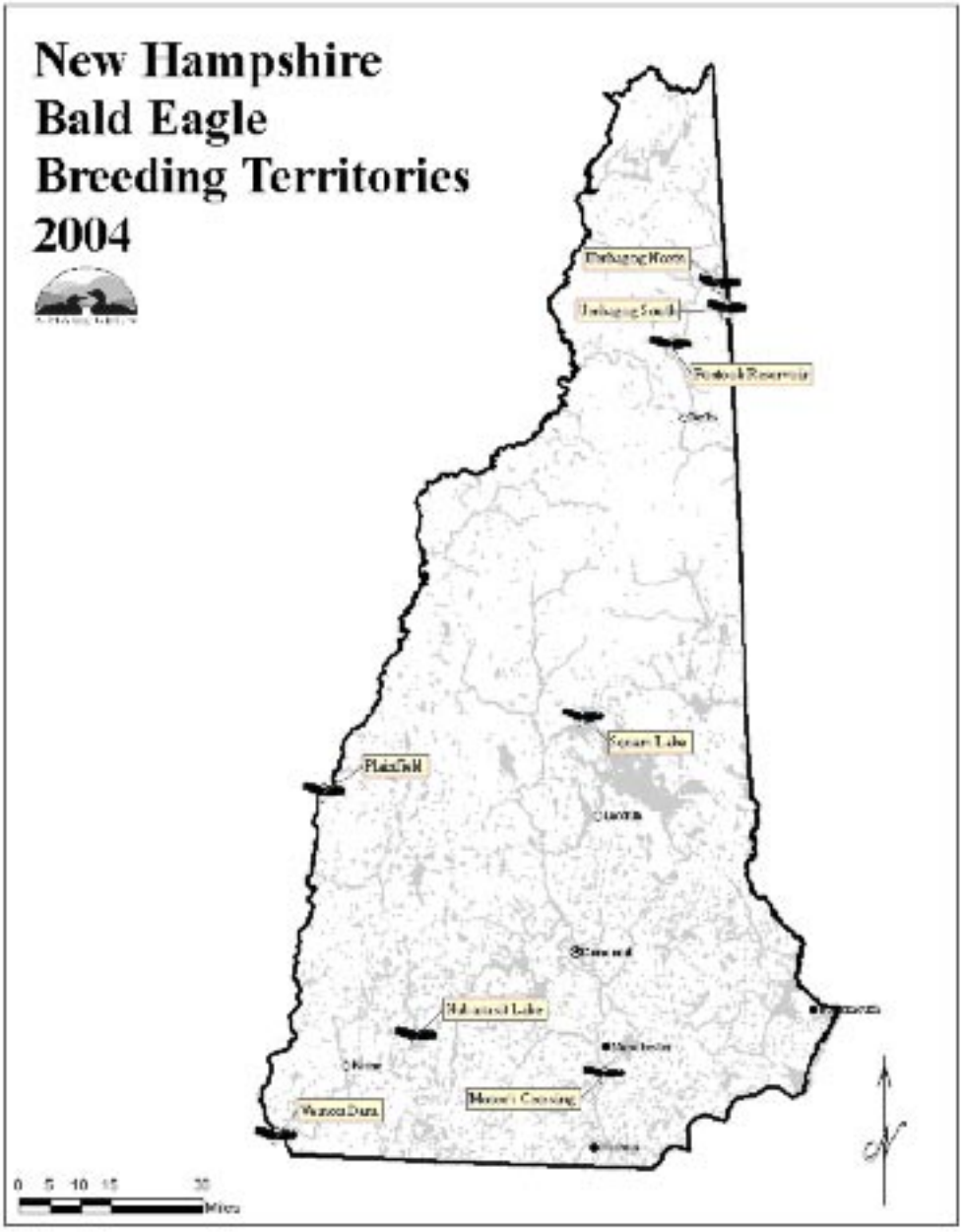


Figure 1. Distribution of bald eagle breeding territories in New Hampshire in 2004.

State	Territorial	Territorial Pairs 2003	Territorial Pairs 2002	Territorial Pairs 2001	# Successful	#	# Young	# Young Fledged 2003	# Young Fledged 2002	# Young Fledged 2001	Source
	Pairs 2004				Pairs 2004		Fledged 2004				
NY	84	75	70	65	66	53	111	87	94	83	P. Nye
VT	0	0	0	0	0	0	0	0	0	0	M. Fowle
NH	8	8	7	8	6	3	11	5	1	6	C. Martin
ME	346	309	290	269	202	190	298	273	280	266	C. Todd
CT	8	8	8	6	4	6	7	10	7	3	J. Victoria
MA	12	15	12	12	13	8	14	13	15	10	T. French
RI	1	1	0	0	1	1	2	1	0	0	M. Amaral
Total	459	416	387	360	292	261	443	389	397	368	
Total in New England	375	341	317	295	226	208	332	302	303	285	

Table 1. Bald eagle territorial pairs and fledged young in the northeastern United States, 2004, 2003, 2002, and 2001.

Year	Territorial Pairs	Active nests	Successful Young Nests	Fledged	Young per Active Nest
1988	1	0	0	0	
1989	1	1	1	1a	1
1990	1	1	1	2	2
1991	1	1	1	1	1
1992	1	1	1	2a	2
1993	1	1	1	2	2
1994	1	1c	0	0	0
1995	1	1	1	1	1
1996	1	1	1	2	2
1997	1	1	0	0	0
1998	2	1	1	2	1
1999	7	2	1	2	1
2000	6	4c	1c	2c	0.5
2001	8b	5	4	6	1.2
2002	7	4	1	1	0.25
2003	8b	5	3	4d	0.8
2004	8b	7b	6b	11b	1.57
Totals for 1988-2004	56	37	24	39	1.05

Table 2. New Hampshire bald eagle productivity summary: 1988-2004.

Breeding Territories (by # years used)	Years Occupied	Years Nesting	Young Fledged	Young / Nesting	Fledged Banded	%Fledged Banded
Umbagog Lake North (1988-2004)	17	14g	16f	1.14	8	50
Nabanusit Lake (1997-2004)	8	6	3	0.5	3	100
Vernon Dam (1999-2004)	6	5	3	0.6	1	33
Pontook Reservoir (1999-2004)	6	4	6	1.5	6	100
Umbagog Lake South (2000-2004)	5	5g	7e	1.4	4	57
Squam Lake (2000-2004)	5	2	2	1	0	0
Moores Crossing (	4	0	0	0	0	0
Ottauquechee River (2003-2004)	2	1	2	2	0	0
Lake Francis (2001)	1	0	0	0	0	0
Surry Mountain Lake (1999)	1	0	0	0	0	0
15-Mile Falls (1999)	1	0	0	0	0	0

Table 3. New Hampshire bald eagle breeding territories: 1988-2004.

Year	Total Eagles	Adults	Immatures	Unknown	Participants
2004	41	27	14	0	55
2003	40	26	14	0	69
2002	50	31	19	0	89
2001	42	28	13	1	58
2000	(no data available)				
1999	35	19	16	0	56
1998	25	15	10	0	39
1997	37	26	11	0	76
1996	33	21	12	0	84
1995	30	16	14	0	94
1994	25	14	11	0	75
1993	21	14	7	0	56
1992	25	20	5	0	50
1991	19	13	6	0	57
1990	19	12	7	0	46
1989	15	9	6	0	42
1988	14	7	7	0	48
1987	9	6	3	0	47
1986	10	7	3	0	31
1985	13	8	5	0	39
1984	12	10	2	0	17
1983	7	5	2	0	17
1982	5	3	2	0	17
1981	8	2	6	0	18

Table 4. New Hampshire mid-winter bald eagle survey results, 1981-2004.

Year	Adults	Sub-ads	Immatures	Totals
2003-2004	57	2	34	93
2002-2003	47	8	37	92
2001-2002	45	12	28	85
2000-2001	29	6	22	57
1999-2000	35	7	16	58
1998-1999	25	7	17	49
1997-1998	32	3	23	58
1996-1997	34	8	32	74
1995-1996	38	5	37	80
1994-1995	37	9	37	83
1993-1994	33	18	19	70
1992-1993	43	5	23	71
1991-1992	38	6	20	64
1990-1991	31	2	20	53
1989-1990	42	8	15	65
1988-1989	39	--	13	52
1987-1988	29	--	27	56
1986-1987	30	--	26	56
1985-1986	40	--	24	64
1984-1985	41	--	29	70
1983-1984	32	--	10	42
1982-1983	9	--	9	18
1981-1982	10	--	6	16
1980-1981	10	--	8	18

Table 5. New Hampshire bald eagle wintering estimates, 1980-1981 through 2003-2004.

SPECIES PROFILE

Bay-Breasted Warbler

Dendroica castanea

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S4B
Author: Jillian R. Kelly, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Bay-breasted warblers use small forest openings, particularly the edges of clearings, bogs, and ponds. They appear to favor vigorous, mature conifers with thick lower branches (MacArthur 1958). In New England, they prefer second growth boreal forest with trees 6 to 10 ft (1.8 to 3.4 m) tall (Pough 1949, DeGraaf and Yamasaki 2001). Bay-breasted warblers have been known to breed at elevations up to 4,000 ft in coniferous or mixed woods in New Hampshire (Andrews in Foss 1994). Bay-breasted warblers forage primarily among the interior branches in the middle section of conifers and often experience population fluctuations in response to spruce budworm outbreaks.

1.2 Justification

Bay-breasted warblers are a species of concern due to the loss of mature spruce-fir habitat from short rotation harvesting and forest conversion. In the eastern spruce hardwood forest, bay-breasted warblers are considered a priority bird species indicative of forest health. According to BCR trend data, bay-breasted warblers are decreasing by 1.4% annually, and in New Hampshire there is a suspected decrease of 6.6% (Hunt 2005). Over a 20-year period, Breeding Bird Survey (BBS) data documented a 77.1% decline of the bay-breasted warbler population in the Northeast (NatureServe 2005). Reasons for bay-breasted warbler decline may include reduced foraging opportunity due to the suppression of spruce budworm, forest fragmentation, large-scale clear cutting, loss of wintering habitat (tropical deforestation) and climate change (Pearson 1996).

1.3 Protection and Regulatory Status

The bay breasted warbler is a BCR 14 priority bird species (Highest concern), and a PIF (physiographic area 28) priority bird species.

1.4 Population and Habitat Distribution

Bay-breasted warblers were once the most common bird in virgin spruce forests at East Inlet, Pittsburg (Andrews 1994) and were considered by some the most abundant warbler at Lake Umbagog (Maynard 1871). In Jefferson, the bay-breasted warbler was considered a "not uncommon summer resident" (Wright 1911). Historic information shows that the species experienced periodic population fluctuations with only few breeding records south of the White Mountains.

Bay-breasted warblers can now be found primarily in the boreal coniferous forests of central and eastern Canada (Pearson 1996). Their breeding distribution in New England is confined to northeast Vermont, northern New Hampshire, and much of central and northern Maine (Andrews 1994). Bay-breasted warbler populations in the Northeastern United States are highly associated with outbreaks of spruce budworm (Andrews 1994).

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

See High Elevation Spruce-Fir Forest habitat profile.

1.7 Sources of Information

Primary sources of information included DeGraaf and Yamasaki (2001), Hunt (2005), NHFG data, BCR and PIF conservation plans, and Internet sources.

1.8 Extent and Quality of Data

New Hampshire lacks data on the distribution and population trends of bay-breasted warblers. Consistent and comprehensive breeding surveys are needed.

1.9 Distribution Research

New Hampshire needs more consistent data from BBS surveys, research into the effects of spruce budworm control on warbler populations (BCR 14), and research into the effectiveness of maintaining existing patches of mature coniferous trees under current forest management practices (BCR 14).

Element 5: References

5.1 Literature

Andrews, R. 1994. Bay-breasted Warbler (*Dendroica castanea).* Page 280 in C.R. Foss ed. Atlas of Breeding Birds in New Hampshire. Arcadia. Dover, New Hampshire, USA.

DeGraaf, R.M., and M. Yamasaki. 2001. New England Wildlife Habitats, Natural History, and Distribution. University Press of New England, Hanover, New Hampshire, USA.

Hunt, P. 2005. A Regional Perspective on New Hampshire's Birds of Conservation Priority: Objectives, Threats, Research Needs, and Conservation Strategies. New Hampshire Audubon.

MacArthur, R.H. 1958. Population ecology of some warblers of northeastern coniferous forests. Ecology 39:599-619.

Maynard, C.J. 1871. A catalogue of the birds of Coos County, New Hampshire, and Oxford County, Maine. Proceedings of the Boston Society of Natural History 14:357-395.

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life (web application). Version 4.2 NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer.

Pearson, S.F. 1996. Bay-breasted Warbler (*Dendroica castanea*). In the Birds of North America, No. 206 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists Union, Washington, D. C.

Pough, R.H. 1949. Audubon bird guide: eastern land birds. Doubleday, Garden City, New York, USA.

Wright, H.W. 1911. The birds of the Jefferson region in the White Mountains, New Hampshire. Proceedings of the Manchester Institute of Arts and Sciences 5. Pt 1. Manchester, New Hampshire, USA.

SPECIES PROFILE

Bicknell's Thrush

Catharus bicknelli

Federal listing: Not listed
State listing: Not listed
Global rank: Not ranked
State rank: Not ranked
Author: Laura S. Deming, New Hampshire Audubon

Element 1: Distribution and Habitat

1.1 Habitat Description

Bicknell's thrush occupies balsam fir-dominated forests on high elevation mountain slopes of the northeastern United States and lower elevation forests further north in the Canadian Maritime Provinces. Dense fir thickets typical of breeding habitat have varying amounts of red spruce, black spruce, paper birch, mountain ash, and other species, depending on latitude and elevation.

Within these forests, Bicknell's thrush are most common in areas that undergo frequent natural disturbance from wind, ice storms, fir waves, fire, and insect outbreaks, as well as chronically disturbed high elevation and coastal forests. At high elevations, such areas are most common along exposed ridgelines. This species has also been found in habitats disturbed by humans, such as regenerating timber harvest sites, roads, and ski trails (Rimmer et al. 2001). Occupied habitats are characterized by high numbers of standing dead conifers with a dense understory of balsam fir. In the White Mountains of New Hampshire, occupied sites were dominated by conifers (75% foliage volume) and had a mean canopy height of 4.8 m (15.7 ft) (Sabo 1980 *in* Rimmer et al. 2001). Bicknell's thrushes also prefer a high density of trees, dead fallen trees, snags and stumps, and moss ground cover (Connolly 2000).

In the Catskills, which lie at the southern end of the range, breeding habitat is found above 1,100 m (3,600 ft). In Maine, territories occur as low as 750 m (2,460 ft), and in southern Quebec and New Brunswick, where Bicknell's thrush reaches the northern edge of its breeding range, territories occur in coastal spruce-fir habitat, as well as in regenerating stands of mixed forests above 450 m (1,476 ft) (Rimmer et al. 2001). In New Hampshire, the Bicknell's thrush is found primarily in the White Mountains, between 1,070 and 1,370 m (3,500 to 4,500 ft) in elevation (Richards 1994).

1.2 Justification

Bicknell's thrush breeding habitat is relatively limited, consisting of a series of "islands" throughout the range. High elevation forests are especially vulnerable to degradation from global climate change, atmospheric pollution, and human disturbance caused by construction and maintenance of ski areas, cell towers, wind farms, and roads, as well as hikers, mountain bikers and other recreational users.

On its wintering grounds, this species occupies moist, primarily broadleaf forests, which have been severely reduced (Rimmer et al. 2001). The Dominican Republic has lost about 90% of its forest habitat, Jamaica has lost 75%, Cuba has lost 80-85%, and Haiti's forests are all but gone, with less than 1.5% remaining (Stattersfield et al. 1998). Bicknell's thrush was found at 7 of 11 surveyed historic sites (14 sites known) in 1995-97, and several sites had been degraded to the point of being unsuitable for this species (Rimmer et al. 2001).

Atlas projects in northern New England and New York indicate that Bicknell's thrush still occupies most of its historic breeding range. In New York, atlas maps of Bicknell's reports were very similar to locations reported by Bull in 1974, and no changes in distribution or abundance have been documented over the past century (Peterson 1988). In Vermont, this

species has probably never been widely distributed, being limited to the small number of peaks above 914 m (3,000 ft) along the spine of the Green Mountains (Kibbe 1985). Bicknell's thrush was known to occur historically on Mt. Greylock (Massachusetts) as early as 1888, but the small breeding population (6-11 pairs from 1934-60) began to decline in 1960, and the species was considered extirpated from the state by 1973 (Veit and Petersen 1993).

In Maine, Bicknell's were documented on several peaks in western Maine, and on Mt. Katahdin in central Maine (Adamus 1983). However, there are about 150 peaks rising above 750 m (2,460 ft) in western and central Maine, and it is likely that many of these support Bicknell's thrush. Most of these peaks are remote and lack access via trails or roads, making surveys extremely difficult (Maine Office of GIS).

1.3 Protection and Regulatory Status

The Bicknell's thrush is protected in the United States under the Migratory Bird Treaty Act of 1918.

1.4 Population and Habitat Distribution

In New Hampshire, Bicknell's thrush breeding habitat is centered in the White Mountains, where this species was first recorded during the breeding season in 1882 (Richards 1994). During the early 1950s, they were reported in Dixville Notch, the Third Connecticut Lake (Pittsburg), Mt. Sunapee (Newbury), and Mt. Monadnock (Jaffrey), and Mt. Kearsarge (Warner/Wilmot). A nest with eggs was found on Mt. Kearsarge in 1957, and the species was present on this site from 1950 through 1970 (Richards 1994). In 1970, Bicknell's thrushes were also documented on Mt. Cardigan, in Orange and Alexandria. Over the past few decades, breeding populations on Kearsarge, Monadnock, Sunapee, and Dixville Notch have disappeared, and today, the Bicknell's thrush is almost entirely restricted to the White Mountains, with possible occurrences on Mt. Cardigan and in the North Country (Richards 1994).

The transient and patchy nature of Bicknell's thrush breeding habitat results in erratic distribution of occupied breeding territories. They also exhibit a unique breeding strategy, termed "female-defense polygynandry" (Briskie 1993 in Rimmer et al. 2001), where both males and females pair with more than one partner. In Vermont, more than 75% of broods had multiple paternity, some males had offspring in two nests simultaneously, and 75% of nests had 2-4 males feeding the nestlings (Rimmer et al. 2001). The inaccessible nature of their breeding habitat combined with a rather complex mating system make this species especially difficult to study.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

The Bicknell's thrush habitat map was based on model developed by New Hampshire Fish and Game (NHFG) that integrates three data sets to capture potential breeding habitat. The first, a habitat model developed by the Vermont Institute of Natural Science (VINS), sets an elevation "mask" that drops 81.63 m for every 1 degree increase in latitude to reflect climatic effects on forest composition and structure (Lambert et al. 2004). This ratio is based on the lowest altitudes documented for Bicknell's in the southernmost sites (the Catskills), and the northernmost sites (southern Quebec), and is nearly identical to the ratio for tree line, which drops approximately 83-m/1 degree in elevation (Cogbill and White 1991). Above this mask, VINS used the 1992 National Land Cover Dataset (NLCD) to map softwood cover as potential Bicknell's thrush breeding habitat.

A second model designed to predict Bicknell's thrush distribution and abundance in the White Mountains used satellite imagery of land cover, digital elevation model, and point count data (Hale in press). This model was accurate in predicting Bicknell's distribution within a decile range of 0.10-0.60, but overestimated the number of birds above 0.60 deciles, which tended to occur at pixels in krummholz and in the alpine zone. This model also included lower elevation forests with high hardwood component, which support much lower densities of Bicknell's (Rimmer et al. 2001). However, because the area of this lower elevation habitat is so extensive, it has the potential to support a greater number of birds than the smaller area of higher elevation habitat.

In addition to these two models, NHFG also used NHNHB data on four high elevation communities to ensure that as much high elevation softwood habitat as possible would be included as potential habitat.

1.7 Sources of Information

Information on historic and recent Bicknell's thrush distribution and habitat was found in breeding bird atlases from New York, Vermont, and New Hampshire, and from the Bicknell's thrush account of the Birds of North America series. Habitat models developed by VINS and S. Hale were combined with NHNHB data in the mapping effort by NHFG. Data on Bicknell's thrush occurrences were derived from monitoring data gathered by Mountain Bird Watch (VINS) and the WMNF monitoring program from 1992 to 2000.

1.8 Extent and Quality of Data

Despite the quantity of data generated by the abovementioned monitoring programs, a substantial portion of the Bicknell's range is inadequately surveyed, and there is incomplete information on their distribution, relative abundance, breeding success, and other population parameters. Due to the remoteness and inaccessibility of their breeding habitat and unique breeding strategy, Bicknell's thrushes are difficult to survey. Breeding Bird Survey (BBS) routes do not typically represent high elevation spruce fir habitat, and not surprisingly, Bicknell's are rarely reported on BBS routes (Sauer et al. 2003). The data gathered so far are not enough to determine significant trends in populations over recent years.

1.9 Distribution Research

The Mountain Birdwatch Program instituted by VINS in 2000 is the most comprehensive approach to determining the distribution of Bicknell's thrush throughout its range in the Northeast. In 2003, this program covered 117 routes throughout New York, Vermont, New Hampshire, and Maine, yet many potential breeding areas are too remote and inaccessible to be surveyed, particularly in northern New Hampshire and west-central Maine. Based on elevation data from the Maine Office of GIS, there are approximately 150 peaks above 750 m (2,460 ft) in Maine, all of which could provide suitable habitat for Bicknell's thrush. These inaccessible mountains would need to be surveyed in order to fully determine the actual extent of the breeding range.

Element 2: Species Condition

2.1 Scale

Based on habitat mapping of high elevation spruce fir habitat conducted by NHFG, 24 units were identified as potential or known habitat. The largest area (approximately 39,000 ha) is on the WMNF, and includes 10 of the units. Another 11 units are located north of the White Mountains, two of which (Nash Stream and Bunnell Preserve) are listed separately because they are conservation lands. The units are grouped according to similarities in their ownership and/or conservation status:

- **North Country:** NHFG WMA North; Lyme Timber; NHFG Natural Area; Magalloway Mt.-Stubb Hill; Crystal Mt.-Blue Ridge; Mt. Dustan; Sanguinary-Rice Mts.; Dixville Peak-Mt. Kelsey; Cambridge
- **North Country west:** Nash Stream; Bunnell Preserve
- **Success:** Mahoosuc Range
- **WMNF:** Pilot-Kilkenny-Pliny Range; Wildcat Mt.; Mt. Washington; Pemi Wilderness; Franconia Ridge-Twin Mt.; Kinsman Ridge; Osceola-Kancamagus; Sawyer Pond-Bear-Moat Mts.; Moosilauke; Cushman-Carr Mts.
- **West Central:** Smarts Mt.; Mt. Cardigan

2.2 Relative Health of Populations

There is no information on the relative health of Bicknell's populations in New Hampshire. Bicknell's thrushes are known to breed throughout most of their historic range in the state, with the exception of the most southern locations, although most of the potential habitat north of the White Mountains is inadequately covered.

Relative abundance of Bicknell's thrush appears to be unchanged from 2000 to 2003, based on Mountain Birdwatch data (Lambert 2003). However, surveys from 1992 to 2000 by VINS and WMNF showed that this species may possibly have increased slightly in Vermont and declined somewhat in New Hampshire (Rimmer et al. 2001). In general, the amount of data collected cover too brief a time to allow detection of significant population changes.

2.3 Population Management Status

Bicknell's thrush populations are not currently managed in New Hampshire.

2.4 Relative Quality of Habitat Patches

Nearly all of the peaks above a threshold elevation of 915 m (3,000 ft) in New Hampshire (Hale 2001) have habitat suitable for Bicknell's thrush, all of which are threatened by atmospheric deposition of acidic compounds, heavy metals, and other pollutants. Peaks in the White Mountains have several ski areas, and thousands of miles of trails that attract millions of visitors each year, making them vulnerable to recreation impacts. An assessment of habitat quality for different patches should include size of habitat block, forest stand characteristics, natural and human disturbance factors, and measures of ecosystem health that could include invertebrate community, soil toxicology, and other factors. Habitat condition should be correlated with Bicknell's thrush population parameters, including mortality rates, blood mercury content, etc.

2.5 Habitat Patch Protection Status

Bicknell's thrush habitat in the northeastern United States is mostly protected by national and state forests. Of the 111,346 ha of potential Bicknell's thrush breeding habitat identified by the VINS GIS model, 90,190 ha 81% is on conservation lands (Lambert 2003). New Hampshire and New York contain the majority of potential Bicknell's thrush habitat (45% and 24%, respectively), and have the highest percentages on protected lands (94% and 93%, respectively). Vermont, which has 8% of the breeding habitat, has 83% on conservation lands, and Maine, with 23% of the habitat, has just 41% on conservation lands (Lambert 2003).

In New Hampshire, approximately 83% of Bicknell's thrush habitat is on the WMNF, about 5% is on state forestlands, and the remainder (about 12%) is protected by private conservation lands, forest preserves, town forests, and timberland easements (Lambert 2003).

2.6 Habitat Management Status

See section 2.5. Habitat is not managed specifically for Bicknell's thrushes in New Hampshire, but populations may indirectly benefit from other management activity on state and federal conservation land.

2.7 Sources of Information

Most information on Bicknell's thrush breeding range, habitat, and conservation status, as well as extent and conservation status of potential breeding habitat was derived from documents and reports produced by VINS. Supplemental information was gathered from breeding bird atlases for the region. Population data were generated by the WMNF high elevation bird surveys and VINS Mountain Birdwatch surveys. Habitat models were developed by VINS and by Dr. Stephen Hale of the University of New Hampshire.

2.8 Extent and Quality of Data

Data on presence and relative abundance of Bicknell's thrush have been gathered by VINS and WMNF for several years, but not long enough to determine statistically significant population trends. The core breeding range continues to be monitored by the Mountain Birdwatch Program (VINS), but many more remote peaks are still not monitored at all. There is very little information on the effects pollution and other impacts on the breeding habitat.

2.9 Condition Ranking

2.10 Condition Assessment Research

The greatest threats to Bicknell's thrush are climate change, atmospheric deposition pollution (e.g., acidic compounds and mercury), and destruction of wintering habitats. To address issues threatening Bicknell's on their breeding grounds, research efforts should focus on determining the effects of pollutants and climate change on Bicknell's thrush as a component of the overall high elevation ecosystem.

Element 3: Species and Habitat Threat Assessment

3.1 Threats

See Form 1: Threat Identification, Form 2: Threat Ranking, and Form 3: Local Threat Weighting (attached). Form 4 (Feasibility Ranking) for Bicknell's thrush will be inextricably linked to the Feasibility Ranking for high elevation spruce-fir and for non-breeding birds. All threats to Bicknell's in New Hampshire are related to either habitat degradation or broader threats such as climate change and acid deposition.

Considerable evidence suggests that habitat loss on the Caribbean winter grounds may be the most critical threat facing Bicknell's thrush. New Hampshire should thus work cooperatively with other northeastern States and Provinces in developing a feasible and effective habitat conservation program in the Dominican Republic (where the majority of the population is believed to winter). Although few Bicknell's have been recorded in Haiti, Jamaica, Puerto Rico, and Cuba, this may be partly because these countries have so little of their original forested habitat remaining. International initiatives should consider these countries potential partners in any activities related to Bicknell's thrush conservation.

3.1.1 Acid Deposition

High elevation spruce fir forests throughout the Northeast have been affected by acid deposition. Acidification has resulted in extensive die-offs of red-spruce, which is not the dominant species in Bicknell's thrush breeding habitat, but makes up a large component of forest composition. Acidification also leaches calcium from the soil, causing declines in tree health, invertebrate prey quality, and ultimately reducing fitness in Bicknell's and other insectivorous vertebrates.

3.1.2 Mercury

Atmospheric deposition of pollutants such as mercury and lead may affect high elevation forests and wildlife. Methylmercury can accumulate in the food chain and pose a risk to insectivorous species such as Bicknell's thrush.

3.1.3 Climate Change

High elevation spruce fir forests and associated wildlife will likely decline as the climate changes and temperatures become too warm for the species to survive or compete with other warm-adapted species. One estimate indicates that a 3° rise in the mean July temperature could result in an 88% to 98% loss of the United States breeding habitat of Bicknell's, including extirpation from the Catskills, southern Adirondacks, Green Mountains, western Maine, and possibly up to 144 mountains in New Hampshire (Lambert and McFarland 2004).

3.2 Sources of Information

Threats information for Bicknell's thrush was derived from the literature and discussions with experts and colleagues during threat identification and ranking meetings. For Bicknell's thrush, the threats forms for high elevation spruce-fir habitat were used and modified as appropriate to address threats to this particular species.

3.3 Extent and Quality of Data

There is substantial information on the effects of forest practices and other habitat conversion (ski area expansion, roads, etc) on forest birds such as Bicknell's thrush. A great deal of research on the effects of acid rain on spruce-fir forests has also been done, although the direct impacts on Bicknell's and other species are not well documented. Less is known about other impacts, including pollutants, wind and cell towers, and recreation impacts.

3.4 Threat Assessment Research

There is little or no data on the effects of pollutants on Bicknell's thrush, but atmospheric deposition of mercury is likely to be a major threat to this species. Also, there is very little known about the effects of recreation along hiking trails and ski trails, nor the impact of developments at high elevation.

Element 4: Conservation Actions

See Element 4 for High elevation spruce-fir and Non-breeding birds.

Element 5: References

5.1 Literature

Adamus, P.R. 1987. Atlas of breeding birds in Maine, 1978-1983. Maine Department of Inland Fisheries and Wildlife, Augusta, Maine, USA.

Cogbill, C.V., and P.S. White. 1991. The latitude-elevation relationship for spruce-fir forest and tree line along the Appalachian Mountain chain. Vegetatio 94:153-175.

Connolly, V. 2000. Characterization and classification of Bicknell's Thrush (*Catharus bicknelli*) habitat in the Estrie region, Quebec. M.S. thesis, McGill Univ., Montréal, Quebec.

Hale, S.R. In press. Using satellite imagery to model distribution and abundance of Bicknell's thrush (Catharus bicknellii) in New Hampshire's White Mountains.

Kibbe, D.P. 1985. Gray-cheeked Thrush. Pp. 242-243 *in* The atlas of breeding birds of Vermont (S. B. Laughlin and D. P. Kibbe, eds.). University Press of New England, Hanover, New Hampshire, USA.

Lambert, J.D. 2003. Mountain Birdwatch 2002: Final Report to the U. S. Fish and Wildlife Service. Unpubl. report. Vermont Institute of Natural Science, Woodstock, Vermont, USA.

Lambert, J.D. 2004. Mountain Birdwatch 2003: Final Report to the U. S. Fish and Wildlife Service. Unpubl. report. Vermont Institute of Natural Science, Woodstock, Vermont, USA.

Lambert, J.D., and K.P. McFarland. 2004. Projecting the Effects of Climate Change on Bicknell's Thrush Habitat in the Northeastern United States. Addendum to Mountain Birdwatch 2003: Final Report to the U. S. Fish and Wildlife Service. Unpubl. report. Vermont Institute of Natural Science, Woodstock, Vermont, USA.

Peterson, J. M.C. 1998. Gray-cheeked Thrush. Pp. 320-321 *in* The Atlas of the Breeding Birds of New York State (R. F. Andrle and J. R. Carroll, eds.). Cornell University Press, Ithaca, New York, USA.

Richards, T. 1994. Bicknell's Thrush. Pp. 218-219 *in* Atlas of breeding birds in New Hampshire (C.R. Foss, ed.). New Hampshire Audubon, Dover, New Hampshire, USA.

Rimmer, C.C., K.P. McFarland, W.G. Ellison, and J.E. Goetz. 2001. Bicknell's Thrush (*Catharus bicknelli*). *In* The Birds of North America, No. 592 (A. Poole and F. Gill, eds.).The Birds of North America, Inc., Philadelphia, Pennsylvania, USA.

Rimmer, C.C., K.P. McFarland, and J.D. Lambert. 2001. Bicknell's Thrush (*Catharus bicknellii*) Conservation Assessment. Unpublished report, Vermont Institute of Natural Science, Woodstock, Vermont, USA.

Rompré, G., V. Connolly, Y. Aubry, J.P. Savard, and G. Seutin. 1997. Distribution, abundance, and habitat requirements of Bicknell's Thrush (*Catharus bicknelli*) in Quebec. Unpubl. Rep. Can. Wildl. Serv., Ste.-Foy, Quebec.

Sabo, S.R. 1980. Niche and habitat relations in subalpine bird communities of the White Mountains of New Hampshire. Ecological Monographs 50: 241-259.

Veit, R.R., and W.R. Peterson. 1993. Birds of Massachusetts. Massachusetts Audubon Society, Lincoln, Massachusetts, USA.

Stattersfield, A.J., M.J. Crosby, A.D. Long, and D.C. Wege. 1998. Endemic bird areas of the world: priorities for biodiversity conservation. Bird Life Conservation Series No. 7.

5.2 Data Sources

Maine GIS. http://apollo.ogis.state.me.us/

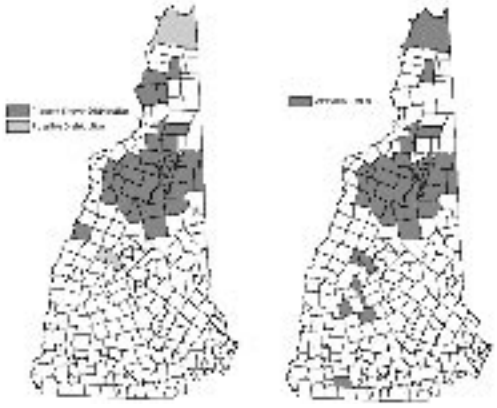
Mountain Birdwatch Program. Vermont Institute of Natural Science (VINS), Woodstock, VT.

White Mountain National Forest Breeding Birds Surveys. White Mountain National Forest (WMNF), Laconia, NH.

Element 6: List of Figures:

Figure 1. Historic (up to mid-1950's) and present distribution of Bicknell's thrush during the breeding season. Towns are coded as known (dark gray) or possible (light gray) sites for Bicknell's thrush.

Figure 1. Historic (up to mid-1950's) and present distribution of Bicknell's thrush during the breeding season. Towns are coded as known (dark gray) or possible (light gray) sites for Bicknell's thrush.



SPECIES PROFILE

American Black Duck

Anas rubripes

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S4
Author: New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

American black duck breeding habitat includes a variety of coastal and freshwater habitats, including brackish marshes, estuaries, river, lake, and pond edges, forested swamps, bogs, beaver ponds, emergent wetlands, and open boreal and mixed hardwood forests. Nests are usually laid on the ground and may be a mile from water. Wintering habitat includes brackish marshes bordering bay, estuaries, and open water areas on freshwater rivers and ponds (DeGraaf and Yamasaki 2001).

The black duck diet varies greatly with habitat. In marine habitats, black ducks feed primarily on mollusks, and in fresh water they feed mostly on aquatic plants. Ducklings and egg-laying females consume significant quantities of protein. Other foods include seeds, acorns, berries, waste corn, crustaceans, and amphibians.

1.2 Justification

Mid-winter black duck surveys indicated that populations were stable over the last 20 years, though wintering black duck numbers have declined dramatically both in total and in the Atlantic Flyway from population numbers in the 1950s (USFWS 2004). The American black duck was ranked as the highest conservation concern (HH) for both Bird Conservation Regions (BCR) 14 and 30 and ranked high Regional priority (rank = 3). The black duck is the most important harvested duck in Canada and is considered a trophy species in the United States. The black duck was once the most common duck in New Hampshire (Lacaillade 1975), though since 1991 is has been only the third most abundant puddle duck harvested (NHFG duck kill unpublished data).

1.3 Protection and Regulatory Status

- Migratory Bird Treaty Act (1918): listed as game bird
- Federal trust species for the USFWS, United States Department of the Interior, through 50 CFR Part 20, establishes frameworks for migratory bird hunting regulations.
- NHFG, in accordance with RSA 209:6, establishes annual New Hampshire waterfowl hunting seasons in compliance with federal frameworks.

See Marsh and Shrub Wetlands and Salt Marshes habitat profiles for habitat-based regulations.

1.4 Population and Habitat Distribution

Black ducks breed from Northern Saskatchewan across Canada east to Northern Labrador and Newfoundland and south to northern Illinois and North Carolina. Wintering populations are found primarily along the Atlantic Coast from New England south to North Carolina but occur as far south as Florida and west to Texas. In New Hampshire, black ducks are found throughout the state and are the third most commonly breeding duck species in the state (Northeast Breeding Plot Survey 2004, unpublished data). Black ducks winter primarily in coastal salt marshes and on Great Bay and are the most common winter puddle duck in coastal marshes (MWS 2005, unpublished data). During spring and fall migration, black ducks are observed statewide but are most common in coastal areas.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

Not completed for this species; See Marsh and Shrub Wetlands and Salt Marshes habitat profiles

1.7 Sources of Information

Information on American black ducks was collected from the North American Waterfowl Management Plan (NAWMP), The Atlantic Coast Joint Venture (ACJV) Plan, Long-term Eastern Waterfowl Survey, the federally coordinated Mid-Winter Waterfowl Survey, the Atlas of Breeding Birds in New Hampshire, NHFG survey data, Waterfowl and Their Management in New Hampshire, Atlantic Flyway Waterfowl Harvest and Population Survey data, The American Black Duck Symposium publication, and personal knowledge of the NHFG Waterfowl Biologist.

1.8 Extent and Quality of Data

North American waterfowl population and harvest surveys were initiated in 1952. The database pertaining to North American waterfowl species, including the American black duck, is one of the most reliable and extensive wildlife data sets in the world.

1.9 Distribution Research

As part of the North American Waterfowl Population and Harvest data sets, annual breeding, wintering, and harvest surveys are conducted throughout the black duck range to monitor population distribution and abundance. Close cooperation between Canada and the United States to maintain harvest parity and coordinate population surveys is critical to the long-term management of the black duck (Atlantic Flyway Council Technical Section-Black Duck Committee).

Element 2: Species/Habitat Condition

2.1 Scale

Black duck harvest and population monitoring surveys remain an international cooperative venture. Key wintering, breeding, and migratory areas were identified for New Hampshire.

2.2 Relative Health of Populations

The American black duck population in North America and in New Hampshire is considered stable. In response to concerns about the population, flyway harvest restrictions were instituted in the United States in 1983 and in Canada in 1984, and reduced harvest by over 40%. Mid-winter waterfowl survey data indicate that population sizes have remained generally stable during the period of harvest restrictions, and breeding surveys in Canada have shown increases (Kehoe 1990).

Black ducks are the fourth most common breeding waterfowl species in the State (4,346 breeding pairs) and breed in the highest numbers in northern areas (NHFG Waterfowl Plot Surveys 1993-2004, unpublished data). Great Bay and coastal salt marshes winter an average of 1,385 black ducks annually (NHFG Mid-winter surveys [MWS] 1952-2005, unpublished data). A small number of black ducks, 493 per year on average, winter at inland sites generally in open water areas below dams on rivers (NHFG Inland Winter Survey 1988-2004, unpublished data).

2.3 Population Management Status

The USFWS and the Canadian Wildlife Service (CWS) have jurisdiction over harvest regulations in their respective countries. In the Atlantic Flyway, provinces, federal agencies, and all states cooperatively fund and conduct population monitoring surveys that inform annual North American hunting regulations for the American black duck. State and provincial wildlife agencies establish annual hunting regulations according to frameworks established by the USFWS and CWS within the context of the Flyway system of waterfowl management.

2.4 Relative Quality of Habitat Patches

Not completed for this species. See Marsh and Shrub Wetlands and Salt Marsh Habitat Profiles.

2.5 Habitat Patch Protection Status

The NAWMP (1986) and the subsequent ACJV plan were established to conserve the most important habitats for waterfowl (breeding, migration, and wintering). Each state was asked to identify the most

important areas for future protection work. In New Hampshire, 3 waterfowl focus areas were established for to protect habitat for black ducks: Lake Umbagog National Wildlife Refuge (for breeding), Connecticut River Silvio O. Conte National Wildlife Refuge (for migration), and Great Bay National Wildlife Refuge (for wintering).

In all 3 areas, state, federal, and private partnerships provide tens of millions of dollars to protect thousands of acres of waterfowl habitat. In all wetland protection efforts, a minimum 91m (300 ft) wide upland buffer area is also protected to provide nesting habitat for waterfowl.

It is anticipated that significant acquisition of waterfowl habitat will continue in each area. It is also anticipated that the Merrimack River Corridor will be designated as a planning area in a future NAWMP update. The NHFG has protected habitat along the Merrimack River Corridor, and partnerships are being established to conserve thousands of acres of wildlife habitat along the river. The Merrimack River is a significant migration corridor for black ducks and is worthy of a "Planning Status" under the NAWMP. Future efforts will focus on establishing that designation.

2.6 Habitat Management Status

Habitat management and protection in New Hampshire began in the late 1940s. NHFG, in coordination with the Atlantic Flyway Council, began acquiring wetland habitat and constructing low-head water control structures to create and maintain habitat for native waterfowl species, including the American black duck. From the late 1940s through 1983, protection and management of these habitats was made possible by donated property value used to match Federal Aid Pitman-Robertson and Dingal-Johnson monies. In 1983, State legislation was passed which established a State Duck Stamp. Revenues from the sale of $4.00 stamps and associated artwork are placed in a dedicated account for waterfowl management in the state. Today, NHFG owns or manages 49 State Waterfowl Management Areas, which include over 3,557 ha (8,790 ac) of habitat. Thirty of the Department's Wildlife Management Areas include water control structures that allow water level manipulations to stimulate the growth of desirable aquatic plants.

Most waterfowl habitat in New Hampshire is in private ownership and is created and managed primarily by beaver (*Castor canadensis*). A healthy beaver population provides the majority of waterfowl habitat in the state for all life stages, with the exception of wintering habitat, which is primarily salt marsh. Historically, salt marsh habitat was degraded by ditching and draining salt marshes for hay production and mosquito control. Today, Ducks Unlimited, along with the other partners in the Great Bay Resource Protection Partnership (NHA, Great Bay National Estuarine Research Reserve, NHFG, TNC, Society for the Protection of New Hampshire Forests, USEPA, USFWS, and the NRCS) have conducted open water marsh management in a number of salt marsh locations to restore various drainage situations to improve black duck habitat.

2.7 Sources of Information

See element 1.7

2.8 Extent and Quality of Data

See element 1.8

2.9 Distribution Research

See element 1.9

Element 3: Species and Habitat Threat Assessment

3.1.1 Development (Habitat Loss and Conversion)

(A) Exposure Pathway

The loss or degradation of wetlands will reduce the number of sites available for breeding, wintering, or migrating American black ducks and other waterfowl. Development of upland buffers can reduce water quality of wetlands, increase disturbance to birds, and eliminate nesting opportunities or increase the disturbance or destruction of nests by humans, pets, or subsidized predators (e.g., raccoons).

(B) Evidence

The major threats to bird populations in the ACJV are habitat loss, fragmentation, and degradation. Along the Atlantic Coast, there has been a 76% increase in the human population from 1950 to 2000 (ACJV Plan). New Hampshire is the fastest develop-

ing New England state, and though wetland loss in New Hampshire has been minimal over time (94% of original wetland habitat remains) (NHOSP 1989), the upland edges along marshes, ponds, lakes, and rivers are rapidly being developed (see Marsh and Shrub Wetlands profile-Threats).

3.1.2 Acid Deposition, Non-Point Source Pollution (Runoff and Sedimentation, Chemical Contaminants)

(A) Exposure Pathway
A number of different water quality issues affect the black duck. Acidification of wetland habitats can decrease the amount of invertebrate food required by duckling and egg-laying females (Kehoe 1990). Runoff, including salt, petroleum products, and silt, from increased road development affects water quality, as do fertilizers from lawns that are adjacent to wetlands, lakes, ponds and rivers.

(B) Evidence
Literature on the negative effects of water quality on wildlife is abundant (see Watershed Profiles). At Great Bay, poor water quality because of untreated sewage from coastal treatment plants has resulted in periodic outbreaks of a "wasting disease" that kills eelgrass (*Zostera marina*). Eelgrass is a critical life-cycle component for most fish and wildlife species that use Great Bay (Short 1992).

3.1.3 Predation and Herbivory

(A) Exposure Pathway
Predators, particularly along wetlands where the upland edge has been reduced in size or quality due to development or other causes, can significantly harm eggs, ducklings, and nesting females. Good wetland habitat and upland buffer habitat minimize the effect of predation.

(B) Evidence
In New Hampshire, raccoons, skunks, foxes, coyotes, weasels, mink, snapping turtles, and a variety of hawks and owls prey on ducks and eggs. The raccoon has long been considered the most significant waterfowl predator in New Hampshire, but after the outbreak of raccoon rabies in the 1980s, the raccoon population was substantially reduced. Warm water fish populations, including largemouth bass (*Micropterus salmoides*), pickerel (*Esox* spp.), and northern pike (*Esox lucius*) can kill ducklings.

3.1.4 Scarcity (Hybridization)

(A) Exposure Pathway
Black ducks and mallards readily hybridize throughout the black duck breeding range. As mallards continue to occupy traditional black duck range in eastern Canada and northern New England, the opportunity for hybridization also increases. There is still significant disagreement among waterfowl experts about the extent and seriousness of hybridization by mallards and black ducks. Where mallards occupy black duck habitat, they tend to do so permanently. Mallards are generally significantly more tolerant of people and their associated disturbances and more tolerant of agricultural practices. It is anticipated that as residential development and agricultural operations expand, the mallard will continue to replace the black duck in breeding habitats.

(B) Evidence
In New Hampshire, mallards over the last 30 years have replaced the black duck as the most common breeding and harvest species. In New Hampshire, during the 1999 to 2002 hunting seasons, 4.3% of the total number of mallards and black ducks shot by hunters were classified as hybrids (Serie and Raftovich 2003).

Competition between mallards and black ducks during the winter is considered minimal in New Hampshire. Black ducks winter primarily in coastal habitats and outnumber the mallard 2.2 to 1. Between 1990 and 2005, wintering black ducks and mallards in coastal areas averaged 1,159 and 526 birds per year respectively (MWS 2005, unpublished data). Mallards winter in much larger numbers on open fresh water sites where they outnumber the black duck 9.7 to 1.0. Between 1988 and 2004, an average of 4,533 mallards per year wintered at inland sites, compared to only 439 black ducks (NHFG Inland Winter Survey, unpublished data).

3.2 Sources of Information

Literature reviews, NHFG and Regional waterfowl surveys, and professional experiences.

3.3 Extent and Quality of Data

The database pertaining to North American waterfowl species, including the American black duck, is one of the most reliable and extensive wildlife data sets in the world. The effects of upland and wetland habitat loss are known.

3.4 Threat Assessment Research

None suggested at this time.

Element 4: Conservation Actions

Habitat protection and management as described in elements 2.5 and 2.6 are priorities. For other habitat-based actions, see Marsh and Shrub Wetlands and Salt Marshes habitat profiles.

Element 5: References

5.1 Literature

DeGraaf, R.M., and M. Yamasaki. 2001. New England wildlife: habitat, natural history, and distribution. University Press of New England, Hanover, New Hampshire, USA.

Hunt, P. 2005. A regional perspective on New Hampshire's birds of conservation priority: objectives, threats, research needs, and conservation strategies.

Kehoe, P. 1990. American black duck symposium. North American Waterfowl Management Plan.

Lacaillade, H.C. 1975. Waterfowl and their management in New Hampshire. New Hampshire Fish and Game Service Report 11. Concord, New Hampshire, USA.

New Hampshire Office of State Planning. 1989. New Hampshire wetlands: priority conservation plan. An addendum to the New Hampshire State Comprehensive Outdoor Recreation Plan. New Hampshire Office of State Planning. Concord, New Hampshire, USA.

Serie, J., and B. Raftovich. 2003. Atlantic flyway waterfowl harvest and population survey data. U.S. Fish and Wildlife Service, Laurel, Maryland, USA.

Short, F.T., editor. 1992. The ecology of the Great Bay estuary, New Hampshire and Maine: an estuarine profile and bibliography. Jackson Estuarine Laboratory. University of New Hampshire, Durham, New Hampshire, USA.

United States Fish and Wildlife Service (USFWS). 1986. North American waterfowl management plan: a strategy for cooperation. United States Department of the Interior, Washington, D.C., USA.

United States Fish and Wildlife Service (USFWS). 2004. Waterfowl population status, 2004. United States Department of the Interior, Washington, D.C., USA.

SPECIES PROFILE

Black Guillemot

Cepphus grylle

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S3
Author: Alina J. Pyzikiewicz, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Black guillemots inhabit rocky coasts and rocky offshore coastal islands (Borror 1994, Butler and Buckley 2002). Eggs are placed directly on rocks, and so to protect against predation, nesting colonies occur along rocky coasts under storm tossed rocks or in rocky crevices (Borror 1994). Cairns (1980) observed black guillemots nesting under tree roots and earth-lined holes. Preferred foraging areas are shallow inshore waters with bottom-dwelling crustaceans, fish, and invertebrates (Borror 1994, Butler and Buckley 2002). Wintering areas are generally the same as breeding areas, except at sites with solid ice cover where black guillemots move offshore to open waters with pack ice (Butler and Buckley 2002).

1.2 Justification

The black guillemot is of conservation concern because New Hampshire is the southernmost extent of its breeding range (Borror 1994) and it is a high priority species in Breeding Conservation Range 14 (Dettmers, unpublished data). Fewer than 5 breeding pairs of black guillemots occur on New Hampshire's coastal islands (Hunt, unpublished data). Increased concentrations of predatory great black backed gulls (*Larus marinus*) pose a threat to black guillemot chicks, further jeopardizing already small populations (Butler and Buckley 2002). Black guillemots are at great risk for biomagnification of heavy metals because they forage in shallow waters of the sea floor where sediment contaminants are highest (Butler and Buckley 2002). Global warming may also affect populations of black guillemots by forcing them to move further south where breeding and foraging habitats may be unsuitable.

1.3 Protection and Regulatory Status

The black guillemot is a species of special concern in New Hampshire. It is protected under the Migratory Bird Act and various non-government coastal water bird programs (e.g., Bird Conservation Regional Plans, Waterbird Conservation for the Americas, Gulf of Maine Council on the Marine Environment).

1.4 Population and Habitat Distribution

The range of black guillemots extends from remote islands in the Canadian Arctic down to offshore islands in southern New England with some birds occasionally wintering as far south as New Jersey (Borror 1994, Butler and Buckley 2002). Population estimates for North America are between 100,000 and 200,000 birds with 25,000 birds in Biological Conservation Region 14 (Kushlan et al. 2002). In New Hampshire, black guillemots have only been found off the coast on the Isles of Shoals, with occasional winter sightings along the mainland coast (New Hampshire Bird Records, Borror 1994).

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

1.7 Sources of Information

Sources of information include Birds of North Amer-

ica, New Hampshire Bird Records, the North American Waterbird Conservation Plan, and peer-reviewed scientific literature.

1.8 Extent and Quality of Data

The habitat and distribution of black guillemots in North America are well studied, but little is known about their distribution in New Hampshire due to a lack of adequate census data.

1.9 Distribution Research

Develop accurate census techniques to track population trends in black guillemots. Conduct breeding surveys to estimate population size and effects of global warming. Identify and monitor important nesting, foraging, and wintering areas.

Element 5: References

5.1 Literature

Borror, A. C. 1994. Black guillemot. Pages 100 –101 i*n* C. R Foss, editor. Breeding bird atlas of New Hampshire. Arcadia, Dover, New Hampshire, USA.

Butler, R. G., and D. E. Buckley. 2002. Black Guillemot (*Cepphus grille*). *In* A. Poole and F. Gill, editors. The Birds of North America, No 675. The Birds of North America, Philadelphia, Pennsylvania, USA.

Cairns, D. K. 1980. Nesting density, habitat structure and human disturbance as factors in black guillemot reproduction. Wilson Bulletin. 92:352-361.

Kushlan, J. A., M. J. Steinkamp, K. C. Parsons, J. Capp, M. Acosta Cruz, M. Coulter, I. Davidson, L. Dickson, N. Edelson, R. Elliot, R. M. Erwin, S. Hatch, S. Kress, R. Milko, S. Miller, K. Mills, R. Paul, R. Phillips, J. E. Saliva, B. Sydeman, J. Trapp, J. Wheeler, and K. Wohl. 2002. Waterbird conservation for the Americas: the North American waterbird conservation plan, Version 1. Waterbird Conservation for the Americas, Washington, DC, USA.

5.2 Data Sources

New Hampshire Bird Records. New Hampshire Audubon, Concord, New Hampshire, USA.

SPECIES PROFILE

Cerulean Warbler

Dendroica cerulea

Federal Listing: Not listed
State Listing: Special Concern
Global Rank: G4
State Rank: S3B
Author: Pamela D. Hunt, NHA

Element 1: Distribution and Habitat

1.1 Habitat Description

During the breeding season, cerulean warblers occupy 2 different types of hardwood forest: floodplain and upland. The species occurs along major rivers, or occasionally on lakes, in closed canopy and among scattered tall trees (Hamel 2000a, b). In parts of Appalachia, cerulean warblers also use mesic forests on mountain slopes. In these uplands, the highest warbler densities occur in oak-hickory and beech-maple stands (Hamel 2000a, Rosenberg et al. 2000).

Within both habitat types, birds prefer areas with taller trees, though empirical data are few (Hamel 2000a). Increasing evidence suggests that canopy gaps are also important (Oliarnyk and Robertson 1996, Hamel 2000a), although the extent to which such an association reflects a preference for old-growth forest conditions is unclear. Gaps in many of the forest types used by the species may be created by flooding or other natural disturbances unrelated to forest age (Jones and Robertson 2001). Gaps may also be mimicked by protruding canopy on forested slopes or by periodic forest management (Hamel 2000a).

Data are equivocal on the effects of disturbance on populations. There is some indication that the species is area sensitive, with minimum areas of 700 and 1,600 hectares (1,750 and 4,000 acres) in the Mid-Atlantic and lower Mississippi regions, respectively (Hamel 2000a). Some stable populations require areas as large as 8,000 ha (20,000 acres). Again, high variability across the species' range makes generalizing habitat needs difficult, and area sensitivity may be tied to broader patterns of landscape use and forest type.

Ceruleans in New Hampshire appear to use both upland and floodplain hardwood forests. The primary population at Pawtuckaway State Park occupies a mixed red oak/red maple/white pine forest (New Hampshire Division of Parks and Lands, unpublished data) that occurs at relatively high elevation (400 to 900 ft) on variable slopes. This is most similar to the habitat used in the northern Appalachians (Rosenberg et al. 2000). Mount Wantastiquet in Hinsdale/Chesterfield is another steep, upland hardwood site (35% grade) with records of ceruleans. The red maple dominated floodplain of the Blackwater River in Salisbury also has multiple records and is typical of floodplain in the area. Here, less prominent trees include American elm, white ash, silver maple, and birches (Foss et al. 2000, unpublished data). Floodplain at the mouth of the Ashuelot River in Hinsdale may also host cerulean warblers.

1.2 Justification

The cerulean warbler has declined dramatically in the last 40 years (Robbins et al. 1992, Sauer et al. 2004), although increases have been noted in parts of the Northeast since the late 1980s. The small New Hampshire population, first detected in 1992, may be associated with this regional increase. Because of its overall rarity in New England, the species is included in the Comprehensive Wildlife Conservation Strategies in all 6 states. Because of its decline, it is similarly listed throughout its range.

1.3 Protection and Regulatory Status

This species is federally protected by the Migratory Bird Treaty Act, which prevents the killing of most non-game birds and the collecting of their nests or

eggs. The cerulean warbler is not protected under the federal Endangered Species Act, although it has been nominated for listing as "threatened".

1.4 Population and Habitat Distribution

With the exception of records from 1918 and 1929, all records of cerulean warbler in New Hampshire come after 1970. If isolated May records represent errant migrators, there remain 8 areas with records suggestive of at least the potential for breeding activity because they were later in the spring (table 1).

Of these areas, only Pawtuckaway has a consistent history of use by ceruleans, although the Wantastiquet and Blackwater sites would benefit from more regular and intensive surveying. Numbers of territorial males at Pawtuckaway have ranged from one to 4 (possibly 5) since the species was first detected there in 1992. The maximum count came during intensive surveys in 2002 (Hunt 2003), and may thus better reflect the actual population at the site. Breeding was first confirmed in 1995, when a female was observed carrying nesting material. The following year a nest was found during construction and was observed through the fledging of 2 to 3 young in June.

Pawtuckaway marks the northeastern-most known locality for ceruleans in North America, and New Hampshire appears to have been colonized fairly recently. Small isolated populations also occur along Lake Champlain in Vermont (Laughlin and Kibbe 1985) and around the Quabbin Reservoir in Massachusetts (Veit and Petersen 1993). The species is more common to the south and west and at several sites in Connecticut (Zeransky and Baptist 1990), New York (Andrle and Carroll 1988), and southeastern Ontario (Jones and Robertson 2001).

This recent colonization is consistent with a gradual shifting of the range to the north and east since 1966 (Hamel et al. 2004). According to BBS data, populations at the northeastern edge of the range have been increasing since the late 1980s (Sauer et al. 2004). However, over the range as a whole, including high-density regions such as the Appalachians, Midwest, and central Mississippi Valley, the species has declined at an annual rate of 4.2% since 1966 (Sauer et al. 2004). Even at the northern periphery, where range expansion is occurring, productivity may not be high enough to compensate for mortality (Jones et al. 2004).

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

1.7 Sources of Information

Basic natural history information in this profile was largely gathered from the literature cited in section 5. Cerulean warbler data for New Hampshire came from New Hampshire Bird Records.

1.8 Extent and Quality of Data

Of the locations listed above for cerulean warblers, only Pawtuckaway is regularly surveyed. Thus, although data indicate the presence of ceruleans at other locations such as Hinsdale and Salisbury, they to not guarantee frequent habitation. Even at Pawtuckaway, there has been only one effort to assess the overall population size (Hunt 2003).

1.9 Distribution Research

Although the cerulean warbler is rare in the state, more data on its actual distribution would be valuable for conservation concerns. Searches of known or potential cerulean habitat could document the species' presence in parts of the state other than Pawtuckaway State Park and thus provide a better idea of its status in the state. Initial efforts should focus on the lower Connecticut Valley and the Blackwater River, where the bulk of recent sightings (away from Pawtuckaway) have occurred.

Element 2: Species/Habitat Condition

2.1 Scale

Cerulean warblers occur primarily in the lower Connecticut River Valley, on the Blackwater River, and in the Pawtuckaway Highlands. Habitat delineations should extend beyond immediate sighting locations to include adjacent areas of suitable habitat, as near Pawtuckaway where the Canadia site may be hospitable.

2.2 Relative Health of Populations

Data are insufficient to address population health for

all areas except Pawtuckaway. At this site, the population appears to have remained relatively constant (1 to 4 males) for over a decade.

2.3 Population Management Status

There is currently no management of cerulean warblers in New Hampshire.

2.4 Relative Quality of Habitat Patches

All 3 units appear to provide quality habitat for cerulean warblers. All are relatively large blocks of forest, and with the exception of the Ashuelot River mouth, are protected to some degree (see section 2.5).

2.5 Habitat Patch Protection Status

All 3 locations with multiple records of cerulean warblers are protected by fee-simple ownership. Mount Wantastiquet and the Pawtuckaway highlands are both owned by NHDRED, and neither is subject to extensive recreational development. The Blackwater River site is owned by the USACE as part of a flood control project. The other high potential sites in table 1 (particularly the Ashuelot River mouth and Granite Lake) are not protected.

2.6 Habitat Management Status

There is no specific management of cerulean warbler habitat in New Hampshire.

2.7 Sources of Information

Information on areas used by cerulean warblers in New Hampshire was obtained from New Hampshire Bird Records.

2.8 Extent and Quality of Data

With the exception of the Pawtuckaway highlands, data on cerulean warbler use of most units identified in section 2.1 are minimal. The absence of records from either should not be taken as an indication that the species has not been present in a given breeding season.

2.9 Condition Assessment Research

In the absence of good distribution data, it is difficult to identify potential research questions pertaining to habitat condition. Given the small size of the known population, it is not clear whether meaningful indicators could be developed to assess population health. The best option may simply be to devise a regular monitoring program to detect changes in population size and site occupancy.

Element 3: Species and Habitat Threat Assessment

3.1 Identification of threats

Over much of the breeding range, habitat loss is a major cause of population decline (Hamel 2000a, b; Rosenberg et al. 2000). Similar conversion of primary forest in the South American wintering range is also implicated in the decline, although data on winter habitat use are incomplete (Robbins et al. 1992, Hamel 2000b). In the Northeast, where populations appear to be increasing, perhaps because of ongoing reforestation (Jones and Robertson 2001), the major threats are likely to be fragmentation and isolation of currently occupied areas. In all areas of the range, land-use may have increased brood parasitism by brown-headed cowbirds (*Molothrus ater*), a species which is more common along marginal areas (Hamel 2000a).

Given that most threats are related to habitat loss, the small cerulean warbler population in New Hampshire does not appear to be under any immediate threats at the state level. The primary population occurs in an undeveloped area of a state park, and other sites with recent sightings during the breeding season are conserved (section 2.5). Cowbird parasitism may be an important factor, but data on its magnitude and effects within the state are completely unknown.

3.2 Sources of Information

Information on threats to cerulean warblers was obtained from the scientific literature on the species.

3.3 Extent and Quality of Data

Data on regionally identified threats to this species at

the scale of New Hampshire are insufficient.

3.4 Threat Assessment Research

It would be worthwhile to determine the rates of habitat loss in the vicinity of the 3 units listed in section 2.1. Although the areas where ceruleans have been recorded are protected, the possibility of area sensitivity in this species should be taken into consideration. In the event that a given unit is under greater threat from landscape-scale habitat conversion, land protection activity in that unit should be considered (element 4).

Element 4: Conservation Actions

No threats to this species are independent of threats to its preferred habitats, and thus no additional conservation actions need detailed discussion. However, the possibility of land protection in the vicinity of core areas should be considered when prioritizing reserve creation. Focusing land conservation on the 3 cerulean warbler units potentially would benefit the warbler, and would enhance habitat quality for associated species and natural communities.

4.2 Conservation Action Research

There are insufficient data to determine whether active management can benefit cerulean warblers (Hamel 2000a), though undue manipulation might harm them. Given what is known about cerulean warbler habitat preferences elsewhere, it may be worth investigating the species' habitat use in New Hampshire in more detail. Any data collected could be compared with those collected elsewhere in an effort to determine whether any specific management practice (e.g., timber harvest rotations, selective cutting, etc.) would affect the species. With sufficient information, it may be possible to manage existing sites for the cerulean warblers, but this should not be undertaken until more about its habitat needs is known.

Element 5: References

5.1 Literature

Andrle, R.F., and J.R. Carroll. 1988. The Atlas of Breeding Birds in New York State. Cornell University Press, Ithaca.

Foss, C.R., P.D. Hunt, and D.B. Wells. 2000. Floodplain Bird report. Report to New Hampshire Department of Environmental Services, New Hampshire Audubon, Concord.

Jones, J., and R.J. Robertson. 2001. Territory and nest-site selection of Cerulean Warblers in eastern Ontario. Auk 118: 727-735.

Jones, J., J.J. Barg, T.S. Sillett, M.L. Veit, and R. Robertson. 2004. Minimum estimates of survival and population growth for Cerulean Warblers (*Dendroica cerulea*) breeding in Ontario, Canada. Auk 121: 15-22.

Hamel, P.B. 2000a. Cerulean warbler status assessment. U.S. Fish and Wildlife Service, Minneapolis, Minnesota, USA.

Hamel, P.B. 2000b. Cerulean Warbler (*Dendroica cerulea*). *In* The Birds of North America, No. 511, A. Poole and F. Gill, editors. The Birds of North America, Inc., Philadelphia, PA.

Hamel, P.B., D.K. Dawson, and P.D. Keyser. 2004. How we can learn more about the Cerulean Warbler (*Dendroica cerulea*). Auk 121: 7-14.

Hunt, P.D. 2003. Summary of 2002 Breeding Bird Atlas at Pawtuckaway State Park. Report to New Hampshire Department of Resources and Economic Development, New Hampshire Audubon, Concord.

Laughlin, S.B., and D.P. Kibbe. 1985. The Atlas of Breeding Birds of Vermont. University Press of New England, Hanover, New Hampshire, USA.

Oliarnyk. C.J., and R.J. Robertson. 1996. Breeding behavior and reproductive success of Cerulean Warblers in southeastern Ontario. Wilson Bulletin 108: 673-684.

Robbins, C.S., J.W. Fitzpatrick, and P.B. Hamel. 1992. A warbler in trouble: *Dendroica cerulea*. Pages 549-562 *in* Ecology and Conservation of Neotropical Migrant Landbirds, J.M. Hagan and D.W. Johnston, editors. Smithsonian Institution Press.

Rosenberg, K.V., S.E. Barker, and R.W. Rohrbaugh. 2000. An atlas of Cerulean Warbler populations.

Report to U.S. Fish and Wildlife Service, Cornell Laboratory of Ornithology, Ithaca, New York, USA.

Sauer, J.R., J.E. Hines, and J. Fallon. 2004. The North American Breeding Bird Survey, Results and Analysis 1966-2003. Version 2004.1, USGS Patuxent Wildlife Research Center, Laurel, MD.

Veit, R.R., and W.R. Petersen. 1993. Birds of Massachusetts. Massachusetts Audubon Society.

Zeranski, J.D., and T.R. Baptist. 1990. Connecticut Birds. University Press of New England, Hanover, New Hampshire, USA.

5.2 Data Sources

NHBR. New Hampshire Bird Records, New Hampshire Audubon, Concord.

SPECIES PROFILE

Common Loon

Gavia immer

Federal Listing: Not listed
State Listing: Threatened
Global Rank: G5
State Rank: S3
Authors: Harry Vogel and Kate Taylor, Loon Preservation Committee

Element 1: Distribution and Habitat

1.1 Habitat Description

Breeding and Nesting Habitat: Loons nest on lakes greater than 6.5 ha (16 ac) but prefer lakes smaller than 24 ha (60 ac) with clear water, small islands, and an irregular shoreline that creates coves. They are also found on major rivers. Lake size and configuration are important determinates for loon density.

Loons nest in close proximity to the water's edge and prefer the lee side of small islands, floating bog mats, and hummocks in marshes (Christenson 1981, Titus and VanDruff 1981, Yonge 1981, Dahmer 1986). Islands can provide the widest range of visibility for loons on the territory and afford better protection from mammalian predators. Marsh and mainland sites are less preferred and are most likely used in response to shoreline development (Alvo 1981, Christenson 1981, McIntyre 1988) and high conspecific densities.

Nest sites generally are within 1 m from the shoreline (Sutcliffe 1980). Available submerged and emergent vegetation is used for nest structures. Extent of the nest bowl diameter varies (27 to 38 cm), and use of depressions, or "scrape" bowls is common (Sutcliffe 1980, Loon Preservation Committee (LPC), unpublished data). Mainland nest sites are more likely to be structures as opposed to scrapes or hummocks (Sutcliffe 1980). Some loons use sites with steep drop-offs that allow for underwater approaches and exits (Olson and Marshall 1952, Christenson 1981, McIntyre 1988), though this is not a predictor of site location (Sutcliffe 1980, Valley 1987). Strong (1987) found between-year reuse of nest sites by Common Loons to be 78-88%. Changes in nest locations were more frequent after nest failures and reuse in subsequent years occurred more often after successful nests (McIntyre 1988).

Chick Rearing Habitat: Chick rearing areas are typically in shallow water close to shore, having prey size classes suitable for feeding young, and experience less prevailing wind and waves that can separate chicks from adults. Chicks have been observed to hide among shoreline vegetation in response to threats or when left unattended (Yonge 1981, Strong and Bissonette 1987).

Winter Habitat: Near-shore coastal waters including bays, channels and inlets serve as winter habitat. Wintering loons generally use more placid waters less than 20 m in depth within 100 km from shore (Haney 1990, Jodice 1992).

1.2 Justification

Lakes and associated shorelines are under great anthropogenic pressure. The response of wildlife and aquatic ecosystems to such pressures needs to be quantitatively monitored using appropriate species. Common Loons have declined or are absent from much of their historical breeding range in North America. Between 1978 and 2000, LPC activities promoted increases in numbers of territorial loon pairs, nesting pairs, successful nests, and fledged young. However, monitoring also revealed a significant decline ($P < 0.05$) in loon reproductive success from 1982 on. Negative trends in loon breeding success have resulted in 5 successive years of declines in the adult loon population in New Hampshire.

The limited dispersal, low population densities, and low reproductive potential of loons limit LPC's ability to recover a declining loon population; only intensive management has increased New Hampshire's population since loons were listed as a state-threatened species.

1.3 Protection and Regulatory Status

Common Loons are protected from illegal take under the Migratory Bird Act of 1918 and are listed as a threatened species in New Hampshire under New Hampshire RSA 212-A, the Endangered Species Conservation Act.

1.4 Population and Habitat Distribution

Loons are widely distributed in freshwater lakes and large rivers in New Hampshire north and south of the White Mountains. Populations are sparse in western parts of Sullivan and Cheshire counties, as well as in Hillsborough county and eastern parts of Strafford and Rockingham counties.

Migration occurs on a wide front throughout New Hampshire, and fall migration is more protracted than spring arrival (Evers 2004). Staging primarily occurs on larger lakes, such as Lake Winnipesaukee, Squam Lake, Lake Sunapee, and Newfound Lake (LPC, unpublished data) before migration to the ocean. Loons from New England winter off the Atlantic coast from Maine south along coastal Massachusetts into Long Island Sound (LPC, unpublished data, BioDiversity Research Institute, (BRI) unpublished data).

1.5 Town Distribution Map

See Figure 1: Distribution of Common Loons In New Hampshire

1.6 Habitat Map

N/A

1.7 Sources of Information

Information on Common Loon habitat, population distribution, and status is from LPC's database and technical field reports, the Status and Assessment Plan for Common Loons in North America (Evers 2004), and peer-reviewed journals.

1.8 Extent and Quality of Data

The Common Loon is one of the most intensively monitored and managed species in New Hampshire. Statewide surveys have been conducted annually by LPC since 1976.

1.9 Distribution Research

The distribution of loons in New Hampshire is well known (see section 1.4). Identification of potential habitat is currently in progress through habitat modeling efforts. Little is known about wintering populations of loons. Cape May Bird Observatory in New Jersey monitors loons during migration in the Northeast. Christmas Bird Counts provide limited wintering loon information, but volunteer observations are not primarily focused on loons. Annual wintering data will enhance current state loon population monitoring and trend analyses and will serve to flag injury from oil spills, contaminants, and other disturbances on the wintering grounds that have the potential of harming breeding success.

Element 2: Species/Habitat Condition

2.1 Scale

Modeling of suitable habitat, in combination with known dispersal distances of loons, suggest distinct populations north and south of the White Mountains (J. Grear, USEPA, personal communication). This assessment is born out by genetic markers in loon blood (McMillian 2004). Levels of management and challenges facing loons also differ north and south of the White Mountains (LPC, unpublished data).

2.2 Relative Health of Populations

Northern and southern loon populations have increased significantly ($P < 0.05$) since 1977; however, the northern population has shown a significant decrease ($P < 0.05$) over the last 10 years. The northern population has lower reproductive success than the southern population, but the reproductive success of both populations has trended upward ($P < 0.05$) over time (LPC, unpublished data).

2.3 Population Management Status

- Rafts were provided to 11% of northern territorial pairs and 8% of southern pairs in 2004.
- Signs and rope lines were placed around 6% of nests in northern New Hampshire and 28% of nests in southern New Hampshire in 2004.
- On Lake Umbagog, water levels are managed for stability during critical nesting periods for 20 territorial loon pairs.
- Taken together, 53% of territorial loon pairs in northern New Hampshire benefited from management efforts as compared to 27% of territorial pairs in southern New Hampshire in 2004.

2.4 Relative Quality of Habitat Patches

Efforts to quantify habitat quality are currently under way. A pilot study in central New Hampshire found a correlation between a loon habitat ranking index and productivity, indicating it as a suitable predictive model of habitat quality for loons.

2.5 Habitat Patch Protection Status

The Comprehensive Shoreland Protection Act RSA 483-B was created in 1994 to protect against activities affecting water quality by setting minimum standards and requirements for the use of land within 250 feet of the water's edge. Loon nests on protected shoreline remain vulnerable to recreational use of public waters.

2.6 Habitat Management Status

See section 2.3

2.7 Sources of Information

Information on habitat patch protection status was obtained from NHDES. Data on rafts, water-level management, and signs were derived from LPC's database.

2.8 Extent and Quality of Data

The Common Loon is one of the most intensively monitored and managed species in New Hampshire. Statewide surveys have been conducted annually by LPC since 1976.

2.9 Condition Assessment Research

Research is needed to determine the minimum number of territorial pairs necessary to sustain a loon population in New Hampshire, and to determine carrying capacity, longevity, and mortality of subadult and adult loons. This information needs to be understood in a spatially explicit way to avoid local extinctions and can be accomplished by identifying habitat availability and the structure of the state's metapopulation and subpopulations.

Element 3: Species and Habitat Threat Assessment

3.1.1. Development (Habitat Loss and Conversion)

(A) Exposure Pathway

The quality of loon breeding habitat is affected by shoreline development through vegetative modification or removal, creation of structures in close proximity to traditional nesting sites, increased predator densities, and human activity. Often sites favored by loons for nesting and chick rearing, such as islands and quiet bays, are of prime development value. Loons, particularly those breeding pairs that are unaccustomed to people, are likely to locate nest and nursery sites distant from human presence (Alvo 1981, LPC, unpublished data). Therefore, shoreline development in high quality loon breeding habitats, such as island habitats, can restrict use of these habitats by a territorial pair. Furthermore, loon presence attracts potential property owners.

Raccoons (*Procyon lotor*) are widely considered the most influential egg-predator of loons. Densities of raccoons and other opportunistic predators, such as gulls and corvids are generally correlated with increasing shoreline development (Evers 2004).

Removal of shoreline vegetation causes erosion and an increase in water temperatures. Ensuing sedimentation and phosphorus enrichment of the lake can contribute to excessive algae and aquatic weed growth, reduced water clarity and quality, and changed prey density and aquatic food webs.

(B) Evidence
Habitat degradation and loss because of shoreline development have been cited as reasons for declines in local breeding populations and in reproductive success (Alvo 1981, Dahmer 1986, McIntyre 1988). Erosion at construction sites is a leading cause of water quality problems in New Hampshire waterbodies (NHDES 2003).

3.1.2 Recreation (Boats and Jet Skis)

(A) Exposure Pathway
Non-motorized watercrafts, such as canoes and kayaks, have access to shallow water near loon nesting and brood sites, which can lead to nest abandonment. Additionally, canoeists and kayakers are more apt to use remote areas and have a greater ability for stealth. This type of activity is most detrimental during early incubation when egg investment is lowest and the likelihood of nest abandonment is highest. Disturbance from sailboats and windsurfing has not been quantified. Anecdotal and behavioral evidence suggests a sail can be perceived as a visual threat, and therefore has the potential to disrupt nesting and brooding activity, even in areas of high recreational use (LPC, unpublished data).

Loons can habituate to moderate use of motorboats. Recreational motor boating represents a greater disturbance and risk to loon adults and young in open water than to those nesting and foraging in shallow water. Habituation to boating activity can dull response times in loons, making them more susceptible to collisions (LPC, unpublished data).

Personal watercraft can cause significant damage since they have a shallow draft and are able to closely approach nests and shorelines at high speeds. Repeated travel of personal watercraft near nest sites or loon families for extended periods of time can disrupt incubation, expose eggs to predators, or impede parental care of young (Burger 1998).

Excessive angler use of shallow, vegetated areas of lakes through wading and boating can disturb nesting and foraging activity (Titus 1978, Titus and VanDruff 1981, Christenson 1981, Kelly 1992). The increased popularity of fishing tournaments offering substantial prizes can create an unfortunate incentive for improper practices. In New Hampshire and Maine, vulnerable nesting pairs are vigorously monitored during bass tournaments, as some participants regularly disregard posted and cordoned-off nest exclosures (LPC, unpublished data.).

(B) Evidence
Washouts of loon nests and blunt trauma mortality to loons from boats have been documented by Maine Audubon Society (unpublished testimony), Jaruzel (1998), Miconi et al. (2000).
Fourteen percent (32/227) of loon mortality in New England from 1989 to 1996 was due to boat trauma (Miconi et al. 2000).

Though loons on lakes with high human use flush at shorter distances and less readily than those on low use lakes (Smith 1981, Titus and VanDruff 1981), any increase in activity near the nest site may serve to attract predators (McIntyre 1977,1988). Kelly (1992) found that time off-nest was significantly less for flushes related to natural causes than those caused by human disturbance. Christenson (1981) found that adults with young moved away when boats were present. The energetic cost of this is unknown; however, movement in response to boating activity increases the likelihood of chicks being separated from adults and decreases time spent feeding young.

3.1.3. Recreation (Lead Shot and Sinkers)

(A) Exposure Pathway
Lead poisoning in loons in New Hampshire is a direct result of ingesting a Pb object, virtually always a Pb sinker or jig (LPC, unpublished data). Lost or discarded Pb sinkers and jigs are ingested with stones to grind food in the gizzard, with fish that have broken free from an angler's line, or by striking at a sinker or jig on the line. Lead mortality peaks in mid-summer, coincident with peak tourism and angling pressure (LPC, unpublished data), and the presence of swivels and hooks in close to half of the Pb-killed loons suggests that direct ingestion as a result of current fishing practices, rather than the reservoir of tackle on lake bottoms, is the major source of mortality.

Once swallowed, stomach acids and the grinding action of the gizzard dissolve Pb sinkers and jigs. Lead is absorbed into the blood and body tissues. Lead affects nerve impulse transmission causing systemic paralysis and neurological dysfunction, evidenced by head shaking, gaping, wing droop, and eye droop. Other symptoms include green feces, listlessness, lethargy, emaciation, increased occurrence in shallow waters,

and frequent bouts of beaching with progression of the condition (LPC, unpublished data). There is no effective treatment for lead poisoning in loons; the ingestion of a single lead sinker or jig can be fatal.

(B) Evidence
Lead poisoning from the ingestion of Pb fishing sinkers and jigs is the largest single cause of known adult loon mortality in New Hampshire and has significantly increased over time ($P<0.001$) (LPC, unpublished data, Tufts University Wildlife Clinic, unpublished data).

Thirteen studies have confirmed a direct link between the ingestion of Pb sinkers and Pb-headed jigs and mortality of Common Loons. Lead poisoning has been identified as a significant cause of Common Loon mortality throughout England, Eastern Canada, and the United States.

3.1.4. Mercury

(A) Exposure Pathway
Mercury (Hg) is a result of anthropogenic sources such as municipal and medical waste incinerators and coal-fired power plants (Swain et al. 1992, USEPA 1997, NESCAUM 1998). Mercury is a highly mobile contaminant with the ability to cycle through land, air, and water. One of its organic forms, methylmercury, bioaccumulates in upper trophic level wildlife, including loons and other piscivorous birds (see Meyer et al. 1995, Evers et al. 1998, 2003, 2005).

Mercury deposition models developed by the USEPA (1997) indicate the northeastern United States to be at particular risk to elevated levels of Hg deposition. Nearly fifty percent of this deposition is from sources within the region. One of the highest exposure areas predicted in these models is the southeastern corner of New Hampshire.

Concentrations of Hg in loon eggs and in adult loons, and the accumulation of Hg in individual loons over time, suggest that current levels of Hg emissions are high enough to pose a threat to loons and other wildlife in New Hampshire. Overall, at least 19% of New Hampshire's adult loon population is at risk to physiological, behavioral, or reproductive impact. At risk individuals have been shown to fledge 37% fewer young. The Hg risk for southern New Hampshire loon populations is at least 32%, while in southeastern New Hampshire the risk is at least 89% (D.C. Evers, unpublished report).

(B) Evidence
The Common Loon has been nationally identified by a USEPA-led working group as one of the best indicators of persistent bioaccumulative toxins, including Hg, in lakes (Wolfe et al. 2004, Evers et al. 2005).

3.2 Sources of Information

Literature review and LPC unpublished data.

3.3 Extent and Quality of Data

Development and associated recreational pressures on lakes have been implicated in loon population declines and reduced breeding success (Titus and Van Druff 1981, Jung 1987, Strong and Bissonette 1987, Kelly 1992). However, loons can successfully breed on water bodies despite disturbance (Jung 1991, K. Taylor and H. Vogel, Loon Preservation Committee, unpublished report) and can adopt adaptive strategies in response to human activity (Alvo 1981, Christenson 1981, Titus and Van Druff 1981, Jung 1987).

Effects of Pb toxicity on loon mortality are well documented, as are levels of Hg in loons in New Hampshire and the effects on loon reproduction.

3.4 Threat Assessment Research

- Efforts are currently under way to assess the relative threat of shoreline development and other factors in order to address overall loon habitat quality. Developing a science-based ranking system to facilitate cooperative restoration efforts in prioritizing habitat of the highest quality is needed for long-term management and protection.
- Continued monitoring of mortality to determine effectiveness of current lead (Pb) tackle legislation is necessary. Research on the mechanisms and severity of various boating activities on likelihood of nesting, hatching success, and chick survivorship needs continuation.
- Continued tracking of Pb mortality to determine effectiveness of current Pb tackle legislation is necessary. Research is needed to assess the persistence of Pb sinkers and jigs in the environment.
- Further research is needed to determine other populations of loons at risk of Hg poisoning in New

Hampshire, to connect known biological hotspots for mercury deposition on lakes and loon territories with source origins in New Hampshire, and to increase our knowledge of Hg in aquatic systems.

Element 4: Conservation Actions

4.1.1 Artificial Nesting Islands ("Rafts")
Category: Restoration and Management

(A) Direct Threat
Loss of nesting habitat from shoreline development, increased nest predators, and artificial water level fluctuations.

(B) Justification
Rafts can facilitate successful nesting for loons that have been displaced from traditional nesting sites due to shoreline development. Rafts also protect nesting loons from water level fluctuations that can flood or strand nests, and provide a measure of protection against mammalian predators associated with shoreline development. DeSorbo et al. (unpublished manuscript) found that nest success in raft nesting loons was higher than that for naturally nesting loons on lakes with and without water level changes. The LPC floats approximately 40 rafts each year in New Hampshire and is experimenting with covers to reduce avian predation and reduce the responsiveness of loons to boaters.

(C) Conservation Performance Objective
Maintain a nesting success rate of 1.2 or higher chicks hatched per raft nesting loon pair.

(D) Performance Monitoring
Monitoring of raft loon nesting loon success will be carried out as part of LPC's regular monitoring duties.

(E) Ecological Response Objective
Long-term ecological response will be to maintain stable or increasing loon populations in southern and northern New Hampshire.

(F) Response Monitoring
Monitoring of raft nesting loon success and population levels will be carried out as part of LPC's regular monitoring duties.

(G) Implementation
The LPC possesses the expertise and infrastructure to build, place, and maintain rafts. A significant expansion of LPC's raft program will require additional personnel and funding.

(H) Feasibility
The LPC is well situated to carry out a raft management program; however, rafts are labor-intensive and an imperfect solution to factors limiting loon nesting success. Rafts are deployed and used as nesting platforms in order to mitigate potential human threats to incubating loon pairs until these threats can be addressed by more permanent solutions.

4.1.2 Signs and Rope Lines

Category: Habitat Protection

(A) Direct Threat
Recreation

(B) Justification
Recreational activities likely play a role in loon hatching and fledging. Territorial pairs on highly developed lakes with signs and float lines surpassed the hatching success of territories without such restrictions (K. Taylor and H. Vogel, Loon Preservation Committee, unpublished report). Use of exclosures should be based on site-specific nest failure history and an understanding of typical lake use patterns. Kelly (1991) recommends floating 3 to 6 signs, approximately 137 m from the nest site for optimal buffering capacity. Exclosures should be removed soon after hatch to maximize public acceptance and compliance.

(C) Conservation Performance Objective
Maintain a nesting success rate of at least 1.2 chicks hatched per protected nest site.

(D) Performance Monitoring
Monitoring of nest sites cordoned off during incubation will be carried out as part of LPC's regular monitoring duties.

(E) Ecological Response Objective
Long-term ecological response will be to maintain stable or increasing loon populations in southern and northern New Hampshire.

(F) Response Monitoring
Monitoring loon pairs in northern and southern New Hampshire will be carried out as part of LPC's regular monitoring duties.

(G) Implementation
An effective design for floating signs and a protocol for roping off nest sites is well established. The LPC possesses the expertise and infrastructure to build, place, and maintain signs and ropes. A significant expansion of LPC's ropes and signs program will require additional personnel and funding.

(H) Feasibility
LPC is well situated to carry out an extensive management program that includes the use of signs and rafts at vulnerable nest sites. However, these techniques are labor-intensive and are an imperfect solution to threats to nesting loons. Rafts and signs can mitigate potential human threats to incubating loon pairs until these threats can be addressed by more permanent solutions.

4.1.3. Boating and Lead

Category: Education and Outreach

(A) Direct Threat
Recreation (Lead Shot and Sinkers)

(B) Justification
Trauma from boats and lead poisoning resulting from the ingestion of Pb fishing tackle have been identified as leading causes of Common Loon mortality throughout Eastern Canada and the United States. Also see sections 3.1.2 and 3.1.3

(C) Conservation Performance Objective
Reduce boating collisions and ingestion of Pb objects in New Hampshire. The current state ban needs to be accompanied by outreach programs and should increase the availability of non-Pb alternatives. Education efforts need to promote responsible fishing and boating practices and continue and expand Pb-exchange programs and increase penalties for use of illegal sinker and jigs. These measures might include forfeiture of license and/or disqualification during fishing tournaments if loon sanctuaries and enclosures are disregarded.

(D) Performance Monitoring
Monitoring of presentations and attendance can be carried out as part of LPC's regular monitoring duties. LPC field biologists can track distribution of non-Pb alternatives.

(E) Ecological Response Objective
The long-term ecological response will be to reduce mortality in order to maintain stable or increasing loon populations in southern and northern New Hampshire.

(F) Response Monitoring
Tracking the causes of loon mortality can be carried out as part of LPC's long-term collaborative mortality study with Tufts University Wildlife Clinic, North Grafton, Massachusetts.

(G) Implementation
LPC regular and field staff can educate through formal and informal contacts in the field.

(H) Feasibility
The LPC is situated to carry out some outreach and non-Pb sinker distribution but is limited by staffing constraints.

4.1.4 Mercury and Lead

Category: Regulation and Policy

(A) Direct Threat
Mercury, Recreation (Lead Shot and Sinkers)

(B) Justification
Lead poisoning resulting from the ingestion of Pb fishing tackle has been identified as a leading cause of Common Loon mortality throughout Eastern Canada and the United States. A long-established culture of Pb use among the angling community and the reluctance of manufacturers to reduce Pb production in favor of alternatives have made voluntary efforts ineffective. Mercury bioaccumulates and biomagnifies in upper trophic level wildlife, including loons and other piscivorous birds, and impairs reproduction (see Meyer et al. 1995, Scheuhammer 1987, 1991). Also see section 3.1.4.

(C) Conservation Performance Objective

End the use of Pb objects in lake systems. Current state-by-state patchwork approach to Pb legislation should be changed to a national ban on Pb accompanied by outreach programs and increasing the availability of non-Pb alternatives. Reduce Hg emissions from known sources in New Hampshire.

(D) Performance Monitoring
Monitoring would assess the effectiveness of efforts to reduce mortality from ingesting Pb tackle and blood Hg levels in loons.

(E) Ecological Response Objective
Long term ecological response will maintain a stable or increasing loon population in southern and northern New Hampshire by keeping loon Hg body burdens below known thresholds (i.e., below 3.0 ppm for blood and below 1.3 for eggs).

(F) Response Monitoring
Monitoring of population levels will be carried out as part of LPC's regular monitoring duties.

(G) Implementation
The LPC will create relationships with legislators and create reports to summarize impacts of Pb and Hg on loons.

(H) Feasibility
Legislation and policy will be conducted by LPC, NHA's Policy Department with testimony by experts from NHDES, NHFG, USFWS, and BioDiversity Research Institute, Gorham Maine.

4.2 Conservation Action Research

- The efficacy of avian guards on rafts to ameliorate avian predation in New Hampshire is yet to be established. Additional research on measures to remove nest platforms and create self-supporting loon territories is needed.
- The efficacy of signs and ropelines on lakes experiencing different levels of recreational use is yet to be fully established. Additional research on this management practice is warranted.
- Research is needed to assess the persistence of Pb sinkers and jigs in the environment and the efficacy of educational efforts to reduce Pb use and irresponsible boating.
- New Hampshire will be included in the national mercury monitoring plan currently being developed (see above "C"). Multiple Hg monitoring stations for collecting levels in the air, water, sediment, fish, and birds will be located in New Hampshire through this effort. Such a national program will be designed to link with Hg emission regulations.

Element 5: References

5.1 Literature

Alvo, R. 1981. Marsh nesting of Common Loons (*Gavia immer*). Canadian Field-Naturalist 95: 357.Burger, J. 1998. Effects of motorboats and personal watercraft on flight behavior over a colony of Common Terns. Condor 100:528-534.

Christenson, B.L. 1981. Reproductive ecology of and response to disturbance by Common Loons in Maine. M.S. Thesis, Univ. of Maine, Orono, ME.

Dahmer, P.A. 1986. Use of aerial photographs to predict lake selection and reproductive success of Common Loons in Michigan. M.S. Thesis, Univ. of Michigan, Ann Arbor, Michigan, USA.

Evers, D.C, J.D. Kaplan, M.W. Meyer, P.S. Reaman, W.E. Braselton, A. Major, N. Burgess, and A.M. Scheuhammer. 1998. Geographic trend in mercury measured in Common Loon feathers and blood. Environmental Toxicology and Chemistry 17:173-183.

Evers, D.C, K.M. Taylor, A. Major, R.J. Taylor, R.H. Poppenga, and A.M. Scheuhammer. 2003. Common Loon eggs as indicators of methylmercury availability in North America. Ecotoxicology 12: 69-81.

Evers, D.C. 2004. Status assessment and conservation plan for the Common Loon (*Gavia immer*) in North America: final draft. United States Fish and Wildlife Service, Hadley, MA. Final Draft.

Evers, D.C, L. Champoux, N. Burgess, A. Major, W. Goodale and R.J. Taylor. 2005. Patterns and interpretation of freshwater avian communities in northeastern North America. Ecotoxicology 14: 193-222.

Haney, J.C. 1990. Winter habitat of Common Loons on the continental shelf of the southeastern United States. Wilson Bulletin 102:253-263.

Jaruzel, L. 1998. Loon Watch. Northern Michigan Journal.

Jodice, P.G.R. 1992. Distribution of wintering loons in the northeastern Gulf of Mexico. In: The loon and its ecosystem: status, management, and environmental concerns. Proceedings from the 1992 American Loon Conference, Bar Harbor, ME, pp. 172-177

Jung, R.E. 1987. An assessment of human impact on the behavior and breeding success of the common loon (*Gavia immer*) in the norther Lower and eastern Upper Peninsulas of Michigan. University of Michigan.

Kelly, L.M. 1992. The effects of human disturbance on Common Loon productivity in northwestern Montana. M.S. Thesis, Montana State Univ., Bozeman, Montana, USA.

Mason, R, M. Abbot, D. Bodaly, R. Bullock, C. Driscoll, D.C. Evers, S. Lindberg, M. Murray, and E. Swain. 2005. Monitoring the response to changing mercury deposition. Environmental Science and Technology, pp 14a-22a.

McIntyre, J.W. 1977. The Common Loon: Part II. Identification of potential predators on Common Loon nests. Loon 49:96-99.

McIntyre, J.W. 1988. The Common Loon: Spirit of Northern Lakes. University of Minnesota Press.

McMillan, A.M., M.J. Bagley, and D.C. Evers. 2004. Preliminary analysis of Common Loon (*Gavia immer*) genetic structure in Northeast North America based on five microsatellite loci. 18th Annual Meeting Society for Conservation Biology, New York.

Meyer, M.W., D.C. Evers, T. Daulton and W.E. Braselton. 1995. Common loons (*Gavia immer*) nesting on low pH lakes in northern Wisconsin have elevated blood mercury content. Water, Air, and Soil Pollution, 80:871-880.

Miconi, R., M. Pokras, and K. Taylor. 2000. Mortality in breeding Common Loons: How significant is trauma? Pp. 19-24 in J. McIntyre and D.C. Evers (eds.). Loons: Old history and new findings. Proceedings of a Symposium from the 1997 meeting, American Ornithologists' Union. North American Loon Fund, Holderness, New Hampshire, USA.

NESCAUM. 1998. Northeast states and eastern Canadian Provinces Mercury Study: A Framework for Action. NESCAUM/NEWMOA/NEIWPCC/EMAN.

NHDES website 2003 – www.des.state.mh.us

Olson, S., and W.H. Marshall. The Common Loon in Minnesota. 1952. Minneapolis, Minnesota, Minnesota. Museum of Natural History, University of Minnesota.

Scheuhammer, A.M. 1987. The chronic toxicity of aluminum, cadmium, mercury, and lead in birds: a review. Environmental Pollution, 46:263-295.

Scheuhammer, A.M. 1991. Effects of acidification on the availability of toxic metals and calcium to wild birds and mammals. Environmental Pollution 71: 329-375.

Smith, E.L. 1981. Effects of canoeing on Common Loon production and survival on the Kenai National Wildlife Refuge, Alaska. M.S. Thesis, Colorado State Univ., Fort Collins, CO.

Strong, P.I.V. 1987. Reuse of nesting and nursery areas by Common Loons. Journal of Wildlife Management 51:123-127.

Strong, P.I.V., and J.A. Bissonette. 1987. Effects of nest-site loss on Common Loons (*Gavia immer*). Canadian Field-Naturalist 101:581-583.

Sutcliffe, S.A. 1980. Aspects of the nesting ecology of Common Loons in New Hampshire. M.S. thesis. University of New Hampshire, Durham, New Hampshire, USA.

Swain, E.B., D.R. Engstrom, M.E. Brigham, T.A. Henning, and P.L. Brezonik. 1992. Increasing rates of atmospheric mercury deposition in midcontinental North America. Science 257:784-787.

Titus, J.R. 1978. Response of the Common Loon (*Gavia immer*) to recreational pressure in the Boundary Waters Canoe Area, northeastern Minnesota. Ph.D. dissertation, SUNY, Syracuse, NY.

Titus, J.R., and VanDruff. 1981. Response of the Common Loon to recreational pressure in the Boundary Waters Canoe Area, northeastern Minnesota. 1981. Bethesda, Maryland, Wildlife Society.

USEPA. 1997. An ecological assessment for anthropogenic mercury emissions in the United States. Report to Congress, U.S. Environmental Protection Agency, Washington, D.C.

Valley, P.J. 1987. Common Loon productivity and nesting requirements on the Whitefish chain of lakes in North-Central Minnesota. The Loon 59: 3-10.

Vermeer, K. 1973. Some aspects of breeding and mortality of Common Loons in East-Central Alberta. Canadian Field-Naturalist 87:403-408.

Wolfe, M.F., T. Atkeson, W. Bowerman, J. Burger, D.C. Evers, M. Murray, and E. Zillouix. 2004.

Wildlife indicators in M. Newman (ed.). Mercury in North America. SETAC Press, Pensacola, Florida: in press.

Yonge, K.S. 1981. The breeding cycle and annual production of the Common Loon (*Gavia immer*) in the boreal forest region. M.Sc. thesis, University of Manitoba, Winnipeg.

SPECIES PROFILE

Common Moorhen

Gallinula chloropus

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S2
Author: Kim A. Tuttle, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The common moorhen is a member of the secretive rail family (Rallidae). In the northern United States, moorhens require permanently flooded freshwater or brackish shallow ponds or deep marshes. Common moorhens frequent cattail (*Typha* spp.) marshes; they prefer robust, emergent, tall grass-like vegetation interspersed with pools and channels containing leafy plants (Bannor and Kiviat 2002). Moorhens eat leaves and stems of aquatic plants, as well as smaller amounts of grasses, herbs, seeds and berries, and some animals such as snails, insects, and worms (DeGraaf and Yamasaki 2001). Young moorhens will often eat dragonfly and mayfly nymphs (Hebert and Elkins 1994).

Moorhens may use altered, artificial, agricultural, or urban wetland habitats, including small ponds and sewage lagoons, and they commonly forage on lawns, fields, and golf courses near water (Bannor and Kiviat 2002). Nests are usually found in emergent vegetation, occasionally in shrubs such as willow (*Salix* spp.) or alder (*Alnus* spp). Water depth surrounding nests is usually 0.3 to 0.91m (1 to 3 ft deep). Nests are well concealed by overhanging wetland vegetation (DeGraaf and Yamasaki 2001).

1.2 Justification

Regional declines in moorhen populations have been attributed to loss or degradation of emergent wetland habitats. The common moorhen appears to have extended its range northward in the last century (Bannor and Kiviat 2002) but is thought to be less abundant than in the early 1900s due to the filling of wetlands (Degraaf and Yamasaki 2001).

Invasive, non-native plant species threaten cattail-dominated wetlands and increase the number of subsidized predators such as raccoons (*Procyon lotor*). These threats may be highest in southern New Hampshire, where development is most severe. For example, replacement of cattail by purple loosestrife (*Lythrum salicaria*) may have contributed to a decline in moorhens at Montezuma National Wildlife Refuge, New York (Sibley 1988 in Bannor and Kiviat 2002). The introduction of predatory game fish, such as the largemouth bass (*Micropterus salmoides*), to New Hampshire may further limit range expansion of the common moorhen. Bell and Cordes (1977, in Bannor and Kiviat 2002) collected 5 largemouth bass in Louisiana containing moorhen chicks.

1.3 Protection and Regulatory Status

- Migratory Bird Treaty Act (1918)
- See Marsh and Shrub Wetlands habitat profile for regulations regarding wetland impacts.

1.4 Population and Habitat Distribution

The North American breeding range extends from southern Maine to Florida, from the west to southern Minnesota and eastern Texas, and from California to southern New Mexico and south along both Mexican coasts. Wintering populations migrate to the southeastern and southwestern United States, with the largest concentrations in Florida (Hebert and Elkins 1994, Bannor and Kiviat 2002).

In New England, the common moorhen is a rare to uncommon local breeder and migrant (DeGraaf

and Yamasaki 2001). It is listed as a Species of Special Concern in Massachusetts (Massachusetts Division of Fisheries and Wildlife 2003) and Endangered in Connecticut (Connecticut Department of Environmental Protection 2004). The breeding population of Massachusetts is estimated between 11 and 20 pairs (Massachusetts Division of Fisheries and Wildlife 2005). Common moorhens have always been thought to be rare and local in Vermont (Environmental Protection Agency 2005).

Common moorhens are rare in New Hampshire and are near the northern edge of the breeding range. The first confirmed nesting occurred in July 1960, with 2 adults and at least 6 young observed on a small pond in Portsmouth, which is no longer considered suitable (Hebert and Elkins 1994). There are New Hampshire breeding records for the towns of Concord, Barrington, Rochester, and Nottingham, as well as a 1998 sighting of an immature moorhen at the Exeter Wastewater Treatment plant. Multiple moorhens have been seen in Rye, Exeter and Orford, whereas single observations in the northern towns of Haverhill, Jefferson, Errol, and Dummer need further documentation to confirm breeding. Single observations have also been recorded in marshes in Hampton Falls, Durham, Newington, Marlow, Hebron, and Holderness (New Hampshire Wildlife Sightings Database 2005, Hebert and Elkins 1994).

1.5 Town Distribution Map

1.6 Habitat Map

See habitat map for Marsh and Shrub Wetlands.

1.7 Sources of Information

NatureServe (2005) was used for status and ranking information. New Hampshire Wildlife Sighting (2005), New Hampshire Heritage Bureau databases (2005), and Hebert and Elkins (1994) were the primary sources of locality records. Habitat and life history information was taken from published literature, including Foss (1994).

1.8 Extent and Quality of Data

The distribution of common moorhen breeding locations in New Hampshire appears to be limited to a few suitable cattail marshes or wastewater treatment facilities in the southeast part of the state. Recent distribution data are largely the result of records submitted to the New Hampshire Wildlife Sightings web page from New Hampshire Bird Records collected and reviewed by NHA. Although common moorhen records are few in the state, submitted reports are carefully reviewed before they are accepted, resulting in high-quality records.

1.9 Distribution Research

Systematic surveys are needed to provide more information regarding distribution, condition, and habitat requirements of the species. NHA volunteers should be recruited to identify common moorhen breeding locations. They should begin around the third week of May, and should concentrate particularly on those areas where breeding is suspected but not confirmed (e.g., Pontook Reservoir in Dummer, Reed Marsh in Orford, and Eel Pond in Rye). Common moorhen, and other uncommon, elusive wetland birds such as the Virginia rail (*Rallus limicola*) and Sora (*Porzana Carolina*) should be incorporated into habitat inventories and management and restoration efforts.

Element 3: Species Threat Assessment

Wetland loss and degradation, including shoreline modification and alteration of vegetated edges, are the greatest threats to common moorhen. See threats in Marsh and Shrub Wetland habitat profile.

Element 4: Conservation Actions

Maintaining natural, tall, grass-like emergent vegetation, especially cattail, at the borders of ponds and wetlands. See Marsh and Shrub Wetland habitat type for relevant conservation strategies.

Element 5: References

5.1 Literature

Bannor, B.K., and E. Kiviat. 2002. Common moorhen (*Gallinula chloropus). In* The birds of North America, no. 685, A. Poole and F. Gill, editors. The Birds of North America, Inc., Philadelphia, Pennsylvania, USA.

DeGraaf, R.M. and M. Yamasaki. 2001. New Eng-

land wildlife: habitat, natural history, and distribution. University Press of New England, Hanover, New Hampshire, USA.

Connecticut Department of Environmental Protection Natural Diversity Database webpage 2004. Connecticut Department of Environmental Protection. Hartford, Connecticut. Available http://dep.state.ct.us/burnatr/wildlife/factshts/cmoorhen.htm. (Accessed 18 February 2005).

Environmental Protection Agency, Region 1 webpage 2005. Species profile: Common Moorhen. Environmental Protection Agency. Washington, D.C. Available http://epa.gov/region1/ge/thesite/restofriver/reports/final_era/B%20-%20Focus%20Species%20Profiles/EcoRiskProfile_common_moorhen.pdf (Accessed 1 March 2005).

Hebert, V.L. and K.C. Elkins. 1994. Common moorhen. Pages 76-77 *in* Atlas of breeding birds in New Hampshire, C.S. Foss, editor. Arcadia, Dover, New Hampshire, USA.

Massachusetts Natural Heritage Program webpage 2005. Massachusetts Rare and Endangered Wildlife. Division of Fisheries and Wildlife, Westborough, Massachusetts. Available http://www.mass.gov/dfwele/dfw/nhesp/nhfacts/galchl.pdf. (Accessed 18 February 2005).

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: 15 February 2005).

5.2 Data Sources:

New Hampshire Natural Heritage Bureau. 2005. Database of Rare Species and Exemplary Natural Community Occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

Wildlife Sightings database. Maintained by the University of New Hampshire Complex Systems, Durham, New Hampshire, USA. (Accessed Feb. 15, 2005)

SPECIES PROFILE

Common Nighthawk

Chordeiles minor

Federal Listing: Not listed
State Listing: Threatened
Global Rank: G5
State Rank: S2B
Author: Pamela D. Hunt, NHA

Element 1: Distribution and Habitat

1.1 Habitat Description

Common nighthawks nest on the ground in prairies, rock outcrops, beaches and dunes, forest openings, abandoned quarries, pine barrens, and flat gravel roofs (Poulin et al. 1996). In New Hampshire, nighthawks primarily use pine barrens, openings in Appalachian oak-pine forests, rocky ridges, and urban habitats. In urban areas, they nest on flat gravel rooftops and forage on insects attracted to streetlights. Nighthawks prefer buildings 5 to 15 m (16 to 48 ft) high (Grazma 1967) that are surrounded by a parapet and surfaced with small "pea" gravel (6 to15 mm in diameter, Marzilli 1986, 1989, Wedgewood 1992). Roofs surfaced with larger crushed stone (more than 25 mm) are rarely used by nighthawks (Marzilli 1986, Wedgewood 1992).

Records from non-urban areas are much rarer, and include pine barrens in Concord and the Ossipee area and gravel pits in parts of Hillsborough and western Rockingham Counties. In both, the birds forage over forest openings and adjacent urban or agricultural areas, occasionally using rocky ridges interspersed with low shrubby vegetation and forbs.

1.2 Justification

Data from the Breeding Bird Survey (BBS) suggest that nighthawks are declining over much of their range (around 1.7% annually), particularly in the East (around 4.6% annually, Sauer et al. 2004). Declines have been greater since 1980 than in the period 1966 to 1979. NHA data suggest declines in the lower Merrimack valley, northwest Merrimack County, and the Pemigewasset valley by 1994 (figures 1a and b). Although data from the late 1990s are limited, they indicate significant declines across most of the range (figure 1c). By this time, the species had largely disappeared from coastal New Hampshire, the North Country, upper Connecticut River valley, and much of the Merrimack Valley. Nighthawks were absent from Manchester and had declined in Concord (NHBR). The absence of nighthawks from historic urban sites in the lower Merrimack Valley was confirmed in 2001 and 2002, when surveys failed to locate the species in either Manchester or Nashua (table 1, see also Hunt 2003). These same surveys detected the species in only four urban areas: Woodsville, Franklin, Concord, and Keene (figure 1d). Reports to NHBR between 2000 and 2004 indicate that the species occasionally occurs in Manchester and Berlin, but there are no indications of persistent populations.

The status of nighthawks in rural areas is more difficult to evaluate over this same period, since potential habitats are less likely to be visited at night and because birds are likely to be more dispersed. The most consistently occupied rural area during the last 20 years appears to encompass the pine barrens and other open habitats of the Ossipee area, including the towns of Sandwich, Tamworth, Madison, Ossipee, and Freedom. Other towns where nighthawks were documented in natural habitats (including gravel pits) since 1990 include Auburn, Concord, Croydon, New Boston, Orange (Mt. Cardigan), and Warner (Mt. Kearsarge).

1.3 Protection and Regulatory Status

This species is protected under the Migratory Bird Treaty Act, which prevents the killing of most non-

game birds and collection of their nests or eggs. In New Hampshire, it is protected by the New Hampshire Endangered Species Conservation Act (RSA 212).

1.4 Population and Habitat Distribution

The distribution of the common nighthawk in New Hampshire prior to European settlement is unknown, but was presumably limited to pine barrens, heaths, bald mountaintops, and small openings created by fire, wind, or indigenous agriculture. Creation and expansion of urban areas in the nineteenth and twentieth centuries probably allowed the species to expand its range considerably (Andrle and Carroll 1988), although by the 1980s it appears to have declined considerably, especially in natural habitats.

During the Breeding Bird Atlas in the early 1980s, nighthawks were believed to occur almost exclusively in urban habitats (Foss 1994). Although distributed statewide, atlas records were concentrated in the lower Connecticut and Merrimack River valleys and parts of Strafford County. Isolated urban sites included Groveton, Berlin/Gorham, and Conway. Known or suspected nesting in natural areas occurred in the Ossipee area and northwestern Merrimack County.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

N/A

1.7 Sources of Information

Basic natural history information in this profile was largely gathered from the literature cited in element 5. Data on common nighthawk distribution in New Hampshire were compiled from NHBR, a database maintained by NHA.

1.8 Extent and Quality of Data

Because nighthawks are largely nocturnal, there are limited data on their overall distribution and abundance in New Hampshire. When surveys of urban areas were conducted, there were good estimates of local abundance, but such surveys have not been conducted recently. Information on nighthawks in natural habitat is even more sparse, although recent surveys in the Ossipee Pine Barrens may provide data for this part of the state. There are no consistent surveys of potential habitat at mountaintop balds.

1.9 Distribution Research

Given ongoing declines throughout the Northeast, common nighthawks are included in a list of species identified by Partners in Flight as in need of comprehensive monitoring efforts, including in urban areas. Northeast Partners in Flight is currently developing a monitoring template for nightjars, which will include a section on urban nighthawks.

Monitoring of nighthawks in rural areas is problematic because of their sparse distribution. Whip-poor-will surveys in the Ossipee Pine Barrens may also record nighthawks. In the absence of a rural monitoring program, an effort should be made to visit known and potential sites and search for this species. This effort could use volunteers or be part of a larger statewide distributional assessment, such as a breeding bird atlas.

Element 2: Species/Habitat Condition

2.1 Scale

For the purposes of this profile, nighthawk sites are divided into 4 categories:

- **Ossipee Pine Barrens:** Available data suggest that this is the largest remaining natural population in the state. It can be defined as areas of Effingham, Freedom, Ossipee, Madison, and Tamworth where appropriate habitat remains.
- **Mountaintop Balds:** These are represented by historic sites such as Mts. Cardigan and Kearsarge. Undoubtedly other balds are suitable, although data on nighthawk use are lacking.
- **Other natural habitats:** This unit includes pine barrens and similar habitats in the Merrimack River Valley, as well as any other areas where the species may occur away from urban centers
- **Urban rooftops:** Tall buildings have historically supported nighthawks or have the potential to be used by the species.

2.2 Relative Health of Populations

Declines in almost all of the state's larger urban nighthawk populations (table 1) are indirect evidence of poor population health. If declines result from deteriorating local habitat quality, then the appropriate conservation unit may need to be identified as an individual city. If declines are more pervasive, then larger regional populations could be considered in poor health. There are insufficient data with which to evaluate population health in any of the non-urban areas used by nighthawks in New Hampshire.

2.3 Population Management Status

Nighthawks are not managed in New Hampshire.

2.4 Relative Quality of Habitat Patches

Given increased conservation interest in the Ossipee Pine Barrens by TNC and its partners, this area may be of relatively high quality. Although loss of habitat to development is still a factor, there are plans to reintroduce fire to the ecosystem, which would create additional openings that nighthawks could use. The same is true to a lesser extent for the pine barrens around the Concord Airport (Fuller et al. 2003). There are insufficient data on other pine barrens or sand plain forests to evaluate their current suitability for nighthawks. Mountaintop balds may remain suitable habitats, although data are lacking. For urban areas, habitat evaluation would require data on rooftop construction and configuration.

2.5 Habitat Patch Protection Status

Portions of both the Ossipee and Concord pine barrens have been preserved by easement or fee ownership. At least two mountaintops used by this species historically are protected as part of state parks (Mts. Cardigan and Kearsarge).

2.6 Habitat Management Status

At the Ossipee Pine Barrens, The Nature Conservancy is in the process of developing a habitat management plan to implement prescribed burning and other disturbances to maintain the habitat in a more open condition. Intensive restoration and management began in Concord in 2002, and a management plan was finalized in 2003. Management prescriptions, including burning, forestry, and plant propagation, are targeted at restoring native grass, heath, and shrubland components of the pitch pine-scrub oak woodland community. No management is in place at any of the other areas occupied or potentially occupied by nighthawks in New Hampshire.

2.7 Sources of Information

Data on population trends for common nighthawks were obtained from NHBR and summaries of annual nighthawk surveys between 1982 and 1991 and 2001 and 2002. Information on management activity at specific sites was obtained through discussions with pertinent parties or from existing management plans or agreements.

2.8 Extent and Quality of Data

In the absence of comprehensive surveys, it is difficult to evaluate variation in habitat condition for this species in New Hampshire. There are no data on the specific characteristics of rooftops that could be used to determine the availability of nesting habitat in urban areas.

2.9 Condition Assessment Research

To the extent that urban rooftops once supported the majority of New Hampshire's nighthawk population, research into this habitat and how it has changed is sorely needed. Important data to collect could include the number and area of flat graveled roofs, roof height, and presence/absence of parapets or similar surrounding structures. Such data, when collected in a consistent manner across the primary known or potential urban breeding areas in the state, would be invaluable in assessing the potential for such areas to support or attract healthy common nighthawk populations.

Element 3: Species and Habitat Threat Assessment

3.1.1 Development (Habitat Loss and Conversion)

See Pine Barrens habitat profile

3.1.2 Development (Habitat Conversion)

(A) Exposure Pathway
The decline of common nighthawks in urban areas over much of its range has been attributed to changes in roof surface materials: from small gravel to large gravel (Wedgewood 1992) or a smooth rubberized surface (Poulin et al. 1996). Smooth rubberized roofs may not provide appropriate camouflage or thermal environment for nighthawk eggs or chicks, and they may allow eggs to roll (Marzilli 1989).

(B) Evidence
Gravel patches were placed on rubber roofs in Orono, Maine in 1986 and 1987 in locations where nighthawks were unlikely to nest. In 3 of 14 cases, nighthawks used these patches for nesting (Marzilli 1989), and they preferred patches placed near parapets, avoiding patches in the center of roofs.

3.1.3 Predation and Herbivory

(A) Exposure Pathway
Several authors (e.g., Laughlin and Kibbe 1985, Petersen and Meservey 2003) have speculated that declines in the closely related whip-poor-will (*Caprimulgus vociferus*) are related to a decline in prey populations. In particular, it has been proposed that saturnid and sphingid moth populations over much of the Northeast were severely depressed following widespread spraying for the introduced gypsy moth (*Lymantria dispar*) from roughly 1950 to 1970. Recovery is believed to have been hampered by a parasitoid fly (*Compsilura concinnata*), which was introduced to combat gypsy moths (Schweitzer 2004). An alternate hypothesis is that moth declines are the result of atmospheric pollution (Andrele and Carroll 1988).

(B) Evidence
There are limited data on the nature and extent of moth declines in eastern North America where most gypsy moth control has historically occurred. In addition, available evidence suggests that moths are a relatively unimportant part of nighthawk diets (Poulin et al 1996). Thus, any connection between large moth populations and nighthawk populations is speculative.

3.1.4 Altered Natural Disturbance (Fire Suppression)

See Pine Barrens habitat profile

3.1.5 Non-Point Source Pollution (Chemical Contaminants)

(A) Exposure pathway
Direct contact with some classes of pesticides is known to cause mortality in birds. Given that nighthawks routinely forage over agricultural areas in both the breeding and non-breeding seasons, the potential exists for them to become contaminated either through their prey or through direct contact.

(B) Evidence
Anecdotal data suggest a link between pesticide spraying and local disappearance of nighthawks (Wedgewood 1992, Foss 1994, Poulin et al. 1996). However, the lack of population recovery following such spraying suggests that additional factors have acted to prevent numbers from increasing once pesticide use was discontinued.

Like several other large aerial insectivores (whip-poor-will, purple martin), nighthawks are potentially affected by events on the winter grounds. Pesticide spraying continues in agricultural areas of southern South America, where the bulk of the population appears to winter (Poulin et al. 1996). Pesticide application during the non-breeding season has been directly implicated in mortality of Swainson's Hawks (*Buteo swainsoni*, Goldstein et al. 1996), and has been suggested for purple martin (Brown 1997) and upland sandpiper (Houston and Bowen 2001).

3.2 Sources of Information

Information used in this section was obtained primarily through a literature review.

3.3 Extent and Quality of Data

Few data are available on listed threats, and data on roof construction and use are highly variable (Bingham 1989). Data are similarly lacking on the effects of pesticides and the nature and extent of changes in the species' prey base.

3.4 Threat Assessment Research

Data are largely lacking on the suitability of urban rooftops for the species, and where they are available there is no way to assess any impact on local nighthawk populations. Data on prey populations and pesticide effects are even more rare. Potential research projects related to threats to nighthawk populations thus include, collection of data on rooftop construction and comparison to historic patterns of nighthawk occupancy, study of nighthawk diets in natural habitats to allow assessment of impacts of presumed moth declines, and study of nighthawk exposure to agricultural pesticides in South America.

Element 4: Conservation Actions

4.1.1 Target Gravel Rooftop Nesting Pads under Backyard Habitat Program, Restoration and Management (see also Strategies, Landowner Incentives Program)

(A) Change in rooftop construction

(B) Justification

- Installation of rooftop gravel nesting pads will replicate nesting substrates that have historically been suitable for nighthawks.
- At the University of Maine in Orono, nighthawks successfully colonized gravel nesting pads (Marzilli 1989).
- Given the rapid rate of decline, immediate action is appropriate. Recolonization attempts are expected to begin upon migration through focal areas.
- Modified rooftops can be monitored for nesting success to inform location and construction of nesting pads.

(C) Conservation Performance Objective
The objective is an increase in the proportion of an urban area's total rooftop space that provides suitable substrate for nesting by common nighthawks. The actual magnitude of change cannot be determined until baseline conditions, and possibly historic conditions, have been assessed as discussed in element 3.

(D) Performance Monitoring
Once current conditions are determined, areas where this action is implemented should be reassessed every 2 to 3 years to determine if the amount of suitable habitat is increasing. Such assessment could include some combination of site visits and review of construction or maintenance records for target buildings.

(E) Ecological Response Objective
The desired ecological response is increased local nighthawk populations in focal areas. There are currently no data on the ability of nighthawk populations to respond to habitat management, so it is impossible to specify a time frame in which this objective should be attained. Until better demographic information is available, nesting success in colonized nest pads may serve as an indicator of response.

(F) Response Monitoring
Responses of local nighthawk populations should be monitored in conjunction with ongoing distribution/trend monitoring proposed under section 1.9. Nesting success in rooftop pads should be monitored (see section 1.9) annually.

(G) Implementation
Potential sites can be identified based on the criteria outlined in section 1.1 (building height, surrounding structures, etc.). If such roofs are surfaced with unsuitable rubber or larger gravel, a gravel patch can be placed on the roof. Gravel patches used in Maine were triangular and 3-m^2 in area, and were placed in the corners of roofs with parapets (Marzilli 1989). Patches should be placed to allow shading by parapets of other roof structures. If these are not available, additional shelter should be provided with the gravel pad. Once in place, such patches may require regular maintenance, although data on patch resiliency are currently unavailable. A program to educate building owners about choices in roof construction would be required to supplement this action.

(H) Feasibility: 1.00
Pending approval of funding for New Hampshire's Landowner Incentive Program proposal, this action can be implemented under the existing Backyard Habitat Program. Implementation will require cooperation with multiple parties that are not traditionally involved with wildlife conservation in New Hampshire, including building managers, construction

companies, and downtown associations. The presence of breeding peregrine falcons in Manchester has made nighthawk conservation more feasible by raising the profile of urban wildlife, and as a result Manchester might be a good place to test this action.

Modifying rooftops using gravel pads is certainly more feasible than any attempt to affect overall roof surfacing guidelines on a statewide basis. However, the option of resurfacing an entire roof with suitable substrate should not be ignored if such an opportunity presents itself. If stakeholder support can be obtained, the primary remaining obstacle to implementation would probably be the costs of materials and labor, and the nature of such costs cannot be determined at this time.

4.1.2 Develop an Urban Wildlife Management Plan, Restoration, and Management (see Strategies, Habitat Management)

4.1.3 Stipulate Roofing Materials on Site Specific Permits, Regulation, and Policy (see Strategies, Environmental Review)

4.1.4 Restore Openings in Pitch Pine-Scrub Oak Woodlands, Restoration and Management (see Pitch Pine-Scrub Oak Woodlands Habitat Profile, see also Strategies, Habitat Management)

4.1.5 Identify Critical Habitats and Focal Populations, Conservation Planning (see Strategies, Conservation Planning)

4.1.6 Advise Town Conservation Commissions on Roof Construction Guidelines, Regulation and Policy (see Strategies, Local Regulation and Policy)

4.2 Conservation Action Research

Evidence in favor of the efficacy of this action is adequate to support implementation.

Element 5: References

5.1 Literature

Andrle, R.F., and J.R. Carroll. 1988. The Atlas of Breeding Birds in New York State. Cornell University Press, Ithaca, New York, USA.

Brigham, R.M. 1989. Roost and nest sites of common nighthawks: are gravel roofs important? Condor 91: 722-724.

Brown, C.R. 1997. Purple martin (*Progne subis*). *In* The Birds of North America, No. 287 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, DC.

Foss, C.R. 1994. Atlas of Breeding Birds of New Hampshire. New Hampshire Audubon, Concord, New Hampshire, USA.

Fuller, S., C. Goulet, and D. Hayward. 2003. Habitat management and monitoring plan for Concord Municipal Airport. Final Draft: April 21, 2003. New Hampshire Fish and Game Department.

Goldstein, M.I., B. Woodbridge, M.E. Zaccagnini, S.B. Canavelli, and A. Lanusse. 1996. An assessment of mortality of Swainson's hawks on wintering grounds in Argentina. Journal of Raptor Research 30(2):106-107.

Gramza, A.F. 1967. Response of brooding nighthawks to a disturbance stimulus. Auk 84: 72-86.

Houston, C.S., and D.E. Bowen, Jr. 2001. Upland Sandpiper (*Bartramia longicauda*). *In* The Birds of North America, No. 580 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, DC.

Hunt, P. 2003. Summary of 2002 common nighthawk surveys in New Hampshire. Report to the New Hampshire Fish and Game Department, Nongame and Endangered Species Program. New Hampshire Audubon, Concord, New Hampshire, USA.

Marzilli, V. 1986. Common nighthawks at the University of Maine, Orono. Report to Endangered and Nongame Wildlife Grants Program, Maine Department of Inland Fisheries and Wildlife, Bangor.

Marzilli, V. 1989. Up on the roof. Maine Fish and Wildlife 31(2): 25-29.

New York State Department of Environmental Conservation (NYSDEC). 2005. NYS Breeding Bird Atlas Website. www.dec.state.ny.us/apps/bba/results.

Petersen, W.R., and W.R. Meservey. 2003. Massachusetts Breeding Bird Atlas. Massachusetts Audubon Society, Lincoln, Massachusetts, USA.

Poulin, R.G., S.D. Grindal, and R.M. Brigham.

1996. Common Nighthawk (*Chordeiles minor*). *In* The Birds of North America, No. 213 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, Pennsylvania, USA.

Robinson, S., and J. Robinson. 2001. The Pittsfield nighthawk watch: 1993-2001. Bird Observer 29: 446-447.

Sauer, J.R., J.E. Hines, and J. Fallon. 2004. The North American Breeding Bird Survey, Results and Analysis 1966-2003. Version 2004.1, USGS Patuxent Wildlife Research Center, Laurel, Maryland, USA.

Wedgewood, J. 1992. Common nighthawks in Saskatoon. Blue Jay 50: 211-217.

Zeranski, J.D., and T.R. Baptist. 1990. Connecticut Birds. University Press of New England, Hanover, New Hampshire, USA.

5.2 Data Sources

NHBR. New Hampshire Bird Records, New Hampshire Audubon, Concord, New Hampshire, USA.

Element 6: List of Figures

Figure 1. Distribution of common nighthawks in New Hampshire, 1985-2004. Color coding indicates the maximum number of nighthawks observed in a given town during the five-year period: yellow = 1-4, red = 5-9, black = 10 or more. During the 20-year period, systematic nighthawk surveys were conducted in 1985-91 and 2001-02.

SPECIES PROFILE

Common Tern

Sterna hirundo

Federal Listing: Not listed
State Listing: Endangered
Global Rank: G5
State Rank: S1
Author: Diane L. De Luca, New Hampshire Audubon

Element 1: Distribution and Habitat

1.1 Habitat Description

Common tern nest on rocky islands, barrier islands, and salt marshes that are close to feeding areas and that provide protection from predators. Common terns nest in the open, on bare ground, or on vegetation, and rarely under cover (but often adjacent to vegetation) (Kress and Hall 2002). On average, nest sites have more than 90% visibility from above (Gochfeld and Burger 1987). A preliminary study of nest site parameters for the New Hampshire Seavey Island colony in 1998 showed that 54% of the nests were located at the rock-vegetation interface, 24% were located on rock and 22% were located in the vegetation.

Common terns feed primarily on juvenile marine fish, but will also eat aquatic and terrestrial invertebrates (Hall 1999, De Luca et al. 1998-2002). Foraging success depends on the abundance and depth of the prey, tidal height, wind speed, and sea surface conditions (Hall 1999). Common terns have a broader diet than roseate and arctic terns and seem to adapt to changing feeding conditions more readily (Safina et al. 1990). At Seavey Island, Isles of Shoals, feeding data collected from 1998 to 2002 identified more than 40 food items. With the exception of 2001, when Atlantic herring *(Clupea harengus)* was eaten with the highest frequency, juvenile white hake *(Urophycis tenius)* has constituted the largest part of the common tern diet on Seavey Island, totaling 45% to 55% of all feedings. Some terns have been observed to feed exclusively on insects or amphipods.

Although no formal study of foraging locations has been conducted, the rate and timing of observed feedings highlight the importance of the waters that immediately surround the Isles of Shoals. Foraging has also been consistently observed in the Hampton and Seabrook harbors, Rye Harbor, and at the mouth of the Piscataqua River.

1.2 Justification

The common tern is a species of regional and state concern. In the Northeast, common tern success is necessary for the recolonization of roseate terns. The common tern colony on Seavey Island should be maintained to successfully manage roseate terns. Managing for common terns will also address the needs of other coastal island species including Arctic Tern, common eider, black guillemot, and purple sandpiper.

Efforts to restore the northeastern common tern population began in the 1970s but have been more organized since 1984, when the Gulf of Maine Tern Working Group was formed. Although common tern restoration efforts have been successful in increasing the number of breeding pairs, the number of islands that support tern colonies remains low. After near extirpation in the late 1800s, the Gulf of Maine now supports over 20,000 pairs of common terns at 47 sites (Kress and Hall 2004). However, 84% of this population nests on 8 islands, leaving them vulnerable to predation, oil spills, and catastrophic weather.

The primary limiting factor for common terns is the loss of nesting sites and predation that led to concentrated colonies in a small number of suitable sites (Kress and Hall 2004, Nisbet 2002). Gull populations took over many of the offshore islands that had supported terns, and other habitats were lost

to erosion. This resulted in common terns nesting at marginal inshore islands where the habitat quality was low and the risk of predation was high.

Regionally, the species is in jeopardy due to predation and loss of suitable nesting habitat. In the northeastern United States, gulls, great horned owls, black crowned night heron, coyote, mink, and rats eat eggs, chicks, and adults. Reduced prey abundance, competition for nest sites, contaminants, human disturbance, inclement weather, and insufficient funds to protect colonies also contribute (Nisbet 2002). Little is known about factors affecting the population on its wintering grounds (Kress and Hall 2004, Nisbet 2002).

Common tern nesting is required for successful recolonization of roseate terns in the Northeast. The Seavey Island roseate tern colony largely depends on the protection and success of the common tern colony. Greater than 85% of the entire northeastern population of roseate terns currently nests on four islands from Buzzard's Bay to Long Island, New York, making the entire population vulnerable

1.3 Protection and Regulatory Status

- The common tern is protected in the United States under the Migratory Bird Treaty Act of 1918, which prohibits the taking of bird, nest, and eggs.
- Seavey Island is under the management of New Hampshire Fish and Game (NHFG). Seavey Island is posted as an endangered species breeding site, and the public is restricted from 1 May to 1 September. Seavey Island is actively managed through the breeding season, and biologists are present at the colony from late April to August.

1.4 Population and Habitat Distribution

Historically, common terns bred on several islands at the Isles of Shoals. Anecdotal evidence suggests that common terns nested in high numbers at Duck Island in the mid 1880s (Borror and Holmes 1990). Jackson and Allen (1931) noted that common terns bred on Lunging Island as early as 1922 and the colony grew rapidly to 1,000 pairs by 1928. Jackson (1947) estimated that 1,500 to 2,000 pairs continued to nest there until 1938, and smaller numbers persisted at this site until the late 1940s. This site was abandoned before 1955 (Taber 1955), apparently because of displacement by herring gulls (Drury 1973, Erwin 1979). Herring and great black-backed gulls continue to nest at this location.

F.B. White (1927) discovered a common tern colony on the mainland coast in Seabrook near the bridge over the Hampton Harbor Inlet. This colony, which fluctuated in size during the 9 years White observed it, apparently peaked in 1929 with at least 118 nests (White 1935). The year of its abandonment is unknown, but existing records indicate the presence of a single nest with eggs in 1953.

Several islands in the Great Bay estuary, including Nannie, Hen, Goat, and the two Footman Islands, have supported nesting terns in recent decades. These colonies apparently peaked around 1970 with approximately 12 pairs on the Footman Islands and 30-40 pairs on Nannie Island (Art Borror, personal communication). Hen Island has supported 1 to 20 pairs of common terns from 1989 to 2004. The Footman Islands have sporadically supported small numbers of nesting pairs in the last 30 years. Nannie Island has not had any documented breeding in recent years. All of these inshore islands have been subjected to significant predator pressures as well as human disturbance.

Tern nesting activity on the salt marshes of the Hampton Harbor estuary dates back to at least 1964. Approximately 50 pairs nested in the salt marsh in the 1970s and 1980s. These numbers have continued to decline and fewer than 25 pairs remain. Heavy predation and flooding have caused very low productivity in most years. This population is unlikely to survive under current conditions.

Although the year of origin for the Back Channel colony is unknown, New Castle residents recall tern activity dating back at least 50 years. Past nesting has occurred on Pest and Leach's Islands as well as on 3 small islands known as the Back Channel Islands. Numbers fluctuated from 15 to 20 pairs in the early 1960s to only 1 pair in 1971, and back up to 44 pairs in 1982 (Foss 1982). This colony continued to decline through the 1980s and early 1990s due to predation and disturbance. This site was abandoned in 1998 after the Seavey Island colony was established.

In 1997, NHFG and the New Hampshire Audubon (NHA) began a project to restore terns to the Isles of Shoals. They worked with the New Hampshire Coastal Program, the Department of Resources and Economic Development – Parks Division, Wild-

life Services of the USDA, Shoals Marine Laboratory, Isles of Shoals Steamship Company, the Gulf of Maine Seabird Working Group and the United States Fish and Wildlife Service (USFWS) to complete the first year of this project using nonlethal means of gull control, along with decoys and sound to attract breeding terns back to the Isles of Shoals. In 1997, a small colony of six pairs raised and fledged six young at this site. This colony has continued to show significant growth, with breeding pairs climbing from 6 pairs in 1997 to 2582 pairs in 2004 (figure 3).

Regionally, the distribution of the common tern is unchanged since the first records in 1870 (Nisbet 2002), although the numbers have fluctuated widely. Common terns nest from North Carolina to Newfoundland and west through the Great Lakes into northwestern Canada (Kress and Hall 2004). Currently, the estimated number of nesting pairs in this entire region is 82,000 (Nisbet 2002).

In New Hampshire, 99% of common terns currently nest on Seavey Island, Isles of Shoals. Seavey Island is part of a cluster of islands known as the Isles of Shoals (see Coastal Islands profile). The Shoals are located approximately 9 km from Rye Beach and 13 km from the mouth of the Piscataqua River (figure 1). Seavey Island is approximately 1.5 hectares in size, with rugged granite outcroppings pocketed with herbaceous vegetation. Seavey Island is connected to White Island by a cobble tombolo at low tide. The predominant plant species found in the Seavey Island nesting areas include grasses, yarrow (*Achillea millefolium*), seaside goldenrod (*Solidago sempervirens*), black mustard (*Brassica nigra*) and dodder (*Cuscuta gronovii*) (De Luca et al. 1998).

Other nesting sites in New Hampshire include the rocky islands at the Isles of Shoals, small inshore islands in Great and Little Bays and along the Piscataqua River, and the extensive thatched areas in the Hampton-Seabrook salt marshes. In the salt marsh, they build shallow nests atop the mats of dead thatch. On Seavey Island and the tern islands in Great Bay they create shallow grass and stick cups atop the rock and/or vegetation.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

The New Hampshire GRANIT System was used to identify coastal islands. Very small islands were grouped with the nearest adjacent neighboring islands. In total, 96 polygons were grouped into 48 islands, which in turn were clustered into 15 conservation units.

Each conservation unit was defined by parameters such as size, shoreline, development, distance from known and potential contaminant sources, and the distances to the nearest aquaculture operations, oil spill response staging areas, recreational fishing areas, marinas and public beaches. New Hampshire Department of Environmental Services provided the locations of known contamination sources, heliports, oil spill response staging areas, recreational fishing, marinas and aquaculture locations, and airport locations were provided by the New Hampshire Department of Transportation.

1.7 Sources of Information

Basic natural history information in this profile was largely gathered from the literature cited in element 5. Information on habitat and distribution was gathered from scientific literature, recovery conservation plans, technical field reports, published literature, NHA and NHFG Seavey Island data, New Hampshire Bird Records data, Gulf of Maine Seabird Working Group (GOMSWG) and Roseate Tern Recovery Team (RTRT) discussion and minutes. Information for mapping was provided as cited in 1.6.

1.8 Extent and Quality of Data

Common terns have been followed closely since the formation of the Gulf of Maine Tern Working Group in 1984. Regionally, common tern breeding colonies have been managed and intensively monitored for more than 20 years. The Seavey Island common tern population has been intensively studied since recolonization in 1997. In New Hampshire, all current and recently occupied tern-nesting sites are surveyed annually during June. Historical habitat at the Isles of Shoals was surveyed in 1977, 1985 and 1995, and an all-island census at the Isles of Shoals is scheduled for June 2005.

Habitat parameters were identified at common tern

nests on Seavey Island in 1998. This pilot study produced baseline data for the development of habitat and vegetation profiles of common tern nest sites. The update and continuation of this study, along with the generation of vegetation profiles, will help in the development of a habitat management plan.

Common tern foraging habitat is largely unknown in New Hampshire, though sightings between 1998 and 2001 suggest that common terns forage close to Seavey Island. It will be important to identify critical foraging areas for this species and to explore staging areas in nearby waters.

Little is known about common tern migration and wintering habitat. Large winter concentrations have been identified in Suriname, Trinidad, Brazil, and Argentina (Hays et al. 1997, 1999). It is important to identify and assess common tern wintering habitat.

1.9 Distribution Research

- Continue intensive monitoring of common terns on Seavey Island
- Characterize common tern breeding habitat on Seavey Island
- Evaluate other islands at the Isles of Shoals for suitable tern habitat. Lunging and Duck Islands both supported common and roseate terns historically
- Identify priority habitats and potential sites for restoration
- Conduct surveys and analyze existing data to determine significant foraging and staging areas
- Band tern chicks on Seavey Island to determine recruitment levels and inter-colony movement
- Develop protocol for re-sighting banded birds and coordinating with other islands for data exchange
- Understand movement patterns of common terns within the Gulf of Maine using the marked known aged population
- Evaluate annual interchange of birds between Gulf of Maine and "warm water" groups
- Continue to research migration routes, winter habitat, and winter distribution

Element 2: Species/Habitat Condition

2.1 Scale

Fifteen conservation units have been identified for coastal islands. All 9 islands at the Isles of Shoals are recognized as separate units.

2.2 Relative Health of Populations:

Productivity on Seavey Island has dropped from an average of 1.63 chicks per pair between 2000 and 2002 to 0.75 chicks per pair in 2004 (table 2). Smaller clutch sizes in 2003 and 2004 may have resulted from cool weather and rough seas. It will be important to follow productivity trends and address low productivity if it persists.

The Isles of Shoals population is home to all of New Hampshire's roseate and Arctic terns, and to more than 98% of common terns. This concentration at one site in New Hampshire makes this population very vulnerable to any form of disturbance or catastrophic event. The potential for tern recolonization at any of the identified conservation units outside the Isles of Shoals is low. Predation, disturbance, and the attendant issues of marginal habitat significantly threaten inshore colonies of terns.

Common terns have not nested on any other islands at the Isles of Shoals since the late 1940s. Anecdotal evidence from Duck Island makes the possibility of common and roseate breeding high, with numbers of terns described in the "thousands". Both Lunging and Duck Island are potential tern breeding habitat but currently support large herring and great black-backed gull colonies.

In 2004, common tern colonies were confirmed at two remaining "mainland" sites—Hen Island in Newington and the Hampton salt marsh. The only nesting site with confirmed productivity was at Hen Island in Little Bay. This colony has had approximately 12 pairs since the early 1990s. Productivity has varied but averaged about 1 chick per pair for most years. Although a few birds still attempt to nest in the Hampton salt marsh, they fledge few chicks. Encroachment, predation, human disturbance, and flooding all threaten the salt marsh terns.

2.3 Population Management Status

The Seavey Island tern nesting colony intensively managed. Biologists live on the island during the breeding season to control predators, monitor the productivity of the colony, and implement public outreach. Seavey Island is also posted from 1 May to 1 September to minimize disturbance.

Common terns were re-colonized at this site using techniques that included nonlethal gull control and tern attraction techniques. Nonlethal gull control at Seavey Island included the presence of a dog during the latter half of April, pyrotechnics, regular circumnavigation of the island beginning 30 minutes before sunrise and continuing until 30 minutes after sunrise, and the placement of a large rock in any gull nest cups (NHA and NHFG unpublished reports 1997-2003). Tern attraction techniques included the placement of decoys in suitable habitat along with the broadcast of tern colony sounds (Kress 1983). Common terns nested at this site in the first year of restoration efforts (1997).

Resident tern biologists are able to continue active gull control through the breeding season. Specialist predatory gulls can be removed from the island. Gull control data clearly show that changes in the intensity of direct intervention can affect the success of the colony.

Although it is difficult to land on Seavey Island, the summer months allow for increased boat traffic and visitation to the Isles of Shoals. Tern biologists act as stewards and can help regulate any visitation. Educational visits from Shoals Marine Lab, Star Island, and various other conservation organizations foster the conservation of this seabird colony.

Lighthouse renovation is scheduled to begin in 2005. Construction crews will be working on the lighthouse and other island structures during the breeding season. Coordination with tern project biologists, New Hampshire Parks and Recreation oversight staff, and construction personnel will be imperative to avoid any disturbance to the terns.

There has not been any systematic identification or monitoring of critical foraging resources for the common tern. It is important to understand variation in prey use and the effects on breeding success. In addition, little is known of staging area usage before and after breeding season.

2.4 Relative Quality of Habitat Patches

Nest parameters on Seavey Island were recorded in 1998 to develop habitat and vegetation profiles for common tern nest sites on Seavey Island. Ongoing studies will evaluate the capacity of the island to support more nesting pairs and to document habitat changes, leading to more effective habitat and vegetation management.

The quality of foraging habitat and prey availability near Seavey Island is largely unknown. Foraging studies will determine how prey availability and foraging effort affect productivity. The productivity level of the Seavey Island colony in 2004 (0.75 chicks per nest) was below the level considered productive in the Northeast (more than 1.1 chicks per nest) and well below the high of 2.24 in 1998. It will be important to evaluate the drop in productivity.

The 2 other historic nesting sites for common terns at the Isles of Shoals are Duck Island and Lunging Island. These islands have good potential for tern nesting, yet they each support large numbers of nesting gulls. The presence of raccoons and gulls make tern nesting impractical on Smuttynose Island, though the island once hosted one of the largest gull populations at the Isles of Shoals. Appledore Island is unsuitable for terns because of large populations of gulls, rats, muskrats, raccoon, and humans.

The Hen Island tern colony in Great Bay, which has averaged 12 pairs since 1989, has been disrupted by rats, Canada geese, great horned owl, and humans. A small but persistent tern colony remains in the Hampton salt marsh, though it has been plagued by flooding, predation and human disturbance. Efforts to protect this habitat may improve the potential for nesting.

2.5 Habitat Patch Protection Status

- White and Seavey Islands have been managed by the Department of Resources and Economic Development (DRED)-Parks and Recreation Division as part of Odiorne State Park since 1993. A Memorandum of Agreement on tern restoration exists between DRED – Parks Division and NHFG. Seavey Island is managed by NHFG as an endangered species nesting area and is afforded both state and federal protection under endangered species law.
- The Coastal Islands National Wildlife Refuge pur-

chased Duck Island in July 2003. This island will be managed for its wildlife resources, protected as a seabird colony, posted for closure during the breeding season, and evaluated for habitat management and restoration (B. Benedict, USFWS, personal communication).
- There is no protection at privately owned Lunging Island beyond current shoreline and wetland regulations.
- Smuttynose Island is privately owned but was protected in August 2001 by a conservation easement held by the Coastal Islands National Wildlife Refuge. This conservation easement allows the refuge to manage the site for wildlife resources (B. Benedict, USFWS, personal communication).
- The Town of Newington owns Hen Island. Since the early 1990s, the town has worked with NHFG and NHA to close the island during the breeding season. The proximity of the island to the mainland has subjected Hen Island terns to disruption by rats, Canada geese, great horned owl, and humans.

2.6 Habitat Management Status

Seavey Island is managed for terns through the NHFG and NHA Tern Restoration partnership. Restoration efforts between 1997 and 2004 focused eliminate gull nesting and controlling predation, which allowed some re-colonization by common terns. There has been a gradual shift in the Seavey Island vegetation from yarrow and seaside goldenrod to tall dense grasses. Although the height of the grass makes the habitat more suitable for roseate terns, the density can cause problems for movement of adults and chicks. In 2005, approximately 100 feet of boardwalk was laid through the grassy area to give more structure and opening to the nesting habitat, and to allow biologists access to this part of the island.

It will be important to continue the common tern nest site analysis to evaluate habitat suitability, and to have baseline data from which to make management decisions regarding habitat improvement. Other islands identified in section 2.4 as having the potential for tern recolonization need to have baseline habitat assessments. If determined to be suitable for restoration efforts, a habitat restoration plan would need to be developed and implemented.

2.7 Sources of Information

Information on habitat and distribution was gathered from scientific literature, recovery conservation plans, technical field reports, published literature, NHA and NHFG data, GOMSWG and Roseate Tern Recovery Team (RTRT) discussion and minutes. Information for mapping was provided as cited in 1.6.

2.8 Extent and Quality of Data

Census and productivity numbers have been taken since common terns began nesting in 1997. Chick provisioning data was collected from 1998 to 2001, and baseline habitat data for common tern nesting sites was collected in 1998. More data are needed to determine the habitat parameters of preferred nesting areas.

The habitat on Lunging and Duck Island needs to be evaluated through a nest census and a vegetation/habitat profile at each site. The identification of important foraging and staging areas for roseate terns in New Hampshire is critical.

2.9 Condition Assessment Research

Monitoring

- Continue intensive monitoring of common terns on Seavey Island, using established methods as outlined by the GOMSWG and the Roseate Tern Recovery Plan to determine productivity
- Resume monitoring of the mainland colonies to assess condition and the potential for protection

Research and Assessment

- Characterize common and roseate tern breeding habitat on Seavey Island. Determine the habitat parameters in preferred nesting habitat. Evaluate the need for vegetation management to maintain and increase common and roseate habitat on Seavey Island.
- Conduct habitat assessments at the other historic Isles of Shoals islands.
- Identify and characterize preferred foraging habitat and evaluate vulnerability of principal foraging sites to human disturbance
- Assess seasonal prey availability and how it relates

to tern productivity
- Assess potential effects of an oil spill near Seavey Island.

Research and Survey:

- Identify the location and use of staging and roosting areas for common and roseate terns
- Determine if pre-migratory staging areas constitute a vulnerable population bottleneck
- Identify important wintering areas

Element 3: Species Threat Assessment

3.1.1 Predation and Herbivory (Gulls)

(A) Exposure Pathway
Herring gulls and great black-backed gulls are major predators on terns and other small seabirds. The protection of all seabirds, changes in human land use along coastal islands, the fishing industry, and the use of open landfills caused gull populations to exponentially increase in the twentieth century (figure 2). Gulls prey on tern eggs and chicks and displace them from prime nesting habitats (Foss 1994). Gulls were partly to blame for the extirpation of roseate terns from New Hampshire, but initiation of active gull control on Seavey Island has allowed for the recolonization of this species. Gulls continue to nest on all the other islands at the Isles of Shoals, making them unsuitable for terns.

Nearshore tern colonies are vulnerable to predators such as rats, raccoons, skunk, and fox. Increased development and human use of coastal areas has allowed for an abundance of potential tern predators (USFWS 1998, Kress and Hall 2004). Great horned owl and black-crowned night heron will fly many kilometers to feed on tern chicks and adults. Other avian predators seen at Seavey Island include peregrine falcon, harrier, and cattle egret. With 99% of the common terns and 100% of the roseate terns in New Hampshire nesting at Seavey Island this species is vulnerable to predation.

(B) Evidence
More effective control of municipal and fishing wastes is helping to control gull populations. However, the New Hampshire seacoast still has a large open landfill located in Rochester, about 46 kilometers from the Isles of Shoals. This landfill supports large numbers of gulls during the winter. The Isles of Shoals remains an active fishing area, and there is evidence that discarded lobster bait and other fishing wastes subsidize local gull populations (Goodale 2000). Lack of gull control has been shown to sharply increase predation and disturbance of nesting terns (Donehower 2003). Although non-lethal gull control has successfully removed nesting gulls from Seavey Island, gull predation continues at this site and is particularly intense during the fledging period.

Nocturnal predators such as the great horned owl and black-crowned night herons prey on terns and may cause colony desertion (Nisbet 1999). A great horned owl killed significant numbers of roseate adults in the 2 largest roseate colonies in Buzzard's Bay, Massachusetts. Black-crowned night heron predation has been documented on Stratton Island, Maine and on Falkner Island, Connecticut. The Stratton Island colony grew from 1 pair in 1995 to 127 pairs in 2001 after black-crowned night herons were controlled. The Falkner Island population fell from 135 pairs in 1997 to 37 pairs in 2004 after black-crowned night heron appeared.

Since 2000, mink have invaded 5 common and roseate tern colonies, resulting in dramatic loss of common and roseate terns and the abandonment of tern colonies from Ship Island, Stratton Island, and Jenny Island. Mink killed every roseate chick on Brothers Island (Canada) in 2 consecutive years. Laughing gulls increased by 75% (close to 4,500 pairs) in the Gulf of Maine in the last 5 years. Laughing gulls may compete with terns for nesting habitat or food and some individuals will eat eggs and chicks. Boats have brought predators (rats and raccoons) to Star, Smuttynose, and Appledore Islands in the Isles of Shoal, causing widespread nesting failure.

3.1.2 Development (Habitat Loss and Conversion)

A) Exposure Pathway
Nearly one-third of the population in the United States (over 75 million people) and Canada (over 9 million people) live within a day's drive of the Gulf of Maine. Vast areas of coastal and offshore marine habitat have been lost or degraded in the last three centuries. The northeastern common tern population is restricted to a small number of islands and many

historic nesting islands been lost to erosion or are occupied by gulls. Degradation and disturbance in these areas would all have a negative impact on common tern success. Little is known of critical habitat (foraging, staging, and wintering habitat) of common or roseate terns. Nisbet (2002) cites the need for increased research into winter habitat where it is believed the highest mortality occurs.

(B) Evidence
Critical habitats for common terns and roseate terns should be identified and protected. Seavey Island is important because most of New Hampshire's common terns and all of its roseate terns nest there. Yet scientists do not know basic information such as the location of foraging or staging areas. The 2 known staging areas in the Northeast are in highly developed areas of the coast and may be vulnerable (Casco Bay, Maine and South Beach, Massachusetts).

3.1.3 Unsustainable Harvest (Overfishing)

(A) Exposure Pathway
According to the United Nations Food and Agriculture Organization, more than 70% of the worldwide marine fish stocks are either fully exploited or depleted. In the North Atlantic, the American Fisheries Society has identified 82 species at risk of extinction including Atlantic salmon, Atlantic halibut, and a number of species of sharks, skates, sturgeons, and groupers. Fishing can change the abundance of exploited species and degrade marine habitat (e.g., trawling) (Collie et al. 1997).

Point and non-point source runoff from agricultural and developed coastal areas can negatively impact estuarine and subtidal areas that support food webs in coastal and offshore waters. Climate change will likely warm sea surface temperatures and oceanic circulation, leading to changes in nutrient cycling and marine productivity (Tyrell 2005). Many other activities threaten coastal marine habitat in the Gulf of Maine (for a review, see Tyrell (2005)).

(B) Evidence
Changes in prey availability affect the growth and survival of chicks and the condition of adults (Safina et al. 1988, Nisbet et al. 1995). Prey availability may also impact the size and distribution of colony sites (Nisbet 1999). However, the correlation of reduced prey availability and common and roseate tern productivity has not been firmly established. Other seabirds, including terns, have shown very significant impacts from changes in prey availability. In Britain, breeding failure and diminished adult survival in Arctic terns was linked to changes in fish prey availability due to commercial fisheries activities (Suddaby and Ratcliffe 1997 in Kress and Hall 2004).

In 2004, disappearance of sand eels devastated Scottish seabird colonies; 1,200 guillemot nests on the isle of Shetland failed completely, 24,000 Arctic tern nests were almost entirely empty, and the world's largest colony of great skuas produced only a few chicks. Scientists believe that the sand eels are disappearing because the cold-water plankton that these fish depend on no longer flourishes in these coastal areas. The North Sea has warmed 3.6°F over the last 20 years, shifting the phytoplankton blooms northward or earlier in the season (Schulman 2005). Global warming is widely believed to be responsible for the relatively rapid rise in worldwide ocean temperatures.

3.1.4 Disease (Avian Cholera, Avian Botulism, Salmonella)

(A) Exposure Pathway
Avian cholera is an increasing threat to seabirds (USFWS 1998) and its spread is linked to the poultry industry. It is a highly infectious, lethal disease caused by the bacterium *Pasteurella multocida* (Kress and Hall 2004). The bacterium can persist in carcasses for up to 3 months and in freshwater sources for upwards of 3 weeks. Another bacterial disease, avian botulism, is transmitted through sewage discharge or buildup of organic matter. It infects scavengers (e.g., gulls) and accumulates in dead birds (Kress and Hall 2004). The source and transmission of salmonella in birds is not well understood.

(B) Evidence
In 1988, 37 common terns were found dead on Eastern Egg Rock from avian cholera. This resulted in complete abandonment of the colony with only 37% recolonizing later in the season (Kress 1997). In 1991, large numbers of terns and laughing gulls died from avian botulism on Eastern Egg Rock after a massive menhaden die-off in Muscongus Bay. Avian cholera has killed terns, gulls, and eiders on islands in

Maine. In 2004, close to 2000 common tern chicks were found dead on the nests at Monomoy Island, Massachusetts, with no evidence of external trauma. Test results identified salmonella as the cause of death, but there is no conclusive evidence for the source or transmission of this bacterium.

3.2 Sources of Information

Information on threats to common terns was taken from the literature, the USFWS Tern Management Plan, from the list of threats developed as part of regional bird conservation planning (BCRs 14 and 30), and from Seavey Island management experience. Threats developed for Coastal Islands were also used, with some modification, in the development of the threats and threat rankings for the roseate tern.

3.3 Extent and Quality of Data

Threats to common terns and their breeding habitat are well documented in management and conservation plans. The threat posed by reduced prey availability still needs research and monitoring to determine the correlation with tern productivity. Direct threats to foraging and staging areas are unclear until these areas have been identified.

3.4 Threat Assessment Research

- Assess the effects of tern predators and evaluate means of controlling those species in different critical habitats and at different times of the year
- Determine laughing gull impacts on common and roseate tern nesting success
- Assess and monitor of the effects of aquaculture, fishing practices, and other stressors on terns, tern predators, and habitats
- Identify and protect (if feasible) critical habitats such as foraging, staging, and wintering areas
- Identify seasonal and spatial variation in prey (composition and abundance) and potential effects on colony productivity

Element 4: Conservation Actions

4.1.1 Manage and monitor the Seavey Island colony, Restoration and Management

(A) Direct Threats Affected: Predation, Human disturbance, Oil spill, Avian cholera (disease)

(B) Justification
Tern restoration projects in Maine and Massachusetts in the last 25 years have documented that the productivity and stability of these tern colonies depends on continued management. Currently, all productive tern colonies in the Northeast are being actively managed (USFWS 1998, Kress and Hall 2004). Since 1997, management of the Seavey Island colony has allowed for the successful recolonization of terns to the Isles of Shoals after a more than 50-year absence. Resident biologists act as stewards for the Seavey tern colony and can enforce the closure of this island during the breeding season, as well as providing annual population and productivity estimates. Active management occurs annually during the breeding season from 21 April to 31 August. Active management through the breeding season allows for an immediate response or change in response to all the threats identified above (predation, human disturbance, disease and oil spill).

(C) Conservation Performance Objective
The objective of continued intensive management at Seavey Island is to increase and secure both the common and roseate tern populations. Although there are no established recovery criteria for common terns in the northeast region, a productivity rate in the range of 1.1–1.8 chicks per nest is considered adequate to sustain population growth. The primary objective of the Northeast region roseate tern recovery program is to promote an increase in breeding population size, distribution, and productivity to warrant reclassification to threatened status and eventual delisting. The criteria for recovery include a minimum of 6 large colonies ($\geq$ 200 pairs) with high productivity (at least 1.0 fledged young/nest) for 5 consecutive years. Successful management and monitoring at Seavey Island would maintain productivity of the common tern colony and expand the roseate population to the level cited above and maintain this level for at least 5 years.

(D) Performance Monitoring
The productivity of the Seavey Island common and roseate terns will be monitored annually using established methods outlined in the Roseate Tern Recovery Plan, The Tern Management Handbook and through the regional roseate tern metapopulation study (Nisbet 1990). An all island census will also be conducted annually during the census window of June 12 to 20 as established by the regional tern working group (GOMSWG). Downward trends in either colony census numbers or productivity estimates need to be addressed immediately.

(E) Ecological Response Objective
The desired ecological response to continued monitoring and management is to increase the likelihood that common and roseate terns will successfully breed, reach target levels of productivity, and increase in population numbers on Seavey Island. Successful management will be indicated by a positive growth rate in common terns and the achievement of roseate tern recovery objectives (USFWS Roseate Recovery Plan).

(F) Response Monitoring
Annual census numbers and productivity estimates will indicate the health and success of the Seavey Island colony. Trend analysis will allow managers to adjust the level of intensity and type of management.

(G) Implementation
Implementation will require the cooperation of the two major partners in the Tern Restoration Project (NHFG and NHA) as well as other cooperators and supporters including the USFWS, DRED, USDA – Wildlife Services, NHCP, Shoals Marine Lab, Roseate Tern Recovery Team (RTRT) and GOMSWG. Collaboration will occur with state and federal partners working with terns in other northeastern states including Maine, Massachusetts, Connecticut and New York, as well as with international partners in Canada. Important guidance for establishing monitoring protocols will be provided by the New Hampshire Tern Management Team along with the methodologies outlined by the Roseate Tern Recovery Plan and the Tern Management Handbook.

(H) Feasibility
Management and monitoring has been occurring at Seavey Island since 1997. The expertise to carry out this project currently exists in New Hampshire. Guidance and collaboration will come from regional tern biologists participating in GOMSWG and members of the RTRT. Securing long term funding will be critical to continued monitoring at this site.

4.1.2 Develop predator management plan, Restoration and Management

(See also: section 3.1.1 and 4.1.1 for predator management on Seavey Island and other island and mainland locations)

(A) Direct Threats Affected: Predation

(B) Justification
Research shows that tern management must continually adapt to changing predator threats. More effective control of municipal and fishing wastes is helping to control gull populations. The New Hampshire seacoast still has a large open landfill located in Rochester, about 46 kilometers from the Isles of Shoals. This landfill supports large numbers of gulls during the winter. The Isles of Shoals remains an active fishing area, and there is evidence that discarded lobster bait and other fishing wastes subsidizes local gull populations (Goodale 2000).

A proactive management plan should exist to better respond to predation from a suite of predators including gulls, great horned owl, black-crowned night heron, and mammalian predators such as mink, raccoons, and rats. Minimizing predator impacts will help achieve long-term growth objectives and reduce the possibility of movement of breeding adults to alternate sites. Incidence of predation and predator concentrations would need to be evaluated periodically (minimum twice per year) to assess management success. If foraging and staging areas are identified, predator management may need to be expanded beyond the breeding season.

(C) Conservation Performance Objective
The objective of continued and more effective management of predator concentrations is to increase and secure common and roseate tern populations, while minimizing mortality and movement.

(D) Performance Monitoring
Methods to evaluate trends in predator populations/

concentrations would need to be established. Obvious sources such as the Rochester landfill could be surveyed on a regular basis to identify changes in predator usage. Fishing regulations, specifically the discarding of fishing wastes, could be assessed in terms of their contribution to predator (gull) populations. Downward trends in either colony census numbers or productivity estimates need to be addressed immediately. See section 3.1.1 for management specific to Seavey Island.

(E) Ecological Response Objective
The desired ecological response to predator management is to increase the likelihood that common and roseate terns will successfully breed, reach target levels of productivity, and increase in population numbers. Successful management will be indicated by a positive growth rate and the achievement of recovery objectives (USFWS Roseate Recovery Plan).

(F) Response Monitoring
Annual census numbers and productivity estimates will indicate the health and success of colonies. Trend analysis will allow managers to adjust the level of intensity and type of management.

(G) Implementation
Implementation will require the cooperation of the two major partners in the Tern Restoration Project (NHFG and NHA) as well as other cooperators and supporters including the USFWS, DRED, USDA – Wildlife Services, NHCP, Shoals Marine Lab, Roseate Tern Recovery Team (RTRT) and GOMSWG. Collaboration will occur with state and federal partners working with terns in other northeastern states including Maine, Massachusetts, Connecticut and New York, as well as with international partners in Canada. Important guidance for establishing monitoring protocols will be provided by the New Hampshire Tern Management Team along with the methodologies outlined by the Roseate Tern Recovery Plan and the Tern Management Handbook.

(H) Feasibility
The expertise to carry out this project currently exists in New Hampshire. Further guidance will come from regional tern biologists. The cooperation of landowners or managers at sites that are identified as predator concentrations is unknown. Wildlife Services has many years of working in collaboration with some of these land managers so their involvement and expertise is critical. The long term funding of mainland predator management will need to be assessed and potential funding sources identified.

4.1.3 Identify and protect important staging and foraging areas for common and roseate terns, Habitat Protection

(A) Direct Threats Affected: Predation, Habitat Loss, Recreation and Tourism, Contamination

(B) Justification
Little is known of common and roseate tern foraging and staging habitat utilized by Seavey Island birds. The identification and protection of these habitats is critical to the long-term stability of this colony (USFWS 1998, Kress and Hall 2004). The distribution of suitable feeding locations and the availability of prey fish at these locations may influence colony size, distribution, and breeding success (Nisbet and Spendelow 1999). Research shows that common and roseate terns from several sites concentrate and stage at a limited number of locations. This concentration makes large numbers of the entire Gulf of Maine tern population vulnerable during these staging periods. Protection of staging areas should be timely and permanent on a year round basis, with increased protection during identified windows of high use.

(C) Conservation Performance Objective
The objective of identifying and protecting tern foraging and staging areas is to maintain breeding colonies and minimize mortality.

(D) Performance Monitoring
The productivity of the Seavey Island common and roseate terns will be monitored annually using established methods outlined in the Roseate Tern Recovery Plan, The Tern Management Handbook and through the regional roseate tern metapopulation study (Nisbet 1990). An all island census will also be conducted annually during the census window of June 12-20 as established by the regional tern working group (GOMSWG). Downward trends in either colony census numbers or productivity estimates need to be addressed immediately.

(E) Ecological Response
The desired ecological response to protection of foraging and staging areas is to increase the likelihood that common and roseate terns will successfully breed, reach target levels of productivity, and increase in population numbers on Seavey Island. Successful management will be indicated by a positive growth rate and the achievement of recovery objectives (USFWS Roseate Recovery Plan).

(F) Response Monitoring
Annual census numbers and productivity estimates will indicate the health and success of the Seavey Island colony. Trend analysis will allow managers to adjust the level of intensity and type of management.

(G) Implementation
Implementation will require the cooperation of the two major partners in the Tern Restoration Project (NHFG and NHA) as well as other cooperators and supporters including the USFWS, DRED, USDA – Wildlife Services, NHCP, Shoals Marine Lab, Roseate Tern Recovery Team (RTRT) and GOMSWG.. Important guidance will be provided by the NH Tern Management Team along with the methodologies outlined by the Roseate Tern Recovery Plan and the Tern Management Handbook.

Coordination with land protection specialists from local, state and federal agencies to maximize the potential for successful protection of identified foraging and staging areas. The protection of these habitats may require the innovative protection strategies such as those outlined in the GOMC Marine Protected Areas Project. Federal and state partners from the NHCP, the Coastal Islands Wildlife Refuge, the Great Bay Refuge, and the Great Bay National Estuarine Research Reserve would be important partners. It is likely that areas will be identified across state boundaries and necessitates coordination with Maine and/or Massachusetts partners.

(H) Feasibility
The expertise to carry out this project currently exists in NH with guidance from regional tern biologists. Securing immediate and long term funding will be critical to the identification and protection of foraging and staging areas. Protection of these habitats will take cooperation and coordination of federal, state and local officials.

4.1.4 Develop regional partnerships, Restoration and Management

(B) Justification:
The Tern Restoration Project will benefit from collaboration with other organizations that are focused on resource conservation and management in the Gulf of Maine. NHCP provides the leadership in coordinating local communities, state and federal agencies in the planning and policy issues needed to balance the preservation of New Hampshire's natural resources with the social and economic needs of the coastal region. The Gulf of Maine Council brings together partners from Massachusetts, New Hampshire, Maine, and the Canadian provinces of New Brunswick and Nova Scotia (www.gulfofmaine.org). The Gulf of Maine Habitat Conservation Subcommittee is working with partners in the region to develop and advance marine habitat conservation strategies.

4.1.5 Monitor prey availability during the tern nesting season, Habitat Protection

(A) Direct Threats: Reduced Prey Availability, Contamination

(B) Justification
Further research is needed to assess the role of commercial fisheries on prey availability for seabird colonies. In addition, it is important to support research and policies that help to reduce negative impacts on nursery areas for prey items such as herring, hake and other fish stocks that are important food for seabirds. Some of te partners outlined in section 4.1.1 (G) could coordinate with the NHFG Department Marine Resources Division and the Shoals Marine Laboratory to monitor prey availability. An established monitoring program coupled with the chick provisioning studies taking place on Seavey Island would allow seabird biologists and fisheries managers to collaborate on actions that could benefit seabird restoration.

4.1.6 Education and Outreach

(A) Direct Threats Addressed: All

(B) Justification
The Tern Restoration Project has provided an excel-

lent opportunity for educational outreach. The focus of this outreach has been to foster stewardship, appreciation, and protection for the seabird colony on Seavey Island as well as other Gulf of Maine seabird nesting islands. Opportunities have come through welcoming visitors and other organized classes to the island, sharing the details of the project with charter and ferry boats that visit the Isles of Shoals, and taking the project out to many groups around New Hampshire through a slide presentation and display. It is important that we continue to strengthen and expand outreach efforts on seabird conservation. The development of classroom curriculum and teacher resources will capture an important audience. A tern restoration web page will foster stewardship, increased understanding and appreciation for seabird conservation issues. A web page addition would reach a large, broad audience and expand educational opportunities manifold. These efforts lay the groundwork for increased awareness and understanding of coastal issues that impact seabird islands, and promote stewardship for coastal resources.

(G) Implementation
Improve public outreach and education on seabird restoration issues in New Hampshire and the Gulf of Maine through the following mediums:

- Further develop and implement outreach and education to Isles of Shoals users including the Shoals Marine Lab, Star Island, Seacoast Science Center, and island visitors
- Further develop and implement an outreach program and educational materials for passengers aboard charter vessels in and around the Isles of Shoals including the Uncle Oscar, ISSCO ferry and the Granite State
- Develop a tern restoration presentation and curriculum to be included in the coastal ecology unit presented to middle and high school students aboard the Granite State
- Further develop and implement a teacher workshop that highlights the tern restoration project and seabird conservation issues
- Develop a seabird conservation curriculum that can be used in classroom presentations. Use roseate terns as an example of a successful restoration model
- Create a Tern Restoration/Seabird Conservation Page with live streaming tern video from Seavey Island on the NHA/NHFG Web pages

4.2 Conservation Action Research

- Monitor and manage predator populations on islands and the mainland
- Identify and protect foraging and staging areas
- Assess prey availability and its effect on breeding success and colony dynamics

Element 5: References

5.1 Literature

Borror, A.C., and D.W. Holmes. 1990. Breeding Birds of the Isles of Shoals. Shoals Marine Laboratory, New York. 76pp.

Brody, S.D. 1998. Evaluating the role of site selection criteria for Marine Protected Areas in the Gulf of Maine. Gulf of Maine Council on the Marine Environment.

Burger, J., and M. Gochfeld. 1988. Nest site selection: comparison of Roseate and Common Terns in a Long Island, New York colony. Bird Behavior 7: 59-66.

Chardine, J.W. 1990. Newfoundland: Crossroads for Marine Birds and Shipping in the North Atlantic. Proceedings: The Effects of Oil on Wildlife. Newfoundland.

Clement, J., and M. Janowicz (Editors). 2003. Aquaculture Physical Remediation: Workshop Proceedings. Gulf of Maine Council on the Marine Environment, www.gulfofmaine.org

Collie, J.S., G.A. Escanero, and P.C. Valentine. 1997. Effects of bottom fishing on the benthic megafauna of Georges Bank. Marine Ecology Progress Series 155: 159-172.

Donehower, C. 2003. Predation rate and predatory behavior of large gulls on Eastern Egg Rock. Unpublished Report. National Audubon Society.

Drury, W.H. 1973. Population changes in New England seabirds. Bird-Banding 44: 267-313.

Duffy, D.C. 1986. Foraging at patches: interactions between common and roseate terns. Ornis Scand. 17: 47-52.

Foss, C. Editor. 1994. Atlas of the Breeding Birds in New Hampshire. New Hampshire Audubon, Dover, New Hampshire, USA.

Gochfeld, M., J. Burger and I.C.T. Nisbet. 1998. Roseate Tern (*Sterna dougallii*). *In*: The Birds of North America. No. 370, A. Poole and F. Gill, editors. The Birds of North America Inc., Philadelphia, Pennsylvania, USA.

Goodale, W. 2000. The importance of lobster bait in Penobscot Bay gull diet. Unpublished Report. College of the Atlantic.

Gulf of Maine Council on the Marine Environment. 2002. Action Plan 2001-2006. Gulf of Maine Council on the Marine Environment.

Gulf of Maine Council Habitat Restoration Subcommittee. 2004. The Gulf of Maine Habitat Restoration Strategy. Gulf of Maine Council on the Marine Environment.

Hays, H., P. Lima, L. Monteiro, J. DiCostanzo, G. Cormons, I.C.T. Nisbet, J.E. Saliva, J.A. Spendelow, J. Burger, J. Pierce, and M. Gochfeld. 1999. A nonbreeding concentration of Roseate and Common Terns in Bahia, Brazil. Journal of Field Ornithology 70:455-464.

Kress, S.W. 1983. The use of decoys, sound recordings, and gull control for re-establishing a tern colony in Maine. Colonial Waterbirds 6:185-196.

Kress, S.W. and C.S. Hall. 2004. Tern Management Handbook – Coastal Northeastern United States and Atlantic Canada. U.S. Department of Interior, Fish and Wildlife Service, Hadley, Massachusetts, USA.

New Hampshire Office of State Planning Coastal Program. 1996. A vision for the New Hampshire coast. National Oceanic and Atmospheric Administration. 61pp.

Nisbet, I.C.T., and J.A. Spendelow. 1999. Contribution of research to management and recovery of the Roseate Tern: Review of a twelve –year project. Waterbirds 22:239-252.

Nisbet, I.C.T. 2000. Disturbance, habituation and management of Waterbird colonies. Waterbirds 23:

Nisbet, I.C.T. 2002. Common Tern (*Sterna hirundo*). In The Birds of North America, No. 618, A. Poole and F.Gill, editors. The Birds of North America, Inc., Pennsylvania, USA.

Pierce, V. 1991. Pathology of Wildlife following a #2 Fuel Oil Spill. The Effects of Oil on Wildlife: Research, Rehabilitation, and General Concerns. IBRRC, TSBR, IWR.

Safina, C., R.H. Wagner, D.A. Witting, and K.J. Smith. 1990. Prey delivered to Roseate and Common Tern chicks; composition and temporal variability. Journal of Field Ornithology 61: 331-338.

Shealer, D.A., and J. Burger. 1993. Effects of interference competition on the foraging activity of tropical Roseate Terns. The Condor 95: 322-329.

Shealer, D.A., and J. Burger. 1995. Comparative foraging success between adult and one-year-old Roseate and Sandwich Terns. Colonial Waterbirds 18: 93-99.

Shealer, D.A., and S.W. Kress. 1994. Postbreeding movements and prey selection of roseate terns at Stratton Island, Maine. Journal of Field Ornithology 65: 349-362

Spendelow, J.A. 1982. An analysis of the temporal variation, and the effects of habitat modification on, the reproductive success of Roseate Terns. Colonial Waterbirds 5:19-31.

Spendelow, J.A., J.D. Nichols, I.C.T. Nisbet, H. Hays, G.D. Cormons, J.Burger, C. Safina, J.E. Hines, and M. Gochfeld. 1995. Estimating annual survival and movement rates of adults within a metapopulation of Roseate Terns. Ecology 76: 2415-2428.

Tripp, B., M. Ernst, and D. Keeley (Editors) 2004. Establishing research priorities in the Gulf of Maine. Final Report. GOMC-RARGOM Theme Meeting.

Tyrell, M.C. 2005. Gulf of Maine Habitat Primer. Gulf of Maine Council on the Marine Environment, www.gulfofmaine.org. vi+54 pages

USFWS. 1989. Recovery Plan for Roseate Tern (*Sterna dougallii*). Northeast Population. Newton Corner, Massachusetts, USA.

USFWS. 1998. Roseate Tern Recovery Plan – Northeastern Population, First Update. Hadley, MA. 97pp.

5.2 Data Sources

New Hampshire Bird Records

New Hampshire Audubon and New Hampshire Fish and Game Department 1997 – 2004 Seavey Island Summary Reports.

Hunt, P. 2004. A regional perspective on New Hampshire's Birds of Conservation Priority: Objectives, threats, research needs, and conservation strategies. Unpublished report.

Roseate Tern Recovery Team Minutes 2000-2004
Gulf of Maine Seabird Working Group Minutes 1997 – 2004.

Element 6: List of Figures

Figure 1. Common tern productivity, 1997-2004
Figure 2. Nesting pairs of herring and great black-backed gulls at the Isles of Shoals 1920-1995 (Numbers compiled from Drury 1973, Borror 1990, USFWS Colonial Waterbird Survey 1995).
Figure 3. Seavey Island common tern population numbers 1997 - 2004

Year	Nests monitored	Mean clutch size	Mean hatch	Fledglings/nest
1997	6	1	1	1
1998	45	2.56	2.02	1.6
1999	25	2.84	2.48	2.24
2000	43	2.6	2.33	1.58
2001	73	2.44	2.18	1.68
2002	184	2.52	2.09	1.63
2003	163	1.96	1.61	1.33
2004	138	1.84	1.67	0.75

Table 1. Common tern census numbers at Seavey Island 1997-2004.

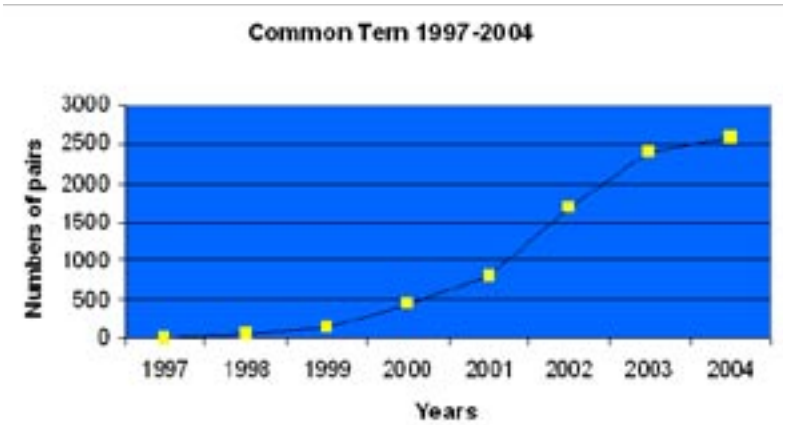


Figure 2. Nesting pairs of herring and great black-backed gulls at the Isles of Shoals 1920-1995 (Numbers compiled from Drury 1973, Borror 1990, USFWS Colonial Waterbird Survey 1995).

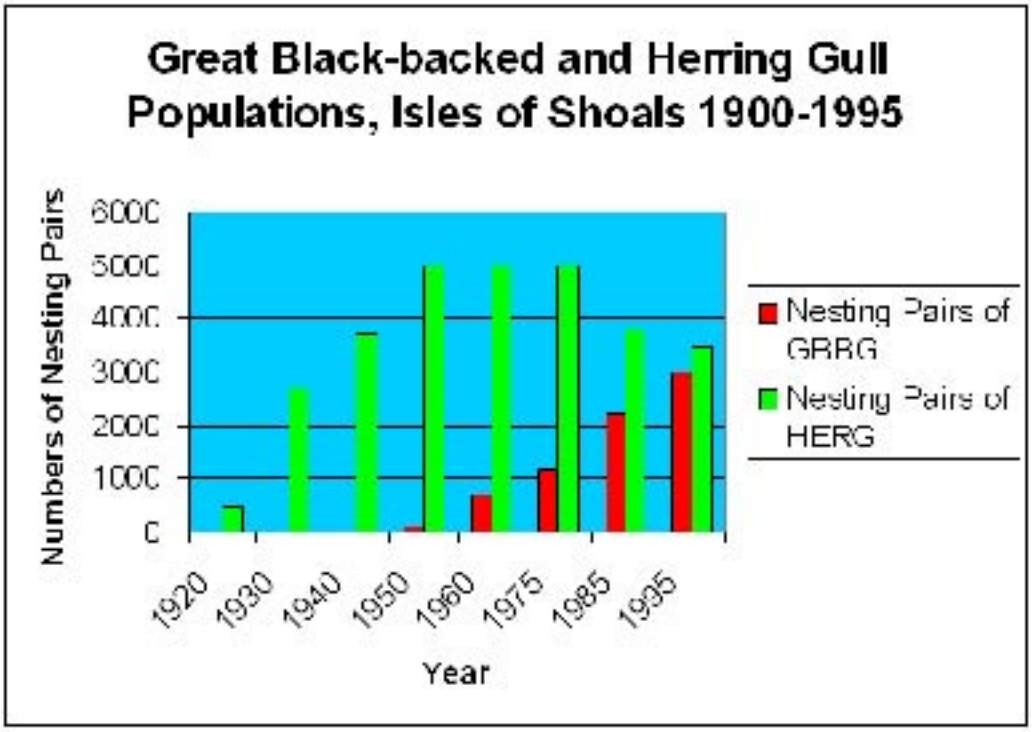


Figure 3. Seavey Island common tern population numbers 1997 - 2004

SPECIES PROFILE

Cooper's Hawk

Accipiter cooperii

Federal Listing: Not listed
State Listing: Threatened
Global Rank: G5
State Rank: S2B
Authors: M. Yamasaki and C. A. Costello, USDA Forest Service

Element 1: Distribution and Habitat

1.1 Habitat Description

Cooper's hawk breeds in various forest types (e.g., coniferous, deciduous, and mixed woods) ranging from extensive forests to woodlots of 4 to 8 ha (Rosenfield and Bielefeldt 1993). Recently, this raptor has been found nesting successfully in suburban areas and city parks in Pennsylvania, Wisconsin, and New York City (Bielefeldt et al. 1998, McConnell 2003) as well as urban areas in Arizona (Boal and Mannan 1998). Thus, Cooper's hawk may be tolerant of human disturbance and habitat fragmentation. Cooper's hawk nests in crotches, limb axils, and limb forks high off the ground in large hardwood and conifer tree species, often under a dense canopy (Titus and Mosher 1981, Bosakowski et al. 1992a, Rosenfield and Bielefeldt 1993, Trexel et al. 1999, McConnell 2003).

Although little research has been done on Cooper's hawk foraging habitat, breeding-season diet studies indicate that Cooper's hawk preys on small mammals such as squirrels and chipmunks as well as on birds (Bielefeldt et al. 1992, Bosakowski et al. 1992b, Estes and Mannan 2003). Open country birds such as starlings and grackles are also reported in diet studies (Bosakowski et al. 1992b) suggesting that Cooper's hawk forages in edge and open habitat as well as forested habitat. Cooper's hawk winter habitat is believed to be similar to breeding habitat (DeGraaf and Yamasaki 2001), though better quantitative data are needed. This raptor is frequently recorded in small numbers at winter bird feeding stations in New Hampshire (NHA website, undated).

1.2 Justification

Cooper's hawk is threatened in New Hampshire, though listing in several northeastern states may be a conservative response to limited data (Mosher 1989). Though data on historic abundance are equivocal, some posit large population declines of Cooper's hawk between the 1940s and 1970s due to DDT poisoning (Snyder et al. 1973). By these accounts, Cooper's hawk populations have partially recovered in some areas since the United States ban of DDT in 1972, but may remain below pre-DDT era levels throughout much of the east (Robbins et al. 1986). Variations in recovery may be due to DDT poisoning of neotropical migratory birds, a major component of the Cooper's hawk prey base (NatureServe 2005).

Cooper's hawk is also threatened in New Hampshire by habitat loss and parceling of forestland (Frieswyk and Widmann 2000), though recent work on nesting Cooper's hawk has noted successful breeding in smaller-sized pine plantations in Wisconsin (Rosenfield et al. 2000) and in urban/suburban areas in Arizona (Boal and Mannan 1998) and Pennsylvania (McConnell 2003).

1.3 Protection and Regulatory Status

Cooper's hawk is protected under the Migratory Bird Treaty Act of 1918.

1.4 Population and Habitat Distribution

Cooper's hawk was common in New Hampshire in the 1800s and 1900s (Elkins in Foss 1994). Pesticide poisoning probably contributed to a population decline throughout the eastern United States. Though

first detected during migration counts in the 1960s, it probably began before 1950 (Bednarz et al. 1990). The Atlas of Breeding Birds in New Hampshire reports only 2 successful nests and 4 locations of territorial pairs from 1980 to1987 (Elkins in Foss 1994). There are insufficient data on Cooper's hawk to accurately estimate its abundance and distribution in New Hampshire.

The latest Breeding Bird Survey (BBS) summary reports a non-significant positive trend (1.2 percent) for Cooper's hawk in New Hampshire from 1966 to 2003 (Sauer 2004). However, BBS data need to be interpreted with caution, as roadside surveys may fail to encounter some elusive raptor species. Cooper's hawk migration counts at Hawk Mountain in Pennsylvania generally show an increasing trend beginning in 1963 (Mosher 1989, Bednarz et al. 1990).

1.5 Town Distribution Map

There are insufficient data available to map current Cooper's hawk distribution in New Hampshire.

1.6 Habitat Map

There are insufficient data available to map Cooper's hawk habitat in New Hampshire, although suitable habitat may be available in forested stands and suburban/urban wooded areas throughout the state.

1.7 Sources of Information

Information on Cooper's hawk habitat, population distribution, and status was compiled from scientific literature and limited agency and non-government organization information.

1.8 Extent and Quality of Data

There are no systematic sampling efforts to assess Cooper's hawk demographics in New Hampshire.

1.9 Distribution Research

- Collect information on the demographics of Cooper's hawk throughout the state during the breeding season in extensive forested habitat, suburban, and urban areas
- Develop a regionally viable broadcast survey to monitor areas for occupancy, detect changes in distribution and abundance, and determine nest locations. Broadcast surveys are time consuming and labor intensive and should be designed to be economical.
- Solicit information from the public on current and historic Cooper's hawk nest sites in the state. Potential sources include New Hampshire Bird list serve subscribers and spring turkey hunters.
- Develop a survey (or consult New Hampshire Bird list serve subscribers, Christmas Bird counts, and NHA feeder watch surveys) to determine Cooper's hawk winter demographics

Element 2: Species/Habitat Condition

2.1 Scale

Cooper's hawk occurs across the state. Potential conservation planning units at the section (M212A, M212B, and 221A) or subsection level appear to be most appropriate (Avers et al. (1994).

2.2 Relative Health of Populations

There are no data available to describe the relative abundance of Cooper's hawk in New Hampshire.

2.3 Population Management Status

There are no population management efforts for Cooper's hawk in New Hampshire.

2.4 Relative Quality of Habitat Patches

There are no data available for meaningful analysis.

2.5 Habitat Patch Protection Status

Cooper's hawk nesting areas on the WMNF and other conservation lands in New Hampshire will retain their nesting potential. Nesting potential on non-conservation lands and in urban/suburban areas will depend on whether these lands remain forested.

2.6 Habitat Management Status

There are no habitat management or restoration efforts for Cooper's hawk in New Hampshire.

2.7 Sources of Information

There are no statewide or regional data upon which to assess the condition of Cooper's hawk.

2.8 Extent and Quality of Data

There are no data available with which to make this assessment.

2.9 Condition Ranking

There are no data in New Hampshire with which to attempt condition ranking.

2.10 Condition Assessment Research

- Characterize breeding and foraging habitat at landscape, stand, and within-stand scales
- Determine how changes in forest structure and landscape patterns affect Cooper's hawk reproductive success, survival rates, territory fidelity, juvenile dispersal, and breeding dispersal
- Determine important prey species of Cooper's hawk and their response to fluctuations in prey availability across differently managed landscapes
- Continue long-term migration counts in order to detect changes in regional abundance patterns
- Characterize Cooper's hawk winter habitat

Element 3: Species and Habitat Threat Assessment

3.1.1 Development (Habitat Loss and Conversion)

(A) Exposure Pathway
Land conversion—such as commercial and residential development—can compromise Cooper's hawk by reducing the number and distribution of available nest sites, foraging habitat, and important prey species. Outside of New Hampshire, Cooper's hawk successfully breeds in small isolated woodlots and in urban areas. Raptors nesting in these types of landscapes are exposed to additional environmental threats such as electrocutions, poisonings, exotic diseases, and collisions with windows and vehicles (Boal and Mannan 1999). Development can also increase populations of Cooper's hawk predators such as raccoons and great horned owls.

(B) Evidence
Forestland in New Hampshire has been declining at an annual rate of 2.7% since 1983 (Frieswyk and Widmann 2000). Development and changing ownership divide forest into smaller parcels and can introduce new sources of injury and mortality (e.g., collisions with windows and vehicles, electrocutions, poisonings, exotic diseases, and subsidized predators).

3.1.2 Non-Point Source Pollution (Chemical Contaminants)

(A) Exposure pathway
The use of chlorinated hydrocarbons such as DDT has been correlated with eggshell thinning in raptors, which leads to lowered reproductive success. Several studies implicate DDT and DDE as the contaminant that once threatened Cooper's hawk (Snyder et al. 1973, Pattee et al. 1985). Acutely toxic organophosphate pesticides may pose a more severe threat in urban areas and agricultural areas (Boal and Mannan 1999, Henny et al. 1985), but there have been minimal efforts to monitor poisonings in dead raptors (NatureServe 2005).

(B) Evidence
The use of DDT is linked to the decline of the Cooper's hawk between the 1940s and the 1970s. Although DDT has been banned in the U.S. since 1972, it is still used on the wintering grounds of many prey species of Cooper's hawk (NatureServe 2005). Effects of this are still unclear. Limited mortality monitoring occurs for most raptor species, so there is much speculation and little evidence of pesticide and contaminant threat.

3.1.3. Disease

(A) Exposure pathway
West Nile Virus (WNV) is carried in birds and is spread through the bite of infected mosquitoes, often causing encephalitis and/or meningitis. It was first detected in the United States in 1999 and is now

found in all of the lower 48 states. Corvids and, more recently, raptors appear to be particularly susceptible to the disease (Gancz et al. 2002).

(B) Evidence
The Raptor Center at the University of Minnesota positively demonstrated WNV in a sample of *Buteo jamaicensis* and Cooper's hawk (Wünschmann et al. 2004). The Raptor Center had admitted 71 raptors with the virus in 2002, of which 60 succumbed to WNV. *Bubo virginianus, B. jamaicensis*, and Cooper's hawk, have been hardest hit in Minnesota. The New Hampshire Department of Health and Human Services has limited their collection of dead birds for WNV testing to crows and blue jays, so it is difficult to determine whether raptors in New Hampshire have yet been exposed to WNV.

3.2 Sources of Information

Information on threats to Cooper's hawk came mainly from a review of research conducted outside of the northeastern United States.

3.3 Extent and Quality of Data

Most data on threats to *Cooper's hawk* come from areas outside of the northeastern United States and may not apply to the New Hampshire population Little is known of *Cooper's hawk* tolerance to habitat fragmentation, human disturbance, various forest management practices, or pesticide use in the United States and Central America.

3.4 Threat Assessment Research

- Compare productivity between Cooper's hawk populations in suburban/urban areas and within extensive forested areas
- Measure impacts of human disturbance (e.g., recreation, logging, urban/suburban obstacles [windows, powerlines, vehicles]) on Cooper's hawk productivity
- Identify effects of various forest management practices on reproductive success, nest site fidelity, and prey availability
- Determine if DDT and contaminants are still harming Cooper's hawk productivity
- Determine what effects West Nile Virus may be having on Cooper's hawk populations in New Hampshire.

Element 4: Conservation Actions

Habitat use, abundance, and distribution data necessary for Cooper's hawk conservation do not exist.

4.1.1 Developing occurrence, habitat and distribution data, Restoration and Management.

(A) Habitat Loss

(B) Justification
Statewide surveys will provide distribution and habitat data upon which population analyses can be conducted. Investigations that increase knowledge of Cooper's hawk demographics and habitat allow for better management.

(C) Conservation Performance Objective
Census surveys will test hypotheses of habitat conversion effects and will better determine the status of this state threatened species. Successful survey protocols will help correctly identify Cooper's hawk habitat and will offer the opportunity to sample live birds for contaminants and WNV exposure.

(D) Performance Monitoring
There is no statewide or regional monitoring of Cooper's hawk.

(E) Ecological Response Objective
There are no data available with which to formulate an ecological response objective.

(F) Response Monitoring
There is no monitoring of Cooper's hawk. Before conservation can occur, surveys of potential habitat must be conducted.

(G) Implementation
There are opportunities to partner with USDA Forest Service, UNH, United States Department of the Interior Fish and Wildlife Service, industrial forestry concerns, New Hampshire Division of Forest and Lands, NHNHB, local land trusts, and NHA to test any systematic survey protocol state-wide, and to further extend population and habitat research being

conducted by USDA Forest Service, Northeastern Research Station state-wide.

(H) Feasibility
Much cooperation and coordination would be required to accomplish a more systematic approach statewide, but it could be accomplished with adequate funding and commitment of personnel and resources.

4.2 Conservation Action Research

Continue monitoring forest raptor populations and habitat in the White Mountains region. Expanding these efforts state-wide would allow the direct testing of the habitat conversion/alteration hypothesis, as well as provide the opportunity to survey for WNV in live raptor populations. Such surveys and habitat assessments are needed to better describe the status of Cooper's hawk and its critical habitats and threats.

Element 5: References

5.1 Literature

Bednarz, J.C., Klem, D. Goodrich, L.J. and S.E. Senner. 1990. Migration counts of raptors at Hawk Mountain, Pennsylvania, as indicators of population trends, 1934-1986. Auk 107:96-109.

Bielefeldt, J., R.N. Rosenfield, J.M. Papp. 1992. Unfounded assumptions about the diet of the Cooper's hawk. Condor 94:427-436.

Bielefeldt, J., R.N. Rosenfield, W.E. Stout, and S.M. Vos. 1998. The Cooper's hawk in Wisconsin: A review of its breeding biology and status. Passenger Pigeon 60:111-121.

Boal, C.W., and R.W. Mannan. 1998. Nest site selection by Cooper's Hawks in an urban landscape. Journal of Wildlife Management 62:864-871.

Boal, C.W., and R.W. Mannan. 1999. Comparative breeding ecology of Cooper's hawks in urban and exurban areas of southeastern Arizona. Journal of Wildlife Management 63(1): 77-83.

Bosakowski, T., D.G. Smith, and R. Speiser. 1992a. Nest sites and habitat selected by Cooper's hawks, *Accipiter cooperii*, in northern New Jersey and southeastern New York. Canadian Field-Naturalist 106: 474-479.

Bosakowski, T.D., D.G. Smith, and R. Speiser. 1992b. Niche overlap of two sympatric-nesting hawks in the New Jersey-New York highlands. Ecography 15: 358-372.

DeGraaf, R.M., and M. Yamasaki. 2001. New England wildlife: habitat, natural history, and distribution. University Press of New England, Hanover, New Hampshire, USA. 482 pp.

Elkins, K.C. 1994. Pages 48-49 *in* C.R. Foss (editor). Atlas of breeding birds in New Hampshire. New Hampshire Audubon, Concord, New Hampshire, USA. 414 pp.

Estes, W.A., and R.W. Mannan. 2003. Feeding behavior of Cooper's hawks at urban and rural nests in southeastern Arizona. Condor 105:107-116.

Foss, C.R. 1994. Atlas of breeding birds in New Hampshire. New Hampshire Audubon, Concord, New Hampshire, USA. 414 pp.

Frieswyk, T.S., and R.H. Widmann. 2000. Forest Statistics for New Hampshire, 1983 and 1997. USDA Forest Service, Research Bulletin NE-146. Newtown Square, Pennsylvania, USA.

Gancz, A.Y. I. K. Barker, R. Lindsay, A. Dibernardo, K. McKeever, and B. Hunter. West Nile virus outbreak in North American owls, Ontario, 2002. Emerging Infectious Diseases [serial on the Internet]. 2004 Dec [*12 April 2005*]. Available from: <http://www.cdc.gov/ncidod/EID/vol10no12/04-0167.htm>.

Henny, C.J., L.J. Blus, E.J. Kolbe, and R.E. Fitzner. 1985. Organophosphate insecticide (FAMPHUR) topically applied to cattle kills magpies and hawks. Journal of Wildlife Management 49:648-658.

McConnell, S. 2003. Nest Site vegetation characteristics of cooper's hawk in Pennsylvania. Journal of the Pennsylvania Academy of Science 76(2): 72-76.

Mosher, J.A. 1989. Accipiters. Pages 47-52 *in* B.G. Pendleton, (editor). Proceedings of the northeast raptor management symposium and workshop held 16-18 May 1988, Syracuse, NY. Institute for Wildlife Research, National Wildlife Federation, Scientific and Technical Series No. 13.

Mosher, J.A., M.R. Fuller, and M. Kopeny. 1990. Surveying woodland raptors by broadcast of conspecific vocalizations. Journal of Field Ornithology 61:453-461.

Pattee, O.H., M.R. Fuller, and T.E. Kaiser. 1985. Environmental contaminants in eastern Cooper's hawk eggs. Journal of Wildlife Management 49: 1040–1044.

Robbins, C.S., D. Bystrak, and P.H. Geissler. 1986. The breeding bird survey: its first fifteen years, 1965-1979. Resource Publication 157. U.S. Fish and Wildlife Service, Washington, DC. 196 p.

Rosenfield, R.N., J. Bielefeldt, S.A. Sonsthagen, and T.L. Booms. 2000. Comparable Reproductive success at conifer plantation and non-plantation nest sites for cooper's hawks in Wisconsin. Wilson Bulletin 112:417-421.

Rosenfield, R.N., and J. Bielefeldt. 1993. Cooper's Hawk; The Birds of North America. Vol. 2, No. 75. American Ornithologists' Union. The Academy of Natural Sciences of Philadelphia.

Snyder, N.C.N., H.A. Snyder, J.L. Lincer, and R.T. Reynolds. 1973. Organochlorines, heavy metals, and the biology of North American accipiters. Bioscience 23:300-305.

Titus, K., and J.A. Mosher. 1981. Nest site habitat selected by woodland hawks in the central Appalachians. Auk 98:270-281.

Trexel, D.R., R.N. Rosenfield, J. Bielefeldt, and E.A. Jacobs. 1999. Comparative nest site habitats in sharp-shinned and Cooper's hawks in Wisconsin. Wilson Bulletin 111:7-14.

Wünschmann, A., J. Shivers, J. Bender, L. Carroll, S. Fuller, M. Saggese, A. van Wettere, and P. Redig. 2004. Pathologic Findings in Red-Tailed Hawks (*Buteo jamaicensis*) and Cooper's Hawks (*Accipiter cooperi*) Naturally Infected with West Nile Virus. Avian Diseases 48:570–580.

5.2 Data Sources

New Hampshire Audubon. undated. Backyard Winter Bird Surveys: Tabular Results for 1999-2002. New Hampshire Audubon website document at: <http://www.nhaudubon.org/BWBSresults2.htm>. Accessed on January 18, 2005.

NatureServe. 2005. NatureServe Explorer. An online encyclopedia of life. Version 4.4. NatureServe, Arlington, Virginia. Available at: <http://www.natureserve.org/explorer/servlet/NatureServe>. Accessed on January 12, 2005.

New Hampshire Fish and Game Department. no date. Endangered and Threatened Species List. <http://www.wildlife.state.nh.us/Wildlife/Nongame/endangered_list.htm>. Accessed on April 15, 2005.

New Hampshire Natural Heritage Bureau. 2005. Animal Tracking List. <http://www.nhdfl.org/formgt/nhiweb/Documents/w_animal.pdf> Accessed on January 26, 2005

Sauer, J. R., J. E. Hines, and J. Fallon. 2004. *The North American Breeding Bird Survey, Results and Analysis 1966 - 2003. Version 2004. US Geological Survey, Patuxent Wildlife Research Center, Laurel, MD website at:* <http://www.mbr-pwrc.usgs.gov/bbs/bbs.html>. Accessed on January 19, 2005.

USDI Fish and Wildlife Service. 1999. Endangered and Threatened Wildlife and Plants List. 50 CFR 17.11. <http://www.fws.gov/endangered/50cfr_animals.pdf>. Accessed on April 15, 2005.

SPECIES PROFILE

Great Blue Heron

Ardea herodias

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S4B
Author: Jillian R. Kelly, New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

Great blue herons breed and nest in fresh and saltwater habitats that include marshes, beaver impoundments, wet meadows, estuaries, tidal flats, sandbars, shallow bays and the margins of lakes, ponds, streams and rivers (DeGraaf and Yamasaki 2001). Nests are commonly found in riparian swamps in dead trees 5 to 15 m above ground (NatureServe 2005, Ogden 1978, McAloney 1973, Vermeer 1969). Great blue herons often nest in colonies or rookeries.

Great blue heron foraging habitat includes freshwater and brackish marsh lakeshores, rivers, bays, lagoons, ocean beaches, mangroves, fields, and meadows (NatureServe 2005). Herons commonly feed on aquatic and terrestrial insects, fish, amphibians, reptiles, crustaceans, and occasionally on small birds and mammals (Short and Cooper 1985).

1.2 Justification

Great blue herons are sensitive to habitat loss and disturbance. For example, loss of nesting habitat, deterioration of water quality, and loss of wetlands can threaten herons (Short and Cooper 1985, Thompson 1979, Kelsall and Simpson 1980, McCrimmon 1981). Thus, herons can indicate changes in the environment. Specifically, heron populations can provide an indication of water quality and wetland health. Because pesticides and heavy metals accumulate in herons' primary prey, contaminated herons can indicate wider contamination of amphibians and fish.

Development and associated human disturbance also threaten great blue heron populations. For example, fledgling success depends on the success of the parents in providing sufficient food when nestlings are 2-6 weeks old (NatureServe 2005). Therefore, extensive disturbance, or loss of foraging habitat, directly reduces heron productivity.

Maintaining habitat for herons will also benefit animals such as osprey (*Pandion halaetus*), great horned owls (*Bubo virginianus*), amphibians, and fish. For example, heron rookeries are associated with potential nesting location of the state threatened osprey. Therefore, monitoring heron rookery locations can aid in identifying present and potential osprey nesting locations.

1.3 Protection and Regulatory Status

- Migratory Bird Treaty Act (1918).
- State wetlands regulations (see Marsh and Shrub Wetland habitat profile).

1.4 Population and Habitat Distribution

The great blue heron is the most common of New Hampshire's herons and occurs throughout the state (Elkins and Swift 1994). Based on the number of documented occurrences in the Breeding Bird Atlas, herons appear to be more numerous in southern New Hampshire than in the White Mountains and northern New Hampshire.

Because great blue herons often nest and forage in beaver (*Castor canadensis*) impoundments, local heron populations may fluctuate with beaver populations. For example, heron use of beaver ponds is now rebounding from the extirpation of beavers in the nineteenth century (Elkins and Swift 1994). The

heron recolonization of beaver impoundments since the 1930s suggests that herons may be more numerous now than 50 or 100 years ago (Elkins and Swift 1994). During the 1990s, it was estimated that New Hampshire had approximately 200 heron rookeries, supporting around 1,600 pairs of herons (Hunt 2005). Great blue heron populations are believed to be increasing or stable in New Hampshire (Hunt 2005).

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

See Marsh and Shrub Wetlands habitat profile element 1.6.

1.7 Sources of Information

Sources of information include the NatureServe database (2005), literature review, expert review and consultation (M. Marchand, Wetlands Biologist, NHFG), and the rare species and natural community database maintained by NHNHB.

1.8 Extent and Quality of Data

Data on the distribution of great blue heron in New Hampshire are limited, as is local and statewide information on population trends. Many records are missing from occurrence data collected as part of the Breeding Bird Atlas and maintained in the New Hampshire rare species database (Elkins and Swift in Foss 1994, C. Martin, NHA, personal communication).

1.9 Distribution Research

More information is needed on habitat use and population fluctuations at known rookeries (e.g., long term monitoring of identified large rookeries). More information on rookeries would also help in monitoring populations and identifying new osprey nesting locations. Newly identified rookeries should be incorporated into NHDES wetland permit reviews.

Element 3: Species Threat Assessment

See Marsh and Shrub Wetlands habitat profile for habitat-based threats.

Element 4: Conservation Actions

See Marsh and Shrub Wetlands habitat profile for habitat-based conservation strategies.

Element 5: References

5.1 Literature Cited

DeGraaf R. M., and M. Yamasaki. 2001. New England wildlife habitats, natural history, and distribution. University Press of New England, Hanover, New Hampshire, USA.

Elkins, K.C., and Swift, E.F. 1994. Great blue heron (*Ardea herodias).* Page 8 *in* Atlas of breeding birds in New Hampshire, C.R. Foss, editor. Arcadia. Dover, New Hampshire, USA.

Hunt, P. 2005. A Regional Perspective on New Hampshire's Birds of Conservation Priority: Objectives, Threats, Research Needs, and Conservation Strategies. New Hampshire Audubon, Concord, New Hampshire, USA.

Kelsall, J.P., and K. Simpson. 1980. A three-year study of the great blue heron in southwestern British Columbia. Proceedings 1979 Conference. Colonial Waterbird Group 3:69-74.

McAloney, K. 1973. The breeding biology of the great blue heron on Tobacco Island, Nova Scotia. Canadian Field Naturalist. 87:137-140.

McCrimmon, D.A. 1981. The status and distribution of the great blue heron (*Ardea herodias*) in New York State: Results of a two-year census effort. Colonial Waterbirds 4:85-90.

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life (web application). Version 4.2 NatureServe, Arlington, Virginia. http://www.natureserve.org/explorer. Accessed 11 February 2005.

Ogden, J C. 1978. Recent population trends of colonial wading birds on Atlantic and Gulf coastal plains. Wading birds. National Audubon Society research report. 7:137-153.

Short, H.L., and R.J. Cooper. 1985. Habitat suitability index models: Great blue heron. U.S. Fish Wildlife Service Biological Report. 82(10.99).

Thompson, D.H. 1979. Declines in populations of great blue herons and great egrets in five Midwestern states. Proceedings of 1978 Conference Colonial Waterbird Group 2:114-127.

Vermeer, K. 1969. Great blue heron colonies in Al-

berta. Canadian Field-Naturalist 83:237-242.

5.2 Data Sources

NH Natural Heritage Bureau. 2005. Database of Rare Species and Exemplary Natural Community Occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

SPECIES PROFILE

Golden Eagle

Aquila chrysaetos

Federal Listing: Not listed
State Listing: Endangered
Global Rank: G4
State Rank: SHB
Author: Carol R. Foss, New Hampshire Audubon

Element 1: Distribution and Habitat

1.1 Habitat description

Golden eagles inhabit remote mountainous areas with one or more cliffs suitable for nesting, abundant wetlands, and minimal human activity within 50 to 100 square miles (Spofford 1971). In Maine, 8 of 12 historical nest sites had a heronry within 20 km; a heronry was located within 35 km of the remaining sites (Weik 1987).

1.2 Justification

Successful breeding has not been documented in New Hampshire since 1956, although the last known home range was occupied until 1982 (W. Spofford, personal communication). Quebec populations in the Laurentian Mountains and on the Gaspe Peninsula (Environment Canada 2004) may provide a source for recolonizing potential breeding habitats in the White Mountains Ecoregion. However, potential habitats may be marginally suitable given human access to formerly remote areas, increasing recreational activity, contamination of surface waters by air-borne pollutants, and historical reductions of beavers and great blue herons in the region.

1.3 Protection and Regulatory Status

The golden eagle is protected in the United States under the Migratory Bird Treaty Act of 1918 (16 U.S.C. 703-712; Ch. 128; 13 July 1918; 40 Stat. 755) as amended by: Chapter 634; 20 June 20 1936; 49 Stat. 1556; P.L. 86-732; 8 September 1960; 74 Stat. 866; P.L. 90-578; 17 October 17 1968; 82 Stat. 1118; P.L. 91-135; 5 December 1969; 83 Stat. 282; P.L. 93-300; 1 June 1974; 88 Stat. 190; P.L. 95-616; 8 November 1978; 92 Stat. 3111; P.L. 99-645; 10 November 1986; 100 Stat. 3590 and P.L. 105-312; 30 October 1998; 112 Stat. 2956) and the Bald Eagle Protection Act (16 U.S.C. §§ 668-668d, 8 June 1940, as amended 1959, 1962, 1972, and 1978). This species is listed as Endangered in New Hampshire.

1.4 Population and Habitat Distribution

Known records of nesting in New Hampshire predate 1855 (Allen 1903). Three currently unoccupied historic nesting locations are known in the state, 2 in the White Mountains and one in the Lake Umbagog region (Allen 1903, Brewster 1925). The New Hampshire Bird Records Database for 1990 to 2004 includes documentation for 1 to 5 golden eagle sightings annually during fall migration (except 2002), single sightings during spring migration in 4 scattered years, and single July sightings in 1991 and 1998.

1.5 Town Distribution Map

There are no recent breeding records of golden eagles in New Hampshire.

1.6 Habitat Map

See the Habitat Map for Cliffs.

1.7 Sources of Information

Information was obtained from a literature review and from the New Hampshire Bird Records Database.

1.8 Extent and Quality of Data

Existing recent data consist of unverified reports to New Hampshire Bird Records. Reports of this species require thorough documentation and any consistent breeding season reports would be subject to field verification.

1.9 Distribution Research

Notify staff and volunteer peregrine falcon observers regarding the potential for golden eagle sightings, provide identification information, and request detailed observation and documentation of any eagles observed in vicinity of potential aeries.

Element 5: References

5.1 Literature

Allen, G.M. 1903. A list of the birds of New Hampshire. Nature Study Press, Manchester, New Hampshire, USA.

Brewster, W. 1925. The birds of Lake Umbagog region of Maine. Part 2. Bulletin of the Museum of Comparative Biology 66. Harvard College, Cambridge, Massachusetts, USA.

Environment Canada. 2004. Species at Risk: Golden Eagle. www.qc.ec.gc.ca/faune/oiseaux_menaces/html/aigle_royal_e.html

Foss, C.R. 1994. Golden Eagle. Pp. 374-375 *in* Foss, C.R., ed. *The Atlas of Breeding Birds in New Hampshire*. Arcadia, an imprint of The Chalford Publishing Corporation, Dover, New Hampshire, and The New Hampshire Audubon, Concord, New Hampshire.

Spofford, W.R. 1971. The breeding status of the Golden Eagle in the Appalachians. American Birds 25(1): 3-7.

Weik, A.P. 1987. The Status of Golden Eagles Nesting in Maine. A thesis submitted in partial fulfillment of the requirements for a degree with Honors at the University of Maine. Department of Forestry and Wildlife Management, University of Maine, Orono.

5.2 Data Sources

New Hampshire Bird Records Database

SPECIES PROFILE

Golden-winged Warbler

Vermivora chrysoptera

Federal Listing: Species of concern
State Listing: Species of conservation concern
Global Rank: G4
State Rank: S2B
Author: Rebecca W. Suomala, New Hampshire Audubon

Element 1: Distribution and Habitat

1.1 Habitat Description

The Golden-winged Warbler prefers early successional habitats such as pastures reverting to woodland, brushy fields, marshes, bogs, stream borders, powerlines, and openings in deciduous woods (Confer 1992, Curson et al. 1994). In New Hampshire, most breeding-season records have been in abandoned fields or clearcuts in an early stage of succession and along powerlines. According to Confer (1992), Golden-winged Warbler nesting territories are consistently found in habitat with patches of herbs, shrubs and scattered trees with a forested edge.

1.2 Justification

Considered rare in the early 1900s, the species expanded its range northward and eastward in response to farmland abandonment (Dunn and Garrett 1997). It began declining in the latter half of the 1900s and by the 1990s populations had decreased in 9 of 12 states (Confer 1992). The Breeding Bird Survey (BBS) data through 2003 show that the Golden-winged Warbler has declined by 8.3% in the USFWS's Region 5 (Sauer et al. 2004). Canada shows an increase on the BBS, although the trend is not significant (Sauer et al. 2004), and northeastern New York and central Ontario appear to have an expanding population (Confer 1992). Interim results on the New York Breeding Bird Atlas web site show only one small section of the state with an increased distribution and the majority of the state with a dramatic decrease when compared with the first Atlas in the 1980s (NYSDEC 2004). The overall regional pattern corresponds with a gradual northward shift in the species range (Dunn and Garrett 1997).

Golden-winged Warblers established breeding populations in the southeastern coastal plain of New Hampshire by early to mid-1900s (Foss 1994, Donsker 2004). In the 1950s through the mid-1970s, up to 10 individuals were reported in New Hampshire nearly every year, but that number has declined to less than five individuals annually between 1988 and 2003 (figure 1), with none reported in six of those years (Donsker 2004). There were only two breeding-season Golden-winged Warbler reports in 2000, one in 2001, and none in 2002-2004. The only reports from 2003 and 2004 were both likely migrants, one from Sandwich and one from Epping, respectively.

The Golden-winged Warbler is on the Partners in Flight Watch List and is one of 28 species in need of immediate conservation attention in the continental United States and Canada due to multiple causes for concern across its entire range (Rich et al. 2004). Reasons for the decline are not clear, but its early successional habitat has declined in the Northeast.

1.3 Protection and Regulatory Status

The Golden-winged Warbler is classified as a species of concern by the USFWS (Confer 1992), and is listed on the Partners in Flight Watch List (Rich et al. 2004), and on the Audubon Society's WatchList (National Audubon 2002). Along with most birds, it is protected more generally under the Migratory Bird Treaty Act, which prevents the killing of most non-game birds and collection of their nests or eggs.

1.4 Population and Habitat Distribution

New Hampshire is at the northeastern edge of the species' range in New England. There was only one record during the Maine Breeding Bird Atlas (Adamus 1983) and it is considered uncommon and declining in Massachusetts (Veit and Peterson, 1993). Most Golden-winged Warbler reported were from southeastern New Hampshire in the early 1980s, particularly Durham, Kensington, Exeter, and Newmarket. The primary locations with multiple reports over the years were Foss Farm, Longmarsh Road, and Packer's Falls Road in Durham, and South Road and North Road in Kensington. Only two locations in these four towns had sightings after 1995: Packer's Fall Road (through 1997), and Bald Hill Road in Newmarket (one report in 2000). The most recent sighting from the southeastern portion of the state during the breeding season was a male in July 2001 along a Northwood powerline. This was most likely a breeding individual and illustrates the potential for this species to occur at inaccessible locations along powerlines. There were also single sightings from seven other southeastern towns: Deerfield (1982), Dover (1984), East Kingston (1983), Hampstead (1999), Hollis (1997), Portsmouth (1996), and South Hampton (1986). There are only two locations outside of southeast New Hampshire where birds were reported regularly:

- Hanover: Goodfellow Road , reported annually from 1991-1997, with two nests in 1992 (although each was paired with a Blue-winged Warbler), and a pair carrying nesting material in 1993 (both Golden-winged Warblers).
- Weare/Dunbarton: Clough State Park and vicinity (a male in 2000, 1997, 1996, 1995). This is a location with many Blue-winged Warblers.

Three other locations had reports from two different years: Fox State Forest in Hillsborough (1985, 1996), Pisgah State Park in Winchester (1982, 1993), and Pembroke Academy area in Pembroke (1997, 1999). The other eight reports away from the southeast are single sightings from scattered locations as far north as Jefferson, none more recent than 1996. Infrequency of the reports may suggest rarity because many of the areas are regularly surveyed.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

N/A

1.7 Sources of Information

Species information was compiled from the pertinent literature. Information on the location of Golden-winged Warblers in the state refers to the period from 1980 through 2004. Only those sightings that represented potential breeding reports were included and those that were most likely migrants are not included unless specifically stated. The primary data source was NHBR with a few reports from the New Hampshire Breeding Bird Atlas (BBA) and the Breeding Bird Survey. There have been no organized survey efforts for this species in the state.

1.8 Extent and Quality of Data

Birders seek Golden-winged Warblers and sightings are likely to be included in NHBR. Many locations where the species was formerly found are still birded regularly, and some sightings were from locations where active reporters still reside.

1.9 Distribution Research

It is important to know if and where breeding Golden-winged Warblers remain in the state so that critical areas can be protected. Surveys should focus on historic locations and nearby suitable habitat. Surveys should also document the distribution of Blue-winged Warblers and Blue-winged Warbler/Golden-winged Warbler hybrids (see section 2.2).

Element 2: Species/Habitat Condition

2.1 Scale

The absence of currently breeding individuals in the state and the regional northward expansion of this species' range make it difficult to establish any appropriate conservation planning units.

2.2 Relative Health of Populations

After the early 1980s Golden-winged Warbler reports declined in number and regularity, with none in 1986-1988, few in the 1990s with the exception of the remarkable record year in 1996 (figure 1), and two during 2000-2004 (note that 1996 was also a record year for Blue-winged Warblers and their hybrids.) The number of Blue-winged Warblers and their distribution in the state has increased rather dramatically during the same period that Golden-winged Warblers have declined (figure 1).

Hybridization between Blue-winged and Golden-winged Warblers has been well documented in New Hampshire (NHBR). In 1992, two mixed pairs were documented in Hanover. One was a male Blue-winged with a female Golden-winged at a nest with four eggs that fledged successfully, and the other was a male Golden-winged with a female Blue-winged at a nest with three young that also fledged. The nests were relatively close to each other on opposite sides of the same road (NHBR). A male Golden-winged Warbler at Langmaid Farm in Durham was believed to nest with a female Blue-winged Warbler in June 1989 (NHBR). In South Hampton during the Breeding Bird Atlas, males of both species and both hybrids were singing in a clearcut, and in Kensington a territorial male Golden-winged Warbler was replaced first by a hybrid and then by a male Blue-winged Warbler in the space of one week during two different breeding seasons (Foss 1994). Details on all hybrid sightings are not included here.

Donsker (2004) summarized all New Hampshire reports of the two species and their hybrids, documenting the arrival of Blue-winged Warblers in 1955, their subsequent increase, the increase in hybrids, and the decline of Golden-winged Warblers (figure 1). The number of hybrids reported between 1999 and 2003 exceeds the number of Golden-winged Warblers reported, although reports of hybrids have declined in the last ten years, as might be expected given the decline of Golden-winged Warblers. The pattern of reports with increasing Blue-winged Warblers followed by "Brewster's" hybrids, declining Golden-winged Warblers and a few "Lawrence's" hybrids matches that described by Dunn and Garrett (1997). Over a 50-year time frame, this results in a population of entirely Blue-winged Warblers and an occasional "Lawrence's" hybrid.

2.3 Population Management Status

Golden-winged Warblers are not currently managed in New Hampshire.

2.4 Relative Quality of Habitat Patches

Current reports indicate that Golden-winged Warblers are no longer breeding in the state and that the quality of current habitat patches is difficult to evaluate.

2.5 Habitat Patch Protection Status

N/A

2.6 Habitat Management Status

There are no habitat management activities taking place for Golden-winged Warblers. There have been some efforts in the state to promote management of some lands for early successional habitat.

2.7 Sources of Information

Species information was compiled from the pertinent literature. Information on hybridization of Golden-winged Warblers with Blue-winged Warblers refers to the period from 1980 through 2004. The primary data source was NHBR with a few reports from the New Hampshire Breeding Bird Atlas (BBA) and the Breeding Bird Survey.

2.8 Extent and Quality of Data

The absence of Golden-winged Warblers in New Hampshire makes it difficult to evaluate the condition of existing habitat and whether habitat degradation was a factor in this species' disappearance from the state.

The presence of Blue-winged Warblers and the occurrence of hybridization with Golden-winged Warblers is adequately documented in New Hampshire by the current reports. Both species are popular among birders and there is awareness of the potential for hybridization such that reports of both these species and their hybrids are most likely to be included in NHBR.

2.9 Condition Assessment Research

- If any Golden-winged Warblers still breed in the state, it is critical to determine their productivity

and assess the habitat parameters, including presence of invasive species and the degree of fragmentation.
- Revisit historical locations to determine if habitat conditions are still suitable for Golden-winged Warblers

Element 3: Species and Habitat Threat Assessment

Threat assessment for Golden-winged Warbler is difficult because few individuals remain in the state. A description of broad-based threats that apply to the species as a whole are listed below, but which of these factors were the cause of Golden-winged Warbler decline in New Hampshire is not clear.

3.1.1. Altered Natural Disturbance (Natural Succession)

Development and the re-growth of forests on formerly open land has reduced early successional habitat throughout the Northeast (see Shrublands habitat profile).

3.1.2. Introduced Species, Development (Fragmentation), Predation and Herbivory

- Invasive species: In Michigan, the planting of non-native autumn-olives for game caused Golden-winged Warblers to disappear from formerly suitable shrub-habitat (Dunn and Garrett 1997). Autumn-olives are also known to invade fields in New Hampshire and their impact on Golden-winged Warblers is not known.
- Fragmentation: Golden-winged Warblers nest on the ground leaving them vulnerable to ground predators, especially in smaller patches where predators can more easily detect nests. Remaining patches of appropriate habitat, especially in the southern part of the state, are likely to be adjacent to suburbia where ground predators are more common. Nearby development or human disturbance may cause Golden-winged Warblers to abandon nests during nest construction or egg-laying, although they will remain on the nest once incubation starts, despite considerable disturbance (Confer 1992).

3.1.3. Scarcity (Competition)

Although Blue-winged Warblers appear to displace Golden-winged Warblers, this may be a result of habitat change and not competition. Local declines correlate with advancing succession and reforestation combined with Blue-winged Warbler range expansion (Confer 1992). Studies support Blue-winged Warbler dominance in some cases and Golden-winged Warbler dominance in others, but in areas of New York and New Jersey with suitable habitat, both species have coexisted for nearly 100 years (Confer 1992, Coker and Confer 1990). Brown-headed Cowbirds are known to parasitize Golden-winged Warblers and Confer (1992) reported that 30% of nests were parasitized out of several hundreds nests, but the effect on nest success was unknown.

3.2 Sources of Information

Pertinent literature was reviewed for determination of threats to the species as a whole. There is no state-specific information on these threats for New Hampshire, although the loss of early successional habitat is well known in the state (see habitat profile).

3.3 Extent and Quality of Data

Information on threats to the species as a whole is well described in the literature, but since Golden-winged Warbler is no longer present in the state, we do not know how each threat affects the species in New Hampshire.

3.4 Threat Assessment Research

More information is needed on the extent to which all threats listed above impact Golden-winged Warbler populations. Should any breeding Golden-winged Warblers remain, more information is needed on the effect of their interaction and hybridization with Blue-winged Warblers and its impact on the population.

Element 4: Conservation Actions

4.1. Regulation and Policy

Due to the dramatic decline of Golden-winged War-

blers in the state, and especially the absence of reports since 2000, this species should be upgraded to Endangered in New Hampshire. The population may be beyond recovery in the state, but this is uncertain and results from inventory, research, and management efforts are needed to guide future status revisions. The absence of known breeding Golden-winged Warblers in the state precludes any further specific conservation actions.

4.2 Conservation Action Research

- Determine if habitat manipulation can attract Golden-winged Warblers to areas with past breeding-season reports and possibly restore the species.
- If any breeding individuals are found remaining in the state, there may be opportunities for research into habitat management regimes most beneficial for Golden-winged Warblers.

Element 5: References

5.1 Literature:

Adamus, P.R. 1983. Atlas of Breeding Birds in Maine, 1978-1983. Maine Department of Inland Fisheries and Wildlife, Augusta, Maine, USA.

Coker, D.R., and J.L. Confer. 1990. Brown-headed Cowbird parasitism on Golden-winged and Blue-winged Warblers. The Wilson Bulletin 102(3): 550-552.

Confer, J.L. 1992. Golden-winged Warbler (*Vermivora chrysopter*). *In* The Birds of North America, No. 20 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Curson J., D. Quinn, and D. Beadle. 1994. Warblers of the Americas. Houghton Mifflin, Boston, Massachusetts, USA.

Donsker, D. 2004. "Brewster's Warbler and "Lawrence's" Warbler: Golden-winged Warbler and Blue-winged Warbler Hybrids. New Hampshire Bird Records Spring 2003 22(1): 42-47.

Dunn, J., and K. Garrett. 1997. Warblers. Houghton Mifflin, Boston, MA.

Foss, C. (editor). 1994. Atlas of Breeding Birds in New Hampshire. New Hampshire Audubon, Concord, New Hampshire, USA.

Golden-winged Warbler Atlas Project web site. 2004. Cornell Laboratory of Ornithology, Ithaca, New York, USA. http://birds.cornell.edu/gowap/.

Hunt, P. 1999. New Hampshire Spring Arrival Dates. New Hampshire Bird Records Spring 1998 17(1): 36-39.

National Audubon. 2002. Audubon WatchList 2002 web page, http://www.audubon.org/bird/watchlist. National Audubon Society, Inc.

NYSDEC. 2004. NYS Breeding Bird Atlas web site, http:/www.dec.state.ny.us/apps/bba. New York State Department of Environmental Conservation.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S.W. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.S. Hunter, E.E. Inigo-Elias, J.A. Kennedy, A.M. Martell, A.O. Panjabi, D.N. Pashley, K.V. Rosenberg, C.M. Rustay, J.S. Wendt, T.C. Will. 2004. Partners in Flight North American Landbird Conservation Plan. Cornell Lab of Ornithology. Ithaca, New York, USA.

Sauer, J.R., J.E. Hines, and J. Fallon. *2004. The North American Breeding Bird Survey, Results and Analysis 1966-2003. Version 2004.1. USGS Patuxent Wildlife Research Center, Laurel, Maryland, USA*

Veit, R.R., and W.R. Petersen. 1993. Birds of Massachusetts. Massachusetts Audubon Society, Lincoln, Massachusetts, USA.

5.2 Data Sources

NHBR. New Hampshire Bird Records database and archives. New Hampshire Audubon, Concord, New Hampshire, USA.

Element 6: List of Figures

Figure 1. Records of Golden-winged and Blue-winged Warblers and their hybrids, "Brewster's" and "Lawrence's" Warblers. New Hampshire 1953-2003. Reprinted from New *Hampshire Bird Records*, Vol. 22, No. 1 (Donsker 2004).

SPECIES PROFILE

Northern Goshawk

Accipiter gentilis

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S3
Authors: Mariko Yamasaki and Christine, A. Costello, USDA Forest Service

Element 1: Distribution and Habitat

1.1 Habitat Description

Northern goshawk breeding home range consists of nesting areas, post-fledgling family areas, and foraging areas (Reynolds et al. 1992). All goshawk breeding activity, from courtship to fledging, centers around the nesting area, which includes the nest tree and surrounding stands that contain prey handling areas, perches, and roosts. In New Hampshire, white pine (*Pinus strobus*), paper birch (*Betula papyrifera*), yellow birch *(Betula alleghaniensis),* Big-toothed aspen *(Populus grandidentata),* and red maple *(Acer rubrum*) are common nesting trees. These stands tend to be mature, containing some large diameter trees, and have relatively dense canopies and open understories. Most have been somewhat disturbed. Nest sites are generally situated close to the bottom of gentle slopes, most below 1,500 ft.

Nests are constructed in large trees with dominant and co-dominant positions in the canopy, but are not necessarily the largest trees in the stand. A nest tree must contain a branching structure suitable for holding a large bulky stick nest. Goshawks will often maintain 1 to 8 alternate nests within their nesting areas (Yamasaki and Costello, unpublished data, Speiser and Bosakowski 1987, Reynolds et al. 1994). Nest trees are often situated close to some type of forest opening (e.g., small breaks in the canopy, trails, forest roads, and upland openings).

The post-fledgling-family area is the area surrounding the nest site used by both adults and juveniles after fledging and until juvenile independence (Reynolds et al. 1992). This area is similar to nesting habitat and is believed to be critical in providing extra cover and abundant prey for unskilled juveniles. Research from the western United States suggests that the post-fledgling-family area varies in size from 121 to 243 hectares (300 to 600 acres), probably due to variation in food availability (Reynolds et al. 1992, Kennedy et al. 1994, Daw and DeStefano 2001).

Goshawk foraging areas consist of large tracts of forestland containing a variety of forest age classes and openings that can support the diverse habitat requirements of important goshawk prey species (Reynolds et al. 1992). These species include ground and tree squirrels, game birds, medium to large-sized songbirds, corvids, rabbits, and hares (Reynolds et al. 1992, Bosakowski et al. 1992, Boal and Mannan 1994, Doyle and Smith 1994). Much research suggests that goshawks forage in closed canopy forests with open under stories where prey is accessible, but that younger stands and openings are important for prey production. Critical winter goshawk habitat in eastern North America is unknown.

1.2 Justification

Concern exists for the goshawk because of their association with large tracts of forests that are being converted to other uses in New Hampshire. New Hampshire is the fastest growing state in New England, and forestland has declined by 134,500 acres (2.7 percent) since 1983. Southern New Hampshire has experienced the greatest decline (Frieswyk and Widmann 2000). Development and changes in ownership divide forest into smaller parcels, compromising goshawks by reducing the availability of nest sites and prey species. Fragmented landscapes may also increase competition with other raptors such as

great horned owls and red tailed hawks, which are better adapted to foraging and nesting in these areas (Crocker-Bedford 1990). Current habitat management guidelines were developed in other regions and are not applicable here due to differences in land-use patterns, forest cover type, disturbance regimes and available prey species.

1.3 Protection and Regulatory Status

Goshawks are protected under the Migratory Bird Treaty Act of 1918.

1.4 Population and Habitat Distribution

Goshawks breed throughout New Hampshire (Janeway in Foss 1994), though data on population dynamics are lacking. Passenger pigeon extirpation and extensive land clearing in the nineteenth century likely caused goshawk populations to decline, but subsequent agriculture abandonment and reforestation have likely contributed to a goshawk range and population expansion (Bent 1937, DeGraaf and Yamasaki 2001, Speiser and Bosakowski 1984, DeStefano in press).

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

1.7 Sources of Information

Information on goshawk habitat, population distribution, and status was compiled from unpublished data from on-going research, scientific literature, limited agency data, surveillance of the New Hampshire bird list-serve, as well as from direct searches.

1.8 Extent and Quality of Data

There are no systematic goshawk sampling efforts in New Hampshire. Breeding bird surveys, hawk watches, and Christmas bird counts do not adequately survey for the seasonal and elusive goshawk. The objectives of current research efforts focused in the White Mountain region by the Northeastern Research Station are to locate breeding territories and describe nesting habitat and do not address demographics. Minimal funding results in inconsistent surveying and monitoring.

1.9 Distribution Research

- Develop a statewide broadcast monitoring program for goshawk that will be regionally viable. Although time consuming and labor intensive, broadcast surveys are the best method available and can be used to monitor areas for occupancy, changes in distribution and abundance, and nest location. Data on distribution are most essential in areas expected to experience the most severe habitat loss.
- Develop a survey method or make use of existing surveys (e.g., Christmas Bird Counts, Feeder Watches) to obtain an index of winter abundance and distribution in the state.
- Test a rapid assessment process developed by USDA Forest Service Wildlife Ecology Unit (Hargis and Woodbridge in press) in New Hampshire and the northeastern United States.

Element 2: Species/Habitat Condition

2.1 Scale

Goshawk occurs across the state. Potential conservation planning units at the section (M212A, M212B, and 221A) or subsection level appear to be most appropriate (Avers et al. (1994).

2.2 Relative Health of Populations

There are no data on the abundance of goshawk in New Hampshire.

2.3 Population Management Status

There are no population management efforts in the state.

2.4 Relative Quality of Habitat Patches

There are no data for meaningful analysis.

2.5 Habitat Patch Protection Status

Goshawk nesting areas on the WMNF and other conservation lands in New Hampshire will remain pro-

tected. Nesting potential on non-conservation lands will depend on whether these lands remain forested.

2.6 Habitat Management Status

There are no habitat management or restoration efforts in New Hampshire.

2.7 Sources of Information

There are no statewide or regional data upon which to assess the condition of goshawk.

2.8 Extent and Quality of Data

There are no data available to make this assessment.

2.9 Condition Ranking

There are no data for this ranking.

2.10 Condition Assessment Research

- Determine home range sizes and characterize breeding and foraging habitat at landscape, stand, and within-stand scales.
- Determine how changes in forest structure and landscape patterns affect reproductive success, survival rates, territory fidelity, juvenile dispersal, and breeding dispersal
- Determine important prey species of goshawk in this region and determine how the abundance and availability of prey is influenced by forest structure, management practices, landscape patterns, and natural cycles
- Identify effects of various forest management practices on goshawk habitat, nest site fidelity, productivity, and prey availability
- Determine migratory status of goshawks breeding in New Hampshire and winter survival rates of adults and juveniles
- Characterize goshawk winter habitat
- Determine if West Nile Virus is affecting goshawk populations New Hampshire

Element 3: Species and Habitat Threat Assessment

3.1.1 Development (Habitat Loss and Conversion)

(A) Exposure Pathway
Development reduces the number and distribution of available nest sites and foraging habitat. Additionally, these activities can increase populations of goshawk predators such as raccoons and great horned owls.

(B) Evidence
White pine and northern red oak can consistently be regenerated in outwash sand and gravel sites (Leak 1982). White pine stands are frequently used for nesting sites by goshawks, and these stands tend to have soils that are moderately to excessively well-drained, making them ideal for both residential and commercial development. Forest planners have expressed concern over the disproportionate conversion of white pine and red oak sites in the last 20 years (Cullen and Leak 1988).

3.2 Sources of Information

Information on threats to the northern goshawk came from a literature review of research conducted outside of the northeastern United States as well as from research conducted by the Northeastern Research Station in the White Mountain region, and personal communications.

3.3 Extent and Quality of Data

Most of the existing data on threats to the goshawk come from areas outside of the northeastern United States and may not be relevant due to differences in land-use, forest cover types, disturbance regimes, and available prey species. Not enough is known about best forest management practices within goshawk nesting habitat or about this raptor's tolerance to disturbance during the breeding season.

3.4 Threat Assessment Research

- Determine the effect of land conversion and consequent habitat loss on goshawk productivity in historical goshawk nesting areas (i.e., compare gos-

hawk productivity in areas where land conversion and parceling processes are minimal, such as the White Mountain National Forest, to areas where the rate of land conversion is high)
- Evaluate the relationships between timber harvesting practices and nesting habitat, post-fledgling-family habitat, and foraging habitat
- Determine effects of human disturbance in goshawk nesting areas during the breeding season
- Monitor the development of West Nile Virus in forest raptors such as goshawk

Element 4: Conservation Actions

4.1.1 Developing occurrence, habitat, and distribution data, Restoration and Management.

(A) Habitat Loss

(B) Justification

- State-wide surveys will provide distribution and habitat survey data upon which population analyses can be conducted
- Statewide surveys can be followed by closer investigation of hemlock-hardwood-pine, northern hardwood-conifer, Appalachian oak-pine, and lowland spruce-fir types
- Investigations that increase knowledge of goshawk demographics and habitat availability (or degradation) will allow for better management

(C) Conservation Performance Objective
Census surveys in likely habitat will provide more information on a poorly understood species and will allow testing of habitat alteration hypotheses. Ecological studies will help determine the urgency of threats to the goshawk.

(D) Performance Monitoring
There is no statewide or regional monitoring of goshawk. Before conservation can occur, surveys must establish species occurrence and must determine whether habitat alteration is a significant threat.

(E) Ecological Response Objective
There are no data with which to formulate any type of ecological response objective.

(F) Response Monitoring
There are no data with which to formulate any type of response monitoring.

(G) Implementation
There are opportunities to partner with USDA Forest Service, UNH, United States Department of the Interior Fish and Wildlife Service, industrial forestry concerns, New Hampshire Division of Forest and Lands, NHNHB, local land trusts, and NHA to test the rapid assessment protocol suggested by Hargis and Woodbridge (in press) state-wide. Opportunities also exist to extend population and habitat research being conducted by USDA Forest Service, Northeastern Research Station statewide.

(H) Feasibility
The USDA Forest Service and UNH wildlife faculty have been conducting low intensity, non-systematic goshawk surveys in likely habitats since 1995 in the White Mountains region. Much cooperation and coordination would be required to accomplish a more systematic approach statewide, but it could be accomplished with adequate funding and the commitment of personnel and resources.

4.2 Conservation Action Research

Continuing support for ongoing goshawk population and habitat work in the White Mountains region and expanding these efforts state-wide would allow the direct testing of the habitat alteration hypothesis. Such surveys and habitat assessments are needed to better describe the status of goshawk and the characteristics of those habitats where goshawk occurs (e.g., associated vegetative communities, habitat condition indicators, any positive or negative forest management and recreational threats to habitat).

Element 5: References

5.1 Literature

Avers, PE., D.T. Cleland, and W.H. McNab. 1994. National hierarchical framework of ecological units. Pages 48-61 in L.H. Foley, editor. Proceedings of the National Silviculture Workshop. Nov. 1-4, 1993. Asheville, NC. General Technical Report SE-88. U.S. Forest Service, Southeastern Forest

Experiment Station, Asheville, NC.

Bent, A.C. 1937. Life histories of North American birds of prey. Part 1. United States National Museum Bulletin, United States Government Printing Office. 409 pp.

Boal, C.W., and R.W. Mannan. 1994. Northern goshawk diets in ponderosa pine forests on the Kaibab Plateau. Studies in Avian Biology 16:97-102.

Bosakowski, T., and R. Speiser. 1994. Macrohabitat selection by nesting northern goshawks: implications for managing eastern forests. Studies in Avian Biology 16:46-49.

Bosakowski, T., D.G. Smith, and R. Speiser. 1992. Niche overlap of two sympatric-nesting hawks, Accipiter spp., in the New Jersey-New York highlands. Ecography 15: 358-372.

Crocker-Bedford, D.C. 1990. Goshawk reproduction and forest management. Wildlife Society Bulletin 18: 262-269.

Cullen, J.B. and W.B. Leak. 1988. New Hampshire's timber resource: past-present-future. NH Dept. of Resources and Economic Development. 34 p.

Daw, S.K., and S. DeStefano. 2001. Forest characteristics of northern goshawk nest stands and post-fledging areas in Oregon. Journal of Wildlife Management 65(1):59-65.

DeGraaf, R.M., and M. Yamasaki. 2001. New England wildlife: habitat, natural history, and distribution. University Press of New England, Hanover, New Hampshire, USA. 482 p.

DeStefano, S. In press. A review of the status and distribution of northern goshawks in New England. Journal of Raptor Research.

Doyle, F.I., and J.M.N. Smith. 1994. Population responses of northern goshawks to the 10-year cycle in numbers of snowshoe hares. Studies in Avian Biology 16: 122-129.

Frieswyk, T.S., and R.H. Widmann. 2000. **Forest Statistics for New Hampshire, 1983 and 1997. USDA Forest Service, Research Bulletin** NE-146. Newtown Square, Pennsylvania, USA.

Hargis, C.D., and B. Woodbridge. In press. A design for monitoring northern goshawks (*Accipiter gentilis*) at the bioregional scale. In Morrison, M.L. (editor). The Northern goshawk: A Technical Assessment of Its Status, Ecology, and Management. Studies in Avian Biology.

Janeway, E.C. 1994. Pages 50-51 *in* C.R. Foss (editor). Atlas of breeding birds in New Hampshire.New Hampshire Audubon, Concord, New Hampshire, USA. 414 pp.

Kennedy, P.L., J.M. Ward, G.A. Rinker, and J.A. Gessaman. 1994. Post-fledging areas in northern goshawk home ranges. Studies in Avian Biology 16: 75-82.

Leak, W.B. 1982. Habitat mapping and interpretation in New England. Research Paper NE-496. USDA Forest Service, Northeastern Forest Experiment Station, Broomall, PA.

Penteriani, V., and B. Faivre. 2001. Effects of harvesting timber stands on goshawk nesting in two European areas. Biological Conservation 101:211-216.

Reynolds, R.T. 1983. Management of western coniferous forest habitat for nesting accipiter hawks. USDA Forest Service, General Technical Report RM-102. Fort Collins, CO.

Reynolds, R.T., R.T. Graham, M.H. Reiser, R.L. Bassett, P.L. Kennedy, D.A. Boyce, Jr., G. Goodwin, R. Smith, and E.L. Fisher. 1992. Management recommendations for the northern goshawk in the southwestern United States. USDA Forest Service. General Technical Report, RM-217. Fort Collins, CO.

Reynolds, R.T., S.M. Joy, and D.G. Leslie. 1994. Nest productivity, fidelity, and spacing of northern goshawks in Arizona. Studies in Avian Biology 16: 106-113.

Speiser, R. 1992. Notes on the natural history of the northern goshawk. Kingbird 42:133-137.

Speiser, R., and T. Bosakowski. 1987. Nest site selection by northern goshawks in northern New Jersey and southeastern New York. Condor 89:387-394.

Speiser, R., and T. Bosakowski. 1991. Nesting phenology, site fidelity, and defense behavior of northern goshawks in New York and New Jersey. Journal of Raptor Research 25(4):132-135.

Squires, J.R., and R.T. Reynolds. 1997. Northern goshawks (*Accipiter gentilis*). In: The birds of North America, No. 298 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.

5.2 Data Sources

NatureServe. 2004. NatureServe Explorer. An online encyclopedia of life. <http://www.natureserve.org/explorer/servlet/NatureServe>. Accessed February

8, 2005.

New Hampshire Fish and Game Department. no date. Endangered and Threatened Species List. <http://www.wildlife.state.nh.us/Wildlife/Nongame/endangered_list.htm>. Accessed April 11, 2005.

New Hampshire Natural Heritage Bureau. 2005. Animal Tracking List. <http://www.nhdfl.org/formgt/nhiweb/Documents/w_animal.pdf> Accessed April 11, 2005.

USDA Forest Service. 2000. Regional Forester Sensitive Animals List. <http://www.fs.fed.us/r9/wildlife/tes/docs/rfss_animals.pdf>. Accessed April 11, 2005.

USDI Fish and Wildlife Service. 1999. Endangered and Threatened Wildlife and Plants List. 50 CFR 17.11. <http://www.fws.gov/endangered/50cfr_animals.pdf>. Accessed April 11, 2005.

SPECIES PROFILE

Grasshopper Sparrow

Ammodramus savannarum

Federal Listing: Not listed
State Listing: Threatened
Global Rank: G5
State Rank: S1
Author: Pamela D. Hunt, New Hampshire Audubon

Element 1: Distribution and Habitat

1.1 Habitat Description

In the eastern United States, grasshopper sparrows use dry fields with sparse grasses (usually bunch grasses) and weeds, few shrubs, and patches of bare ground. Although areas with more than 35% shrub cover are rarely used, a few scattered shrubs or other tall plants provide important song perches. Airports, abandoned agricultural fields, blueberry barrens, capped landfills, and sandplain grasslands provide suitable habitat (Vickery 1996). In many parts of the East, the species will also use reclaimed surface mines (Whitmore 1980).

The grasshopper sparrow prefers large fields over 40 ha (100 ac), although the species will use sites as small as 12 ha (30 ac). However, not all large grasslands may be used. In Maine, sparrows occupied only 50% of suitable sites over 100 ha (250 ac; Vickery et al. 1994), and in Massachusetts only 1% of hayfields and 8% of barrens over 64 ha (160 ac) were occupied (Vickery et al. 1994).

In the Midwest and Great Plains, grasshopper sparrows use smaller fields more regularly, but this may vary across regions (Helzner and Jelinski 1999, Heckert 1994, Davis 2004). Davis (2004) also determined that sparrows were less likely to occur in patches with a perimeter-area ratio less than 0.018 m/m^2. This result is corroborated by work in Minnesota where sparrow nests were more likely to be located at least 45 m from a forest edge (Johnson and Temple 1986).

Habitat in New Hampshire is generally of the sparse dry grassland type described above. It is possible that sparrow rarity, and the patchiness of available habitat in the Northeast, have been conflated with choosiness on the part of the bird. Indeed, near the core of its range, less suitable habitat is more often occupied.

1.2 Justification

Although never common in New Hampshire, grasshopper sparrows have declined significantly since the 1960s (Foss 1994, New Hampshire Bird Records (NHBR)). The species is now restricted to 5 sites, of which at least 3 are seldom used (table 1). Their peak distribution in the state probably corresponded to the height of forest clearing for agriculture. There are insufficient data from the Breeding Bird Survey (BBS) to evaluate grasshopper sparrow population trends in the last two decades.

The species is of conservation concern throughout the Northeast, where range contractions and declines have been observed since the mid-1900s (Laughlin and Kibbe 1985, Andrle and Carroll 1988, Zeranski and Baptist 1990, Veit and Petersen 1993). Breeding Bird Survey data indicate a range-wide decline of 3.9% per year, and a 4.9% annual decline in the Northeast (Sauer et al. 2004).

1.3 Protection and Regulatory Status

This species is federally protected by the Migratory Bird Treaty Act, which prevents the killing of most non-game birds and collection of their nests or eggs. The New Hampshire Endangered Species Conservation Act (RSA 212) protects grasshopper sparrows.

1.4 Population and Habitat Distribution

Since the 1960s, most of New Hampshire's grasshop-

per sparrows have been sighted in the Merrimack Valley south of Concord and in the Great Bay area (figure 1). Records are scant in the southern Connecticut Valley and Pemigewasset Valley/Squam Lake areas, and many are of single non-breeding birds. The state probably supports roughly 25 pairs of sparrows, with 80% of these at the Concord and Keene Airports. The regional population numbers approximately 500, with most at 2 locations in Massachusetts (Jones et al. 2001).

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

A habitat map for grasshopper sparrow was based on the overall habitat map for extensive grasslands developed by New Hampshire Fish and Game (J. Oehler personal communication) (see Extensive Grasslands habitat profile). Potential grasshopper sparrow habitat within the population of extensive grassland polygons was selected as follows:

- Only the southern half of the state was considered (south of White Mountains and Vermont Piedmont ecoregions)
- Sites with a perimeter-area ratio greater than 0.02 m/m^2 were eliminated based on the work of Helzer and Jelinski (1999)
- Remaining patches were placed in 1 of 3 size categories, in order of increasing suitability: (1) < 40 ha, (2) ≥ 40 ha and < 100 ha, (3) >100 ha
- Sites within the lower Connecticut River Valley (2 towns east of river, north to Claremont), Merrimack River Valley (2 towns to either side of river, north to Concord), and Seacoast (roughly the Coastal Lowlands ecoregion) were given priority, based on more regular historic and current records of grasshopper sparrows

Ideally, such a habitat model would also consider the type of soil underlying a grassland, since grasshopper sparrows tend to occupy sites growing on sandy or otherwise poor soils. However, because digital soils data are not available for all parts of the state, this feature was not included.

1.7 Sources of Information

Basic natural history information in this profile was largely gathered from the literature cited in element 5. Data on grasshopper sparrow distribution in New Hampshire were compiled from NHBR, a database maintained by the New Hampshire Audubon.

1.8 Extent and Quality of Data

Because surveys of historic grasshopper sparrow locations have been conducted in recent years, our understanding of the species' abundance at known sites is relatively good. However, most of the state's airfields are closed to the public, and the "discovery" of the large population at the Keene Airport in 2003 is testament to the potentially large gaps in our knowledge of its statewide distribution.

1.9 Distribution Research

A comprehensive survey of suitable habitat (including area requirements)—particularly at airfields—in southern New Hampshire is needed. Such a survey should include ground inventories of potential habitat identified with maps and GIS. Sites identified using the habitat model described above should be given priority, as should airports, capped landfills, and other extensive areas of "disturbed" habitat that may not have been identified in the above model.

Element 2: Species/Habitat Condition

2.1 Scale

Based on the known distribution, it is reasonable to treat grasshopper sparrows at the scale of occupied (or potentially occupied) habitat patches. These are all discrete units on the landscape, and for known sites there is generally some information pertaining to the level and types of threats that occur there. Since these sites represent a wide variety of ownerships and management needs, they are best treated independently. The proposed conservation planning units for grasshopper sparrows in New Hampshire are as follows:

- Concord Airport, Concord
- Keene Airport, Swanzey
- Pease Tradeport, Portsmouth/Newington

- Manchester Landfill, Manchester
- Derry Landfill, Derry
- Cemetery Fields, Amherst
- Old Mill Road, Lee
- Anheuser-Busch fields, Merrimack
- Souhegan River Fields, Amherst

Two sites in the lower Merrimack River Valley that have been unoccupied since the early 1980s may still support suitable habitat and should be considered potential grasshopper sparrow sites. These sites are Manchester and Nashua airports.

2.2 Relative Health of Populations

Most grasshopper sparrow populations have not been sufficiently monitored to determine how they vary in size or productivity. Four sites (Concord, Pease, Anheuser-Busch, Cemetery Fields) have supported the species consistently for the last decade, and population estimates do not seem to vary (Hunt 2003). Although data are limited, it is suspected that the Keene Airport also fits in this category.

2.3 Population Management Status

Management is not occurring at the level of sparrow populations at any site in New Hampshire. See element 2.6 for status of habitat management activity at sites where the species occurs.

2.4 Relative Quality of Habitat Patches

Of the sites identified in section 2.1, Concord, Keene, and Pease airports are considered high quality. All contain extensive acreage of suitable grassland or grassy heath. Habitat management is already in place at Pease to benefit upland sandpipers, and the mowing schedule should benefit sparrows. As a result, the low numbers and sporadic occurrence of sparrows cannot be attributed to mowing. Mowing at the Concord airport does not currently occur during the sparrows' breeding season, nor does it occur at the most important sparrow areas at the Keene airport. However, alteration of the mowing regime in other areas of the Keene airfield would probably benefit the species. At 2 other reliable sparrow sites—Cemetery Fields and Anheuser-Busch—mowing does not interfere with sparrows. However, these 2 sites are relatively small and not as critical as the large airfields. The remaining small sites would benefit from altered mowing practices, and these may be relatively easy to implement at the capped landfills.

2.5 Habitat Patch Protection Status

None of the units defined in section 2.1 is protected. Grassland habitat protected by Great Bay National Wildlife Refuge is adjacent to that at the Pease Airfield, but grasshopper sparrows have not been documented there. Management agreements or memoranda of understanding are in place at the Concord and Pease airports and at Cemetery Fields.

2.6 Habitat Management Status

Most of the sites currently known to support grasshopper sparrow populations are managed in either a beneficial or neutral manner. Such activities include late mowing (Anheuser-Busch, Cemetery Fields, Concord Airport, parts of Keene Airport) and partial mowing timed to benefit upland sandpipers (Pease Tradeport). At Cemetery Fields, there is a Memorandum of Agreement between the Town of Amherst Cemetery Trustees and NHFG that allows the latter to manage the site in a manner beneficial to grasshopper sparrows. Specifically, each half of the site will be mowed on alternate years and mowing will not occur between 15 May and 7 August. The management agreement for the Concord Airport (Fuller et al. 2003) stipulates that safety areas at the airport not be mowed until after 1 October, and that adjacent areas be mowed every 3 years. Because of the poor conditions at this site, such a mowing regime is sufficient to prevent excessive invasion by woody shrubs. At Pease, mowing of safety zones is initiated before 1 May, but all remaining areas are not mowed until August or later. At the smaller sites such as capped landfills and old gravel pits, mowing is not currently done in a manner compatible with maintaining grasshopper sparrow populations, although at least 1 land manager (Manchester landfill) is amenable to implementing such management. Although areas of the Keene Airport that support the majority of its sparrow population are not mowed until late in the season, sparrows do use areas that are mowed more regularly. Implementation of a mowing protocol similar to that at Pease may ultimately benefit birds at

Keene without detracting from the airport's need to comply with safety regulations.

2.7 Sources of Information

General data on habitat condition for grasshopper sparrows were compiled from the literature. Information on management activity at specific sites was obtained through site visits, discussions with pertinent parties, or existing management plans or agreements.

2.8 Extent and Quality of Data

At sites where grasshopper sparrows have been actively monitored in the last decade, the data on population size and habitat condition are of relatively high quality. A thorough assessment of grasshopper sparrow status in New Hampshire will require access to large areas of suitable habitat that have not been surveyed, particularly larger airfields in the southern half of the state.

2.9 Condition Assessment Research

At sites where grasshopper sparrows are know to occur, monitoring will determine if management affects abundance and productivity. Mapping singing locations or territories can inform managers of which areas are being used and may help determine if birds are breeding or simply wandering among patches of habitat.

Element 5: References

5.1 Literature

Andrle, R.F., and J.R. Carroll. 1988. The Atlas of Breeding Birds in New York State. Cornell University Press, Ithaca, New York, USA.

Davis, S.K. 2004. Area sensitivity in grassland passerines: effects of patch size, patch shape, and vegetation structure on bird abundance and occurrence in southern Saskatchewan. Auk 121: 1130-1145.

Foss, C.R. 1994. Atlas of Breeding Birds of New Hampshire. New Hampshire Audubon. Concord, New Hampshire, USA.

Fuller, S., C. Goulet, and D. Hayward. 2003. Habitat management and monitoring plan for Concord Municipal Airport. Final Draft: April 21, 2003. New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

Heckert, J.R. 1994. The effects of habitat fragmentation on mid-western grassland bird communities. Ecological Applications 4:461-471.

Helzer, C.J., and D.E. Jelinski. 1999. The relative importance of patch area and perimeter-area ratio to grassland breeding birds. Ecological Applications 9:1448-1458.

Hunt, P.D. 2003. Status and Conservation of the Grasshopper Sparrow in New Hampshire. Report to the New Hampshire Fish and Game Department. New Hampshire Audubon, Concord, New Hampshire, USA.

Hunt, P.D. 2004. Grasshopper sparrow monitoring protocol for New Hampshire. Report to the New Hampshire Fish and Game Department. New Hampshire Audubon, Concord, New Hampshire, USA.

Johnson, R.G. and S.A. Temple. 1986. Assessing habitat quality for birds nesting in fragmented tallgrass prairies. Pages 246-249 *in* Wildlife 2000: Modeling habitat relationships of terrestrial vertebrates (J. Verner, M.L. Morrison, and C.J. Ralph, eds.). University of Wisconsin Press, Madison, Wisconsin, USA.

Jones, A.L., and P.D. Vickery. 1997. Distribution and population status of grassland birds in Massachusetts. Pp. 187-199 *in* Grasslands of northeastern North America: Ecology and conservation of native and agricultural landscapes (P. D. Vickery and P. W. Dunwiddie, eds.). Massachusetts Audubon Society, Lincoln, Massachusetts, USA.

Jones, A.L., G. Shriver, and P.D. Vickery. 2001. Regional inventory of grassland birds in New England and New York, 1997-2000. Report to National Fish and Wildlife Foundation. Massachusetts Audubon Society, Lincoln, Massachusetts, USA.

Laughlin, S.B., and D.P. Kibbe. 1985. The Atlas of Breeding Birds of Vermont. University Press of New England, Hanover, New Hampshire, USA.

Sauer, J.R., J.E. Hines, and J. Fallon. 2004. The North American Breeding Bird Survey, Results and Analysis 1966-2003. Version 2004.1, USGS Patuxent Wildlife Research Center, Laurel, Maryland, USA.

Veit, R.R., and W.R. Petersen. 1993. Birds of Massachusetts. Massachusetts Audubon Society, Lincoln, Massachusetts, USA.

Vickery, P.D. 1996. Grasshopper Sparrow (A*mmodramus savannarum*). *In* The Birds of North America, No. 239 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.

Vickery, P.D., M.L. Hunter, Jr., and S.M. Melvin. 1994. Effects of habitat area on the distribution of grassland birds in Maine. Conservation Biology 8: 1087-1097.

Vickery, P.D., M.L. Hunter, Jr., and J.V. Wells. 1999. Effects of fire and herbicide treatment on habitat selection in grassland birds in Maine. Pp. 149-159 *in* Ecology and conservation of grassland birds of the Western Hemisphere (P.D. Vickery and J.R. Herkert, eds.). Studies in Avian Biology 19.

Whitmore, R.C. 1980. Reclaimed surface mines as avian habitat islands in the eastern forest. American Birds 34: 13-14.

Zeranski, J.D., and T.R. Baptist. 1990. Connecticut Birds. University Press of New England, Hanover, New Hampshire, USA.

5.2 Data Sources:

NHBR. New Hampshire Bird Records, New Hampshire Audubon, Concord, NH.

Element 6: List of Figures

Figure 1. Distribution of breeding season records of grasshopper sparrow in New Hampshire 1960-2004. Towns are coded according to the number of years in each period when sparrows were reported: yellow = 1, red = 2-5, black = > 5 (data from NHBR and Hunt 2003). Records of birds in late May but not later in the season are excluded as being possible migrants.

Table 1. Sites supporting grasshopper sparrows in at least 2 years during the period 1990 to 2004 (data from NHBR and Hunt 2003). Sites believed to support the species on a consistent basis are indicated with an asterisk.

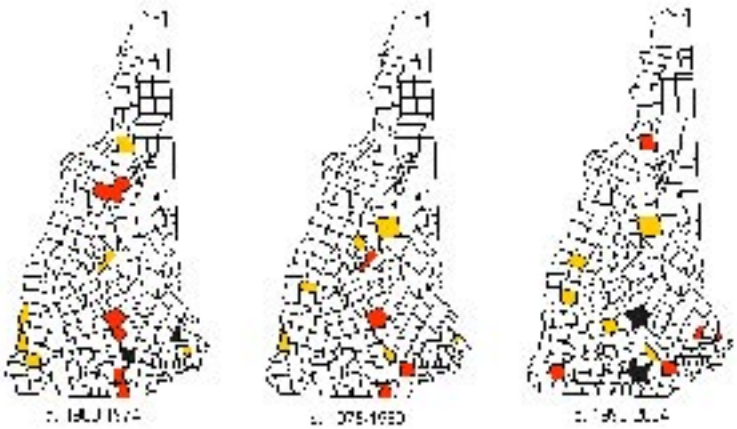


Figure 1. Distribution of breeding season records of grasshopper sparrow in New Hampshire 1960-2004. Towns are coded according to the number of years in each period when sparrows were reported: yellow = 1, red = 2-5, black = > 5 (data from NHBR and Hunt 2003). Records of birds in late May but not later in the season are excluded as being possible migrants.

Town	Site	Occupancy	abundance
Concord	Concord Airport*	1997 onward	10± pairs
Merrimack	Anheuser-Busch fields*	1996 onward	1-3 pairs
Amherst	Cemetery Fields*	1996 onward	1-2 pairs
Newington/ Portsmouth	Pease Airfield*	1995 onward	single males
Amherst	Souhegan River fields	1994,1999, 2003	male or pair
Derry	old landfill	1999 and 2003	single males
Lee	gravel pit on Old Mill Rd.	2001 and 2002	single males
Swanzey	Keene Airport*	2003 and 2004	10± pairs

Table 1. Sites supporting grasshopper sparrows in at least 2 years during the period 1990 to 2004 (data from NHBR and Hunt 2003). Sites believed to support the species on a consistent basis are indicated with an asterisk.

SPECIES PROFILE

Pied-billed Grebe

Podilymbus podiceps

Federal Listing: Not listed
State Listing: Endangered
Global Rank: G5
State Rank: S1B
Author: Pamela D. Hunt, New Hampshire Audubon

Element 1: Distribution and Habitat

1.1 Habitat Description

Pied-billed grebes inhabit a range of wetlands, especially ponds or slow portions of streams with dense stands of emergent vegetation (Muller and Storer 1999). In the Northeast, they also appear to prefer areas with submerged aquatic beds (Gibbs et al. 1991). Nearby open water is needed for foraging and take-off prior to flight; sites in Maine averaged at least 34% open water (Gibbs et al. 1991). In Maine, most wetlands occupied by the species were those created by beavers (*Castor canadensis*) or by humans (Gibbs and Melvin 1992).

Two additional features appear critical in nest site selection: water depth of at least 25 cm (10 in) and emergent stem densities of at least 10 cm^2/m^2 (0.15 in^2/ft^2) in adjacent wetland patches (Muller and Storer 1999). Home range size is variable, and may depend on habitat type and quality. In the prairie pothole region, home ranges average between 1 and 3.5 ha (2.5-8.75 ac, Muller and Storer 1999). In Maine, however, grebes rarely breed in wetlands less than 5 ha (12 ac) in size (Gibbs et al. 1991, Gibbs and Melvin 1992), suggesting that home range needs may be larger in this part of the country. Alternatively, lower population densities in the Northeast may allow grebes to be more selective since available habitat is not saturated.

All sites in New Hampshire where the species has occurred regularly contain open water and surrounding cattail (*Typha* sp.) marsh and may include ponds or small lakes (Center Harbor, Jefferson, Lyman, Tuftonboro), beaver ponds (Nottingham, Hopkinton, Durham), fens or slow streams (Alton, Danbury, Pittsburg, Sutton), impoundments (Dummer, Peterborough, Springfield, Wentworth, Newington), sewage lagoons (Exeter, Rochester), and backwaters of larger lakes (Errol, Hebron). With the exception of sewage ponds, most pied-billed grebe habitat includes some woody vegetation such as alder (*Alnus* sp.) or buttonbush (*Cephalanthus occidentalis*).

1.2 Justification

Lacking consistent statewide coverage makes it difficult to evaluate changes in New Hampshire's pied-billed grebe population, although sighting data indicate a decline (Foss 1994, NHBR). The species has shown declines over much of its range elsewhere in the Northeast and is absent from large areas of apparently suitable habitat in Vermont (Laughlin and Kibbe 1985) and Massachusetts (Petersen and Meservey 2003). In New York, although declines have been noted (Andrle and Carroll 1988), recent atlas data do not suggest any change in the species' range, and it may even be increasing slightly (New York State Department of Environmental Conservation 2004). The latter trend may reflect a general increase in the central part of the of the species' range based on the BBS (see below). In addition, the loss and degradation of wetlands in most of New England make the species particularly vulnerable to decline.

Winter abundance data from the CBC (National Audubon Society 2002) suggest that grebe populations in the eastern United States have been stable or slightly increasing since the mid-1960s. The exception was a pronounced increase during the 1990s that was followed by a consistent decline between 2000 and 2004. The latter has resulted in grebes returning to pre-increase levels or slightly higher along the

Gulf and South Atlantic coasts. Grebes are probably better surveyed than many other species on the CBC, so these broad regional trends may accurately reflect trends in breeding populations, and in this case corroborate the increases noted by the BBS. However, such increases do not preclude declining populations in the Northeast (including New Hampshire), since the wintering locations of the region's breeding population are unknown.

1.3 Protection and Regulatory Status

- Migratory Bird Treaty Act (1918)
- New Hampshire Endangered Species Conservation Act (RSA 212A)
- See Marsh and Shrub Wetlands habitat profile for regulations pertaining to wetland habitats

1.4 Population and Habitat Distribution

The pied-billed grebe occurs throughout the state, but has always been rare and local in distribution (Foss 1994). Old regional ornithological works variously describe the species as a breeder, primarily a migrant, or absent, and a lack of comprehensive statewide coverage until relatively recently makes it difficult to ascribe any clear pattern to its distribution and abundance. Recent records of the species have come from all over the state, with the exception of the southwest and the White Mountains (figure 1). Within this range, there are 7 areas of more regular occurrence (see also elements 2.1 and 2.2):

- Extensive wetlands in Coos County
- Small wetlands in the Connecticut River valley between Hanover and Littleton
- Ponds around the northern portion of Lake Winnipesaukee
- Several larger wetlands in west-central New Hampshire (centered on northwestern Merrimack County)
- Upper Merrimack River Valley
- Southern Piscataquog River watershed
- Southeastern New Hampshire away from the immediate coast

Not all these areas have been occupied consistently, however, as a comparison of figures 1a and 1b indicates. Between 1984 and 1993, records were somewhat concentrated in regions 1, 3, 4, and 5, and between 1994 and 2003 most records were from regions 1, 4, 6, and 7. Over the last 25 years (figure 1c), only 7 sites (indicated by black towns) have been used consistently by pied-billed grebes. Even at these sites, there are few records from 2000 onward. Whether this paucity reflects the species' actual absence or simply a lack of coverage is unknown.

Grebes show a similarly patchy distribution elsewhere in New England. Massachusetts probably hosts fewer than 20 pairs (Petersen and Meservey 2004), and the species is absent from apparently suitable habitat in much of the Champlain Valley of Vermont (Laughlin and Kibbe 1985). Grebes are more common in Maine, where one study documented them in 17% of available wetlands (Gibbs et al. 1991) and in 22% of Breeding Bird Atlas blocks (Adamus 1988).

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

A pied-billed grebe habitat model for New Hampshire was modified from a model developed by USFWS Gulf of Maine Project (Banner and Schaller 2001). An NHNHB composite wetland map provided the base map, in which contiguous wetlands were grouped into complexes and given attributes related to wetland size, proportions of different wetland types, and a number of additional variables related to threat and condition (see Marsh and Shrub Wetlands habitat profile). Potential grebe habitat was selected from the larger wetland data set using the following criteria ("wetlands" refers to "wetland complexes" as defined in the wetland habitat plan):

1. Elimination of all wetlands less than 5 hectares (12.5 acres).
2. Lacustrine wetlands (lakes: all wetland types beginning with "L") were added to adjacent wetlands in the New Hampshire Natural Heritage Inventory (NHNHI) wetland complex map. Three coverage values were recalculated for each resulting wetland:

a. Percent open water (lacustrine and "other," which includes wetlands coded as PAB and PUB)
b. Percent emergent marsh (PEM)
c. Percent shrub wetland (PSS)

d. Elimination of wetlands with less than 25% or greater than 90% open water
e. Elimination of wetlands with greater than 90% shrub
3. Wetlands greater than 10 hectares (25 acres) were given a higher ranking than wetlands less than 10 ha (as per Gibbs et al. 1991).

Of 50 pied-billed grebe sites in the NHNHI database, this model correctly identified 24. Several sites were not identified because they are located in semi-isolated wetlands connected to lakes or rivers. As a result, they were eliminated from the model at step 3. Other grebe locations not captured by the model include wetlands that were not identified by the National Wetland Inventory (NWI) maps, or wetlands whose current condition is different from that coded on the NWI maps. For instance, some sites currently contain an area of open water because of recent beaver activity, whereas the NWI maps indicate a continuous emergent marsh or shrub swamp. Because of the inaccuracies in the underlying NWI data, and difficulties related to wetlands associated with large water bodies, a modeling approach is not a valuable tool for identifying potential grebe habitat at this time.

1.7 Sources of Information

Basic natural history information in this profile was largely gathered from the literature cited in element 5. Habitat modeling was informed by the Gulf of Maine Program (Banner and Schaller 2001) and wetland mapping conducted by NHNHB. Data on grebe distribution in New Hampshire were compiled from NHBR, a database maintained by NHA.

1.8 Extent and Quality of Data

Information on pied-billed grebe distribution in New Hampshire is limited by habitat inaccessibility and inconsistency of coverage. Because grebes have a history of both patchiness and site fidelity, the discontinuation of regular visits to a given site can significantly alter our broader knowledge of current statewide distribution. Thus, the absence of reports from a known breeding site cannot be taken as evidence of the species' absence.

1.9 Distribution Research

To fill the significant gaps in the knowledge of grebe distribution in New Hampshire, it would be valuable to implement a statewide monitoring program for this and other wetland birds. Surveys should target known or high-potential sites (as identified by habitat mapping) and use methods consistent with other efforts in the region. Marsh bird monitoring is a priority project in BCR 30, and a coordinated regional effort would be invaluable in understanding trends in distribution and abundance of this and other wetland species throughout the Northeast.

Element 2: Species/Habitat Condition

2.1 Scale

New Hampshire's known pied-billed grebe locations are here divided into three conservation units based on the type of management known to be in place and the potential for future management. The 24 recently active pied-billed grebe sites in New Hampshire were placed into one of these three categories based on available information (table 1). These three types are:

- **Impoundment-associated wetlands.** These wetlands are associated with some sort of water control structure, thus theoretically allowing water levels to be regulated. Included in the category are many Wildlife Management Areas, Lake Umbagog, Pontook Reservoir, and reservoirs associated with flood control projects.
- **Sewage ponds.** In some wastewater treatment facilities, ponds associated with certain stages of treatment contain emergent vegetation that mimics the structure of natural wetlands. Grebes have used such habitats in the past, and inactive sewage ponds may retain suitable habitat and thus the potential to attract grebes.
- **Natural wetlands.** All remaining wetlands in the state are in this category, which includes those associated with the backwaters of larger rivers (Reed's Marsh, Town?), beaver ponds (Nottingham, Durham), small ponds and lakes (Cherry Pond, Copp's Pond Towns?), and bogs and fens (Scott's Bog, Town?).

2.2 Relative Health of Populations

In the absence of consistent data, populations in a given unit can only be evaluated indirectly, through a combination of population persistence and the number of occupied sites within a unit. Table 1 includes all sites where grebes were reported during the breeding season in at least 2 different years within any 5-year period since 1980. Sites shaded gray meet the criteria of a) grebes present in at least 4 years since 1980, b) confirmed breeding in at least 1 year, and c) grebes present in at least 1 year since 1990. Sites are grouped by region as described in element 2.1.

Twelve sites meet these criteria and could thus be considered "priority" grebe locations in the state. Of these sites, only Copp's Pond, Cascade Marsh, the Rochester lagoons, and the Umbagog marshes have hosted more than a single pair of grebes in a given year, and even at these sites more than a single pair is rare. Potential sites identified through habitat mapping cannot be reliably evaluated for population health, although their overall condition can be assessed using the same geographic information system (GIS) methods as developed for wetland habitats as a whole.

2.3 Population Management Status

The pied-billed grebe is not currently managed in New Hampshire.

2.4 Relative Quality of Habitat Patches

There are no data with which habitat quality could be evaluated for this species. The habitat model, which generates scores from 0.5 to 1.5, could be used as an approximation of habitat quality on a statewide scale.

2.5 Habitat Patch Protection Status

Of the 24 recent locations for the species in table 1, 15 (62.5%) are protected in whole or in part by easement or fee-simple. Of protected areas, 7 are impoundments (conservation unit A) and 8 are natural wetlands (conservation unit B). Protected status of potential locations will be unknown until such locations have been identified.

2.6 Habitat Management Status

At Cascade Marsh, management of water levels to benefit pied-billed grebes has been in place since the 1980s (E. Robinson, New Hampshire Fish and Game (NHFG), personal communication). Water levels at this site are first lowered after ice goes out to levels suitable for grebes while still allowing for vegetation growth. This water level is maintained through the summer and is raised in September when grebes are no longer nesting. It is feasible to apply similar water level management at 3 additional grebe sites in State Wildlife Management Areas (Hirst, MacDaniel's Marsh, Danbury Bog; TOWNS?? E. Robinson, NHFG, personal communication).

2.7 Sources of Information

Data on site occupancy were compiled from NHBR. Information pertaining to management at some grebe sites (state wildlife management areas) was obtained from the NHFG (E. Robinson, NHFG, personal communication).

2.8 Extent and Quality of Data

As indicated above, data on pied-billed grebes and their habitat in New Hampshire are inconsistent. There are no data on management activity at the majority of sites where the species is known to occur.

2.9 Condition Assessment Research

In the absence of comprehensive information on grebe distribution in the state, any assessment of population/habitat condition would be premature. When grebe distribution is better understood, additional research will be useful in determining why apparently suitable potential habitat is unoccupied. However, even this research will need to consider the regionally low population size, because the species' absence from a site may just as easily reflect low colonization rates as low habitat quality.

Element 3: Species and Habitat Threat Assessment

3.1.1 Altered Hydrology (Water Withdrawal and Drawdowns)

A) Exposure Pathway
Many suitable wetlands are located above man-made dams. The purpose of such dams includes creation of impoundments for recreation, hydroelectric power, flood control, and wildlife management. If water levels rise or fall significantly during the nesting season, grebe nests may be flooded or grounded. Nest flooding is likely to result in either egg or nestling mortality and may cause adults to abandon the nest. If grebes do not abandon a nest after water levels fall, the nest may be more exposed to terrestrial predators. In either case, changes in vegetation following a change in water level may also make the nest more visible to predators.

B) Evidence
Although anecdotal evidence is conflicting, studies suggest that changing climatic conditions and variable water levels are to blame for a significant percentage of unsuccessful nests (Glover 1953, F. von Mertens, NHBR, observer, personal communication). These studies corroborate suspicions that lower water levels increase threats from terrestrial predators.

3.2 Sources of Information

Information on threats to pied-billed grebes was taken from the literature and from lists of threats developed as part of regional bird conservation planning (BCRs 14 and 30, etc.). Threats developed for Marsh and Shrub Wetlands profiles were also used with modification in development of the threat rankings for pied-billed grebe.

3.3 Extent and Quality of Data

In the absence of detailed study at the vast majority of pied-billed grebe breeding locations in New Hampshire, it is difficult to provide specifics on how any particular threat affects the species here. Data are similarly lacking on most potential broad-based threats.

3.4 Threat Assessment Research

Although various environmental pollutants have been proposed as threats to pied-billed grebes (Gibbs and Melvin 1992), there are few, if any, data on the presence and effects of such contaminants on grebe populations. Given increasing concern for the effects of mercury in other aquatic birds, it may be valuable to expand mercury research to grebes and other marsh-nesting birds.

Hunting and fishing in wetlands has the potential to introduce lead shot and sinkers where they may be ingested by grebes. However, ingestion and mortality have not been documented in pied-billed grebes or any other North American grebe species, though lead is recognized as a major source of mortality in loons and some fish-eating raptors (H. Vogel, Loon Preservation Committee, personal communication). Nonetheless, given the smaller size and secretive nature of grebes, mortality is almost certainly underdocumented.

Additional research is necessary on the effects of human disturbance, particularly that caused by small watercraft (larger and faster watercraft are less of an issue in areas used by grebes). There are currently few, if any, data on the incidence of nest abandonment or failure caused by such watercraft. In the absence of such data it is premature to propose conservation actions such as no-entry zones for this species. Finally, although grebes are known to use wetlands dominated by non-native, invasive plants (Esler 1992, Whitt et al. 1999), there are few data on their productivity in such habitats or on how regularly they are occupied.

Element 4: Conservation Actions

4.1.1: Stabilize water levels during the nesting season at reservoirs or impounded areas that support pied-billed grebes. This action fits within the "Restoration and Management" category, but also has elements of "Regulation and Policy," as follows. Appropriate water level management as described below should be instituted as a standard NHFG activity at state Wildlife Management Areas that support or potentially support grebes. It would also be beneficial to determine ownership and management policy of dams associated with other grebe sites, and to improve grebe nesting success at these locations.

A) Threat: Altered Hydrology

B) Justification
If water levels are maintained at levels present during nest initiation, the threat is eliminated, along with attendant stresses. The action can be implemented

at single locations where the threat can potentially occur

If the action is implemented at the appropriate time, the affected population will benefit immediately.

Given that water levels can be controlled, careful monitoring of both local conditions and the status of a grebe nesting attempt will allow for either additional adjustment of water level (e.g., if high rains cause water to rise) or cessation of the action (e.g., if the grebes abandon for other reasons and the action is no longer necessary)

C) Conservation Performance Objective

This action requires knowledge of the presence and potential breeding of pied-billed grebes at a location where water levels are subject to human manipulation. At the least, the potential for implementation of this action should be acknowledged at sites where it is possible and where there is a history of use by pied-billed grebes. This action will need to be implemented no later than completion of nest-building activity, when the position of the grebe nest above the bottom will be relatively fixed. Water levels will need to be maintained at that level until the young grebes have left, or are likely to have left, the nest.

D) Performance Monitoring

Implementation of this action can be monitored by checking water levels over the course of the breeding season. With the exception of rain-induced flooding (see below), there should be no significant changes in water level between May and September.

E) Ecological Response Objective

Increase likelihood that grebes nesting in impounded areas produce young. Increased productivity in turn increases the pool of potential recruits into the New Hampshire breeding population.

F) Response Monitoring

In addition to local monitoring of productivity at action sites, it will be necessary to continue monitoring grebes at a broader scale to determine if there are any effects on the statewide population. Such monitoring could be more intensive at suitable wetlands closer to the implementation site (although there are no data on natal dispersal distances in this species).

G) ImplementationAt the one site where this action has been implemented (Cascade Marsh Wildlife Management Area, Sutton) water levels were lowered in April – after ice out – to levels suitable for pied-billed grebes. Although site-specific conditions may result in this level varying among sites, enough water should remain to allow for nest site selection (minimum 25 cm), foraging, and take off. At least 34% of the total wetland area should remain open water of sufficient depth.

Water levels should be maintained at this level through the summer and allowed to rise in September. Although this action maintains water level at a depth and extent suitable to grebes, it can be negated by rain that floods impounded areas too quickly for additional water to be released. Such events can destroy grebe nests or cause abandonment, but are beyond the scope of this action. Depending on location, implementation of this Action may require cooperation between state agencies (NHFG, Department of Environmental Services, Department of Resource and Economic Development), power companies, the USACE, and private citizens.

H) Feasibility

In most cases, the partnerships described above already exist in some form. In addition, this action is inexpensive. Where impoundments are associated with hydroelectric dams, maintenance of water levels may simply not be possible. Many impoundments are drawn down to during the summer to encourage vegetation that will provide food for waterfowl in the fall. When this was done at Cascade Marsh (Town?), increased vegetation did not deleteriously affect waterfowl habitat= (E. Robinson, NHFG, personal communication).

4.2 Conservation Action Research

Given the patchy distribution of pied-billed grebes in New Hampshire and the highly variable nature of the sites they occupy, it is not clear that any one conservation action will have a dramatic effect on the population. The majority of occupied sites are already conserved in some manner, and as a result the only broadly applicable conservation strategy is the maintenance of appropriate water levels at sites where this is possible. In light of this, the most important

conservation action of this and other wetland birds in New Hampshire is the implementation of a standardized inventory and monitoring plan (coordinated on a regional scale). Such a program would provide much-needed information on distribution and population trends at a larger scale – a scale that is perhaps more indicative of the health of this species' population in the northeast. Once baseline data are collected, other conservation actions may be reconsidered.

Element 5: References

5.1 Literature:

Adamus, P.R. 1988. Atlas of breeding birds in Maine, 1978-1983. Maine Department of Inland Fisheries and Wildlife, Augusta, Maine, USA.

Andrle, R.F., and J.R. Carroll. 1988. The Atlas of breeding birds in New York state. Cornell University Press, Ithaca, New York, USA.

Banner, A., and S. Schaller. 2001. U.S. Fish and Wildlife Service Gulf of Maine Watershed Habitat Analysis. USFWS Gulf of Maine Program, Falmouth, Maine, USA. (http://r5gomp.fws.gov/gom/habitatstudy/Gulf_of_Maine_Watershed_Habitat_Analysis.h tm)

Chabrek, R.H. 1963. Breeding habits of the pied-billed grebe in an impounded coastal marsh in Louisiana. Auk 80: 447-452.

Esler, D. 1992. Habitat use by piscivorous birds on a power plant cooling reservoir. Journal of Field Ornithology. 63:241-249.

Foss, C.R. 1994. Atlas of breeding birds of New Hampshire. New Hampshire Audubon. Concord, New Hampshire, USA.

Gibbs, J.P., J.R. Longcore, D.G. McAuley, and J.K. Ringleman. 1991. Use of wetland habitats by selected nongame water birds in Maine. U.S. Fish and Wildlife Service, Fish and Wildlife Research Publication. 9.

Gibbs, J.P., and S.M. Melvin. 1992. Pied-billed Grebe, *Podilymbus podiceps*. Pages 31-49 *in* (K. J. Schnieder and D. M. Pence, eds.) Migratory nongame birds of management concern in the Northeast. U.S. Department of the Interior, Fish and Wildlife Service, Newton Corner, Massachusetts, USA.

Glover, F.A. 1953. Nesting ecology of the pied-billed grebe in northwestern Iowa. Wilson Bulletin 65: 32-39.

Laughlin, S.B., and D.P. Kibbe. 1985. The atlas of breeding birds of Vermont. University Press of New England, Hanover, New Hampshire, USA.

Muller, M.J., and R.W. Storer. 1999. Pied-billed Grebe (*Podilymbus podiceps*). *In* (A. Poole and F. Gill, eds.) The Birds of North America, No. 410. The Birds of North America, Inc., Philadelphia, Pennsylvania, USA.

New York State Department of Environmental Conservation. 2004. New York State breeding bird atlas website. www.dec.state.ny.us/apps/bba/results. Accessed 2005, April 7.

Petersen, W.R., and W.R. Meservey. 2003. Massachusetts breeding bird atlas. Massachusetts Audubon Society, Lincoln, Massachusetts, USA.

Sauer, J.R., J.E. Hines, and J. Fallon. 2003. The North American breeding bird survey, results and analysis 1966-2002. Version 2003.1, U.S. Geological Survey Patuxent Wildlife Research Center, Laurel, Maryland, USA.

Whitt, M.B., H.H. Prince, and R.R. Cox, Jr. 1999. Avian use of purple loosestrife dominated habitat relative to other vegetation types in a Lake Huron wetland complex. Wilson Bulletin 111: 105-114.

5.2 Data Sources:

National Audubon Society (2002). The Christmas Bird Count Historical Results [Online]. http://www.audubon.org/bird/cbc. Accessed 2005 February 8.

New Hampshire Bird Records, New Hampshire Audubon, Concord, New Hampshire, USA.

Element 6: List of Figures

Figure 1. Distribution of recent (1980-2004) breeding season records of pied-billed grebe in New Hampshire. Towns are coded according to the number of years in each period when grebes were reported: yellow = 1, red = 2-5, black = > 5.

Table 1. Sites hosting pied-billed grebes in at least two years since 1980. See text for details.

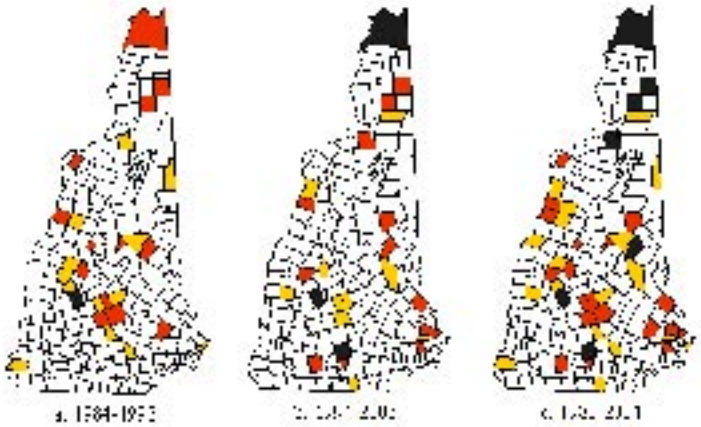


Figure 1

Table 1. Sites hosting pied-billed grebes in at least two years since 1980. See text for details.

Region/Town	Wetland	Conservation Unit Type (Section 2.1)	# years reported (1980-2004)	Most recent report	# probable or confirmed nestings
North Country			-29	-2002	-5
Dummer	Pontook Reservoir	A	9	2002	2
Errol	Lake Umbagog marshes	A	6	2001	1
Jefferson	Cherry Pond	C	6	2003	0
Pittsburg	East Inlet	C	8	2000	2
Central Connecticut Valley			-6	-1998	-3
Lyman	Dodge Pond	C	2	1986	2
Orford	Reed's Marsh	C	2	1991	1
Piermont	Lily Pond	C	2	1998	0
Lakes Region			-10	-1998	-5
Center Harbor	Winona R./L. Waukewan	C	2	1988	2
Tamworth	Hemingway Pond	C	2	1989	0
Tuftonboro	Copp's Pond	C	6	1998	3
West-Central Wetlands			-30	-2004	-16
Hebron	Hebron Marsh	C	2	1992	0
Danbury	Danbury Bog	A	3	2002	0
Springfield	MacDaniel's Marsh	A	4	1998	1
Sutton	Cascade Marsh	A	21	2004	15
Upper Merrimack Valley			(9+)	-2002	-4
Boscawen	Hirst WMA	A	4	1993	2
Concord	South End Marsh	C	2	1988	2
Hopkinton	Chase sanctuary	C	3+	2002	0
Piscataquog Watershed			(5+)	-2003	(3+)
Mont Vernon	Roby Pond	C	2	1997	2
New Boston	Great Meadow	C	3+	2003	1+
Coastal Wetlands			-20	-2004	-10
Durham	Packers Falls Road Marsh	C	4	2004	1
Exeter	Sewage ponds	B	5	2003	2
Newington	Stubb's Pond	A	3	2002	0
Nottingham	Rollin's Brook	C	4	1990	3
Rochester	Sewage ponds	B	4	1997	4

SPECIES PROFILE

Horned Lark

Eremophila alpestris

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S3B
Author: Alina, J. Pyzikiewicz, New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

The horned lark breeds in sparsely vegetated open lands that include airports, golf courses and cemeteries (MacLeod 1994, Beason 1995). Nest sites are on the ground beside grass, rocks, or wood that protect the nest from snowmelt and wind-blown snow (MacLeod 1994). Winter habitat is similar to breeding habitat, with the addition of beaches, dunes, and roadsides (when the ground is covered with snow) (MacLeod 1994, Beason 1995). Bare agricultural fields with ample seeds and insects provide year-round foraging and are augmented in winter by feedlots (Beason 1995, DeGraaf and Yamasaki 2001).

1.2 Justification

The horned lark has been slowly declining throughout its range, most noticeably in the Northeast, where farms and open land are forested and developed (Beason 1995, Vickery et al. 1999).

1.3 Protection and Regulatory Status

The horned lark is protected under the Migratory Bird Treaty Act and through grassland bird conservation programs (North American Bird Conservation Initiative, Partners in Flight Northeast Grassland Bird Working Group).

1.4 Population and Habitat Distribution

The horned lark can be found year-round in much of North America, with the exception of interior Canada, the Pacific Northwest, and the southeastern United States (Beason 1995). It is a breeding resident in Canada and Alaska and a permanent resident in the lower 48 states and Mexico (Ridgely et al. 2003).

In New Hampshire, historical records show that horned larks, most likely the northern subspecies (*E. a. alpestris*), bred in the White Mountains region and North Country and were uncommon in the south (MacLeod 1994). Horned larks nesting in the southern part of the state in the early 1900s were most likely the prairie subspecies (*E. a. praticola*) (MacLeod 1994). Between 1940 and 1970, horned larks sighted in winter were of the northern subspecies, and those sighted in summer were of the nesting prairie subspecies (MacLeod 1994). Current observations of breeding horned larks have been recorded at the Concord Municipal Airport, Lebanon Municipal Airport, Manchester Airport, Diliant Hopkins Airport, Pease International Air Force Base, Hampton Harbor Inlet, and Hampton Beach State Park (NHNHB 2005).

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

See Extensive Grassland habitat profile.

1.7 Sources of Information

Sources of information included the NHNHB database, MacLoed (1994), Beason (1995), and DeGraaf and Yamasaki (2001).

1.8 Extent and Quality of Data

Horned lark habitat and population distribution is well studied throughout its range. Population data in New Hampshire are limited.

1.9 Distribution Research

- Identify and protect key grassland habitat areas
- Continue monitoring grassland habitats to better assess horned lark population declines
- Determine the status of population in New Hampshire's coastal dunes
- Determine effects of airport management techniques on populations that occur in such habitats.

Element 3: Species Threat Assessment

See Grasslands habitat profile.

Element 4: Conservation Actions

See Grasslands habitat profile.

Element 5: References

5.1 Literature

Beason, R.C. 1995. Horned lark (*Ermophila alpestris*). *In* The Birds of North America, A. Poole and F. Gill, editors. The Academy of Natural Sciences, Philadelphia, Pennsylvania, and The American Ornithologists' Union, Washington, D.C., USA.

DeGraaf, R.M., and M. Yamasaki. 2001. New England wildlife: habitat, natural history, and distribution. University Press of New England, Hanover, New Hampshire, USA.

MacLeod, I.C. 1994. Horned lark. Pages 164-165 *in* Breeding bird atlas of New Hampshire, C.R. Foss, editor. Arcadia, Dover, New Hampshire, USA.

Vickery, P.D., P.L. Tubaro, J.M. Cardoso da Silva, B.G. Peterjohn, J.R. Herkert, and R.B. Cavalcanti. 1999. Conservation of grassland birds in the western hemisphere. Studies in Avian Biology 19: 2-26.

5.2 Data Sources

New Hampshire Natural Heritage Bureau. 2005. Database of rare species and exemplary natural community occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

Ridgely, R.S., T.F. Allnutt, T. Brooks, D.K. McNicol, D.W. Mehlman, B.E. Young, and J.R. Zook. 2003. Digital Distribution Maps of the Birds of the Western Hemisphere, version 1.0. NatureServe, Arlington, Virginia, USA.

SPECIES PROFILE

Least Bittern

Ixobrychus exilis

Federal Listing: Not listed
State Listing: Species of Special Concern
Global Rank: G5
State Rank: S1
Author: Kim A. Tuttle, New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

The least bittern is the smallest member of the heron family. Its laterally compressed body, long toes, and curved claws are well suited to sliding through and grasping the stems of the tall, emergent vegetation where it often clings in order to fish over deep, open water (Gibbs et al. 1992). Least bitterns are associated with cattail (*Typha* spp.) marshes in northern regions, including managed impoundments, lake coves with stable water regimes, and occasionally sedgy bogs (Gibbs et al. 1992). It prefers freshwater or brackish marshes with scattered woody vegetation.

Least bitterns may build small foraging platforms at the best feeding sites, enabling them to hunt over water 25-60 cm deep, as deep as is used by the largest herons (Gibbs et al. 1992). Small fish are the primary prey, though snakes, frogs, tadpoles, crayfish, insects (primarily *Odonata* and *Orthoptera)*, small mammals (shrews and mice), and vegetation may be eaten (Gibbs et al. 1992). Least bitterns nest in dense stands of emergent vegetation near or over open water (DeGraaf and Yamasaki 2001).

1.2 Justification

The least bittern is thought to have declined in many areas of the eastern United States and adjacent Canada (Gibbs et al. 1992). Palustrine freshwater and brackish emergent wetlands, where least bitterns make their homes, are among the most threatened habitats in the country (Gibbs et al. 1992). The least bittern is listed as endangered in Massachusetts (Massachusetts Natural Heritage Program 2003), threatened in Connecticut (Connecticut Department of Environmental Protection 2004) and is a species of special concern in Vermont and New Hampshire. Pollution, sedimentation and invasion by purple loosestrife (*Lythrum salicaria)* and phragmites (*Phragmites australis)* degrade cattail-dominated wetlands (Gibbs et al. 1992), especially in southern New Hampshire, where development pressures are highest. Although least bitterns seem tolerant of human presence and may persist in highly urbanized areas if wetlands remain relatively undisturbed, they may be subject to increased predation by generalist predators such as snapping turtle (*Chelydra serpentina)*, crow (*Corvus brachyrhynchos*), and raccoon (*Procyon lotor)* that are also tolerant of human activity (Gibbs et al. 1992).

1.3 Protection and Regulatory Status

Protection under the Federal Migratory Bird Treaty Act of 1918.

1.4 Population and Habitat Distribution

The least bittern is a rare and local breeder in New England. It is found primarily in eastern Massachusetts and Rhode Island, as well as Connecticut, Vermont and coastal Maine (DeGraaf and Yamasaki 2001). It has apparently always been rare in New Hampshire, where historical sightings were few and were concentrated in the southern part of the state. There are historical records from Concord, Hampton, Seabrook and the Connecticut River valley, of which some may have been migrants (Vernon 1994). There were no breeding records at the time of the compilation of the *Atlas of Breeding Birds in New Hampshire,*

although it was thought that the species had likely nested here (Vernon 1994). Multiple individuals seen during the mid to late 1980s at Eel Pond in Rye and recently at Stubbs Pond in Newington (2002), and a lone juvenile observed at the Exeter sewage lagoons in early September 1994, suggest possible breeding at these locations.

Similarly, single occurrences of least bittern over several years during the mid 1980s at Cascade Marsh in Sutton indicate potential breeding habitat for the species. Towns with single records are Durham, Derry, Candia, and Newmarket. A 1997 least bittern record in a cattail wetland at Pondicherry Wildlife Refuge in Jefferson, Coos County, is the northernmost record in New Hampshire.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

See Habitat Map for Marsh and Shrub Wetlands.

1.7 Sources of Information

NatureServe (2005) was used for status and ranking information. New Hampshire Wildlife Sightings (2005) and NHNHB databases (2005) and Vernon (1994) were the primary sources of locality records. Habitat and life history information was taken from published literature, including the *Atlas of Breeding Birds in New Hampshire* (Foss 1994).

1.8 Extent and Quality of Data

In New Hampshire, the least bittern appears to be limited to a few suitable cattail marshes, mainly in the southern part of the state. Because its secretive nature makes it unlikely to be detected even in the most suitable habitat, the lack of sightings does not imply the absence of the least bittern (P. Hunt, NHA, personal communication). Among the few least bittern records, recent distribution data are largely the result of records submitted to the New Hampshire Wildlife Sightings web page from NHBR.

1.9 Distribution Research

Experienced birders should identify and report least bittern locations. Standardized census techniques, including the use of tape-recorded vocalizations to elicit responses from breeding birds, are needed to provide more information regarding distribution. The least bittern, American bittern, Virginia rail, sora, and other elusive wetland birds should be incorporated into comprehensive wetland bird monitoring efforts.

Element 3: Species Threat Assessment

The loss of wetlands likely poses the most significant threat to least bittern in the northeastern United States (Gibbs et al. 1992). See Threats in Marsh and Shrub Wetlands profile.

Element 4: Conservation Actions

See Marsh and Shrub Wetlands habitat profile for relevant conservation strategies. Tall grass-like emergent vegetation, especially cattail, should be maintained at the borders of ponds and wetlands. Management of federal and state impoundments to encourage dense, emergent vegetation, especially cattails, will create potential breeding habitat (Gibbs et al. 1992).

Element 5: References

5.1 Literature

Connecticut Department of Environmental Protection Natural Diversity Database webpage 2004. Connecticut Department of Environmental Protection. Hartford, Connecticut. Available http://dep.state.ct.us/burnatr/wildlife/factshts/cmoorhen.htm. Accessed 18 February 2005.

DeGraaf, R. M., and M. Yamasaki. 2001. New England wildlife: habitat, natural history, and distribution. University Press of New England, Hanover, New Hampshire, USA.

Gibbs, J.P., F.A. Reid and S.M. Melvin. 1992. Least Bittern. *In* The birds of North America, No. 17, A. Poole, P. Stettenheim, and F. Gill, editors. The Birds of North America, Inc., Philadelphia, Pennsylvania, USA.

Massachusetts Natural Heritage Program webpage 2005. Massachusetts Rare and Endangered Wildlife. Division of Fisheries and Wildlife. Westborough, Massachusetts. Available http://www.mass.gov/dfwele/dfw/nhesp/nhfacts/galchl.pdf. Accessed 18 February 2005.

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. http://www.natureserve.org/explorer. Accessed 2005 March 3.

Vernon, R.C. 1994. Accounts of historically or potentially breeding species, least bittern. Pages 370-371 *in* Atlas of breeding birds in New Hampshire, C.S. Foss, editor. Arcadia, Dover, New Hampshire, USA.

5.2 Data Sources

New Hampshire Natural Heritage Bureau. 2005. Database of Rare Species and Exemplary Natural Community Occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

Wildlife Sightings database. Maintained by the University of New Hampshire Complex Systems, Durham, New Hampshire, USA. Accessed 15 February 2005.

SPECIES PROFILE

Least Tern

Sterna antillarum

Federal Listing: Not listed
State Listing: Endangered
Global Rank: G4
State Rank: SHB
Author: Allison M. Briggaman, New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

Least terns use open beaches and vegetation-free islands for nesting. Although they may nest in areas with a substrate of larger stones, they prefer sand, shell, or gravel substrates high above the tide line. Like other terns, least terns tend to nest in colonies and are most productive at locations where colonies have been successful in previous years (Thompson et al. 1997). Unlike other terns, least terns tend to nest in areas attached to the mainland (Kress and Hall 2004).

1.2 Justification

Least terns, whose nesting colonies are sensitive to disturbance, are declining in number in some areas of their range (NatureServe 2005). In New Hampshire, the least tern is listed as endangered due to the absence of a breeding pair and the loss of nesting habitat due to anthropogenic factors.

Development along the Atlantic coast has resulted in significant habitat loss and degradation (United States Fish and Wildlife Service (USFWS) 1985), and New Hampshire Bird Records indicate that least terns have been rare and non-breeding in the state since 1980. The combined pressures of development and increased human recreation have in some areas caused least terns to abandon their natural habitats and nest on flat, gravel rooftops (Thompson et al. 1997, Kress and Hall 2004).

Although North American Breeding Bird Survey (BBS) data indicate a significant decline of least terns in North America between 1978 and 1988, populations were stable or increasing from the mid 1970s to the mid 1980s. This increase may have been the result of improved and expanded monitoring efforts during this period, especially along the Atlantic coast from Virginia to Maine (USFWS 1987).

1.3 Protection and Regulatory Status

New Hampshire RSA 212-A:6 IV(a) Endangered Species Conservation Act
Federal Migratory Bird Treaty Act of 1918
BCR 30 priority bird species (Highest concern)
PIF (physiographic area 28) priority bird species

1.4 Population and Habitat Distribution

Few records exist of least terns nesting in New Hampshire. Terns fed in Portsmouth in 1932 and the New Hampshire Audubon recorded 2 to 10 pairs nesting in Seabrook from 1953 to 1960. New Hampshire Bird Records indicate that least terns have been rare and non-breeding in the state since 1980. Although least terns are common in many parts of their range in North America, their preferred nesting habitat is also prime coastal real estate prone to development and human recreation (Thompson et al. 1997).

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

See coastal sand dune systems.

1.7 Sources of Information

Information on least tern habitat, population distribution and status was collected from literature, New Hampshire Fish and Game data, Tern Management Plans and Partners in Flight and the internet.

1.8 Extent and Quality of Data

Although least terns have been much studied throughout their breeding range, and although data regarding their biology and behavior is extensive, little is known about their demography and associations between wintering areas and breeding populations. Locally, the extent and quality of data on the distribution of the species is limited.

1.9 Distribution Research

Globally, more research is needed to understand the species' use of associated breeding and wintering areas, evaluate the success of management practices, identify the species' behavioral and demographic responses to humans and other animals (both domestic and wild), identify contaminant threats, and obtain better estimates of the species' demographics.

Locally, consistent survey and monitoring efforts would provide data on the current distribution and abundance of the species in the state. Along with more research, management of remaining habitat is necessary if least terns are to breed again along the New Hampshire coast.

Element 5: References

5.1 Literature Cited

Kress, S.W., and C.S. Hall. 2004. Tern Management Handbook: Coastal Northeastern United States and Atlantic Canada. National Audubon Society. Ithaca, New York, USA.

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life (web application). Version 4.2 NatureSErsve, Arlington, Virginia. <http://www.natureserve.org/explorer> Accessed 16 February 2005.

Thompson, B.C., J.A. Jackson, J. Burger, L.A. Hill, E.M. Kirsch, and J.L. Atwood. 1997. Least Tern (*Sterna antillarum*). *In* The Birds of North America, No. 290, A. Poole and F. Gill, editors. The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.

United States Fish and Wildlife Service (USFWS), Endangered and Threatened Wildlife and Plants: Determination of endangered and threatened status for the piping plover: Final rule. Federal Register 50 (238): 50726-50734.

United States Fish and Wildlife Service (USFWS), Office of Migratory Bird Management. 1987. Migratory nongame birds of management concern in the United States: the 1987 list.

SPECIES PROFILE

Nelson's Sharp Tailed Sparrow

Ammodramus nelsoni

Federal Listing: Not listed
State Listing: Special Concern
Global Rank: G5
State Rank: S3B
Authors: Megan J. McElroy and Kimberly J. Babbitt, University of New Hampshire

Element 1: Distribution and Habitat

1.1 Habitat Description

In New Hampshire, Nelson's sharp-tailed sparrows (hereafter, Nelson's sparrow) inhabit salt marshes, which are grass-dominated tidal wetlands existing in the transition zone between ocean and upland (Niering and Warren 1980) (see Salt Marshes habitat profile). They breed in marshes where smooth cordgrass, saltmeadow grass, and blackgrass are bordered by cattail, reed, and marsh elder (Greenlaw and Rising 1994). Sparrows forage on the ground in dense, wet grasses (e.g., cordgrass, blackgrass), areas of wrack, and edges of ditches, pools, and salt pannes (Greenlaw and Rising 1994). Their diet consists mainly of adult and larval insects, spiders, and amphipods. Grass seeds and herbaceous plants become an important part of their diet during fall migration (Greenlaw and Rising 1994).

1.2 Justification

Nelson's sharp-tailed sparrow has been designated a species of high conservation priority (Breeding Tier I) by Partners in Flight. In New Hampshire, Nelson's sparrow is a species of special concern. Few data exist on population trends, estimates, and threats in the state, and a long-term study of this species in New Hampshire has not been conducted. Ongoing and historical habitat loss and degradation are probably the most pressing threats to Nelson's sparrow populations in the Northeast. Protecting breeding habitat and Nelson's sparrow populations in New Hampshire is important to regional survival of this species.

High-quality salt marsh habitat available in large patches across a landscape is required for a population's persistence and growth. Degradation and loss of salt marsh habitat caused by tidal restrictions have resulted in the replacement of typical salt marsh vegetation with invasive reeds and grasses, such as cattails and common reed (Sinicrope et al. 1990, Burdick et al. 1997, Brawley et al. 1998). Areas of invasive plants in and around salt marshes decrease available habitat for breeding Nelson's sparrows because they are not suitable habitat.

The current lack of knowledge regarding Nelson's sparrow populations in New Hampshire and threats to these populations is similar to that for other closely related salt marsh birds, such as salt marsh sharp-tailed sparrow and seaside sparrow. With further research and monitoring, this salt marsh guild may serve as an indicator of marsh health, the effects of marsh degradation, and the success of management practices.

1.3 Protection and Regulatory Status

- The Migratory Bird Treaty Act of 1918 legally protects Nelson's sparrows from the take, transport, and use of the species, including eggs, nests, and feathers.
- NHDES regulates human impacts on salt marshes. Any activity that may involve filling, dredging, or destroying wetlands is subject to strict guidelines and requires approved permits before work can commence (RSA-A).

1.4 Population and Habitat Distribution

Nelson's sparrow is a northern species that breeds in the Gulf of Maine and Nova Scotia west to Alberta

(Sibley 1996), and much of its breeding populations occur in the Northeast (Hodgman et al. 2002). New Hampshire is the southern periphery of the breeding range, yet they do breed in salt marshes in southeastern New Hampshire (Gavutis 1994, NHBR, McElroy and Babbitt, unpublished data). Any of these marshes can be used as migratory habitat for Nelson's sparrows; however, the largest breeding population occurs at sites around Great Bay (NHBR, McElroy and Babbitt, unpublished data).

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

1.7 Sources of Information

A literature review was conducted on Nelson's sparrows to obtain habitat, population distribution, and status data. NHA database of Bird Records was used for historical information on the distribution of Nelson's sparrows. Detailed information on current population distribution and status was obtained from data collected in 2004 by researchers from UNH.

1.8 Extent and Quality of Data

Historical bird records from NHA include sightings reported by birders. Although this information is vital to knowledge of historical distribution, it does not give an accurate account of population size or confirmed breeding locations throughout the state. In addition, the American Ornithologists' Union Committee in 1995 redefined the sharp-tailed sparrow (*Ammodramus caudacutus*) into two separate species: Nelson's sharp-tailed sparrow and saltmarsh sharp-tailed sparrow (*Ammodramus caudacutus*). Therefore, historical records prior to the split do not distinguish these 2 species. The most extensive dataset comes from UNH researchers. It includes confirmed breeding locations and population estimates throughout the state for the breeding season in 2004. Significant gaps exist in knowledge of breeding populations and long-term trends in abundance throughout the state.

1.9 Distribution Research

A long-term survey of salt marsh habitat (i.e., point counts conducted during breeding season at established points) is needed to determine the distribution of Nelson's sparrow in New Hampshire. It is essential that this effort be long-term because the quality of salt marsh habitat changes over time, potentially affecting Nelson's sparrow populations from one breeding season to the next.

Element 2: Species/Habitat Condition

2.1 Scale

The New Hampshire conservation unit for Nelson's sparrow is Great Bay and Portsmouth.

2.2 Relative Health of Populations

In New Hampshire, the abundance of the Nelson's sparrow population during the breeding season is estimated at approximately 50-75 individuals (McElroy and Babbitt, unpublished data). Because a sufficient long-term survey for Nelson's sparrows has not yet been implemented and Breeding Bird Survey routes do not sufficiently cover salt marshes, population trend data are not available. In 2004, a complete survey of all potential breeding salt marshes in New Hampshire was conducted for the presence and abundance of Nelson's sparrows.

Data collected during the 2004 breeding season showed sparrow activity in the following locations, categorized by breeding status (Confirmed Breeding = nests found and/or fledglings observed; Possible Breeding = adults present throughout season, singing activity, no evidence of nests and/or fledglings; Potential Breeding = a few birds present feeding at some point in the season, no evidence of any current breeding activity) (table 1). Estimated Relative Abundance (ERA) categories are also included.

2.3 Population Management Status

There are currently no ongoing population management efforts for Nelson's sparrows in New Hampshire (see Salt Marsh Habitat Profile, Element 2.3). All populations should be considered priorities for conservation.

2.4 Relative Quality of Habitat Patches

Currently in New Hampshire, Nelson's sparrows breed in *Spartina*-dominated salt marshes on Great Bay that are approximately 20-30 hectares in size (McElroy and Babbitt, unpublished data). Shriver et al. (2004) found that the occurrence of Nelson's sparrows in the Gulf of Maine was correlated with marsh size, proximity to other marshes, and road density surrounding the marsh. However, all New Hampshire salt marshes have the potential to fulfill key ecological functions (e.g., small marshes may not provide suitable nesting habitat, but may be important stopover sites). Research is needed to fully understand habitat quality with respect to Nelson's sparrow ecology.

2.5 Habitat Patch Protection Status

See Salt Marshes habitat profile (element 2.5)

2.6 Habitat Management Status

See Salt Marshes habitat profile (element 2.6)

2.7 Sources of Information

A literature review provided information on research and habitat management. Research conducted by UNH scientists was used to determine the current health of the population and population management status. The New Hampshire Coastal Program (NHCP) website was used to obtain habitat protection and management information and articles on habitat restoration.

2.8 Extent and Quality of Data

Currently, the most extensive dataset comes from researchers at the University of New Hampshire and includes confirmed breeding locations and population estimates throughout the state. However, this dataset is only from one field season. Therefore, a long-term study is needed for an adequate assessment of population health and habitat suitability. There are still significant gaps in knowledge and understanding of Nelson's sparrow populations and the effects of habitat restoration.

2.9 Condition Assessment Research

Long-term monitoring of these populations is essential to knowledge of population dynamics, trends, and ecology. Monitoring will provide valuable data to increase understanding of threats to Nelson's sparrow and effects of habitat management efforts.

To determine population abundance at sites of known use and therefore a more accurate assessment of marshes of high protection/conservation priority, a more in-depth monitoring of the breeding population—in addition to point count surveys—is needed. Because this species is non-territorial, point-count surveys and similar methods cannot accurately estimate population abundance. A long-term mark-recapture banding effort of the population would provide a more accurate estimate of sparrow abundance.

With a long-term dataset of presence/absence and abundance estimates at marshes throughout New Hampshire, a map could be produced targeting locations with high densities of breeding birds and hot spots for additional research, conservation, and habitat protection. This information is critical for any future conservation efforts and for research into habitat suitability for this species in New Hampshire.

Element 3: Species and Habitat Threat Assessment

3.1.1 Development (Habitat Loss and Conversion)

(A) Exposure Pathway
See Salt Marsh Habitat Profile

(B) Evidence
Habitat loss is a significant factor in the localized extinctions and decline of wetland birds in northern New England, especially species such as the Nelson's sparrow that use salt marshes for nesting (Greenlaw and Rising 1994). Shriver et al. (2004) found that occurrence of Nelson's sparrows around the Gulf of Maine correlated positively with marsh size and the proximity to other marshes. Therefore, continued habitat loss due to land development likely will reduce Nelson's sparrow populations in New Hampshire.

3.1.2 Development (Fragmentation)

See Salt Marsh Habitat Profile

3.1.3 Altered Hydrology (Tidal Restriction), Transportation Infrastructure

See Salt Marsh Habitat Profile

3.1.4 Introduced Species (Introduced Plants)

See Saltmarsh Sharp-tailed Sparrow Profile

3.1.5 Altered Hydrology (Mosquito Ditching)

See Saltmarsh Sharp-tailed Sparrow Profile

3.1.6 Mercury

See Saltmarsh Sharp-tailed Sparrow Profile

3.2 Sources of Information

Information on threats to Nelson's sparrows was obtained from a literature review, NHCP, NHNHB, and Biodiversity Research Institute in Gorham, Maine.

3.3 Extent and Quality of Data

Researchers and managers have recently given significant attention to threats to Nelson's sparrows. It is well documented that historical marsh degradation from human activities is correlated with decreases in sparrow populations. However, researchers studying the effects of mercury are attempting to evaluate the significance of this new threat to Nelson's sparrows and other salt marsh nesting birds, and continued research is warranted.

3.4 Threat Assessment Research

Scientists are assessing threats to Nelson's sparrow populations in Maine and New Hampshire (see references for published studies, McElroy and Babbitt, unpublished data). The impacts of invasive plant species and increased human disturbance surrounding marsh habitat (e.g., increased road density and noise) are two important areas for future research.

Of critical importance, more research is needed to determine the effects of methylmercury on Nelson's sparrow populations in New Hampshire. Methylmercury has become a regional ecological and human health concern. Although the Biodiversity Research Institute is investigating the effects of mercury on salt marsh birds in New England, research is needed especially in New Hampshire. Once mercury effects have been assessed through scientific research, conservation actions can be implemented to combat the problem.

Element 4: Conservation Actions

4.1.1 Protecting remaining salt marsh habitat and surrounding upland buffer habitat, Habitat Protection

See Saltmarsh Habitat Profile and Saltmarsh Sharp-tailed Sparrow Profile

4.1.2 Restoring degraded salt marshes back to Spartina-dominated systems, Restoration and Management

See Saltmarsh Habitat Profile and Saltmarsh Sharp-tailed Sparrow Profile

Element 5: References

5.1 Literature:

Benoit, L. K., and R. A. Askins. 1999. Impact of the spread of Phragmites on the distribution of birds in Connecticut tidal marshes. Wetlands 19: 194-208.

Benoit, L. K., and R. A. Askins. 2002. Relationship between habitat area and the distribution of tidal marsh birds. Wilson Bulletin 114:314-323.

Brawley, A. H., R. S. Warren, and R. A. Askins. 1998. Bird use of restoration and reference marshes within the Barn Island wildlife management area, Stonington, Connecticut, USA. Environmental Management 22:625-633.

Broome, S. W., E. D. Seneca, and W. W. Woodhouse, Jr. 1988. Tidal salt marsh restoration. Aquatic Botany 32:1-22.

Burdick, D. M., M. Dionne, R. M. Boumans, and F. T. Short. 1997. Ecological responses to tidal restorations of two northern New England salt marshes. Wetlands Ecology and Management 4: 129-144.

Clarke, J. A., B. A. Harrington, T. Hruby, and F. E. Wasserman. 1984. The effect of ditching for mosquito control on salt marsh use by birds in Rowley, Massachusetts. Journal of Field Ornithology 55:160-180.

DiQuinzio, D. A., P. W. C. Paton, and W. R. Eddleman. 2002. Nesting ecology of saltmarsh sharp-tailed sparrows in a tidally restricted salt marsh.

Wetlands 22:179-185.
Gavutis, G. W., Jr. 1994. Sharp-tailed Sparrow (Ammodramus caudacutus). Pages 324-325 *in* C.
Foss, editor. Atlas of breeding birds in New Hampshire. New Hampshire Audubon, Concord, New Hampshire.
Greenlaw, J. S., and J. D. Rising. 1994. Sharp-tailed Sparrow (Ammodramus caudacutus).
Number 112 *in* A. Poole and F. Gill, editors. The birds of North America. The Academy of Natural Sciences, Philadelphia, Pennsylvania, USA.
Hodgman, T. P., W. G. Shriver, and P. D. Vickery. 2002. Redefining range overlap between the
sharp-tailed sparrows of coastal New England. Wilson Bulletin 114:38-43.

Hunt, P. 2004(Draft). A regional perspective on New Hampshire's birds of conservation priority:
objectives, threats, research needs, and conservation strategies. New Hampshire Audubon, Concord, New Hampshire.
Johnson, R. G., and S. A. Temple. 1990. Nest predation and brood parasitism of tallgrass prairie birds. Journal of Wildlife Management 54:106-111.
Kamman, N. C., P. M. Lorey, C. T. Driscoll, R. Estabrook, A. Major, B. Pientka, and E.
Glassford. 2004. Assessment of mercury in waters, sediments, and biota of New Hampshire and Vermont lakes, USA, sampled using a geographically random design. Environmental Toxicology and Chemistry 23:1172-1186.
Lane, O., and D. Evers. 2005. Developing a geographic exposure profile of methylmercury
availability in salt marshes of New England. Report BRI 2005-04 submitted to the Maine Department of Inland Fisheries and Wildlife, Maine Department of Environmental Protection, and Rachel Carson National Wildlife Refuge. Biodiversity Research Institute, Gorham, Maine.
Mitsch, W. J., and J. G. Gosselink. 2000. Wetlands. Third edition. John Wiley & Sons, Inc., New York, New York.
NHCP (New Hampshire Coastal Program). New Hampshire Department of Environmental
Services, Concord, New Hampshire. NHCP home page: http://www.des.state.nh.us/Coastal/ Accessed 2004 November.
NHNHB (New Hampshire Natural Heritage Bureau). 2004. Natural communities of New
Hampshire. http://www.nhdfl.org/formgt/nhiweb/Documents/NaturalCommunitiesWeb.pdf Accessed 2004 November.
Niehaus, A. C., S. B. Heard, S. D. Hendrix, and S. L. Hillis. 2003. Measuring edge effects on
nest predation in forest fragments: do finch and quail eggs tell different stories? American Midland Naturalist 149:335-343.
Niering, W. A., and R. S. Warren. 1980. Vegetation patterns and processes in New England salt marshes. BioScience 30:301-306.
Post, W., and J. S. Greenlaw. 1994. Seaside sparrow (Ammodramus maritimus). Number 127 *in*
A. Poole and F. Gill, editors. The birds of North America. The Academy of Natural Sciences, Philadelphia, Pennsylvania, USA.
Reinert, S. E., F. C. Golet, and W. R. DeRagon. 1981. Avian use of ditched and unditched salt
marshes in southeastern New England: a preliminary report. Presented at the 27th Annual Meeting, Northeastern Mosquito Control Association, Nov. 2-4, 1981, Newport, Rhode Island.
Roman, C. T., W. A. Niering, and R. S. Warren. 1984. Salt marsh vegetation change in response to tidal restriction. Environmental Management 8: 141-150.
Shriver, W. G., D. Evers, and T. Hodgman. 2002. Mercury exposure profile for sharp-tailed
sparrows breeding in coastal Maine salt marshes. Report BRI 2002-11 submitted to the Maine Department of Environmental Protection. BioDiversity Research Institute, Gorham, Maine.
Shriver, W. G., T. P. Hodgman, J. P. Gibbs, and P. D. Vickery. 2004. Landscape context
influences salt marsh bird diversity and area requirements in New England. Biological Conservation 119:545-553.
Sibley, D. 1996. Field identification of the sharp-tailed sparrow complex. Birding 28:197-208.
Sinicrope, T. L., P. G. Hine, R. S. Warren, and W. A. Niering. 1990. Restoration of an impounded salt marsh in New England. Estuaries 13:25-30.
Warren, R. S., P. E. Fell, R. Rozsa, A. H. Brawley, A. C. Orsted, E. T. Olson, V. Swamy, and W.
A. Niering. 2002. Salt marsh restoration in Connecticut: 20 years of science and management. Restoration Ecology 10:497-513.

5.2 Data Sources:

NHBR. New Hampshire Bird Records, New Hampshire Audubon, Concord, New Hampshire.

PIF (Partners in Flight). Species assessment database. Bird conservation regions: breeding scores for BCR 30 and BCR 14. PIF homepage: http://www.rmbo.org/pif/pifdb.html
Accessed 2005 April

Element 6: List of Figures

Table 1. New Hampshire salt marshes with Nelson's sharp-tailed sparrows during the 2004 breeding season (McElroy and Babbitt, unpublished data).

MARSH	TOWN	BREEDING	ERA
Chapman's Landing	Stratham	Confirmed	16 – 30
Squamscott River	Newfields	Confirmed	< 15
Sagamore Creek	Portsmouth	Possible	< 15
Hampton Beach	Hampton	Potential	< 15
Little River	Hampton	Potential	< 15
Bay Road	Newmarket	Potential	< 15

SPECIES PROFILE

Northern Harrier

Circus cyaneus

Federal Listing: Not listed
State Listing: Endangered
Global Rank: G5
State Rank: S2B
Author: Pamela D. Hunt, New Hampshire Audubon

Element 1: Distribution and Habitat

1.1 Habitat Description

Northern harriers use a variety of open and semi-open habitat throughout the year, including grassland, cattail marsh, salt marsh, shrub-steppe, and agricultural land (MacWhirter and Bildstein 1996). In the Northeast, the species may nest in wetter habitat, although birds still forage extensively in upland areas (Serrentino 1992). The species also frequents bogs and fens with open foraging areas and a brushy border for nesting. Important features of nesting areas in northern New Hampshire include dense stands of low woody plants (*Spirea, Alnus, Cornus*, heaths) near open grassland areas for foraging (Serrentino 1992, 1998).

In northern Coos County, key habitats included hayfield, pasture, early successional field, late successional field, and shrub wetland (Serrentino 1998). Collectively, open and partially open upland habitats in this study comprised 59-75% of total habitat in each focal area. In west-central New Hampshire, historic sites in Danbury and Sutton are large wetlands bordered by shrubs and cattails.

Winter records of harriers in New Hampshire are almost entirely from the Seacoast (NHBR), where the species is found in salt marsh and associated upland brushy edges. There are also a few breeding records from salt marsh and nearby open areas.

Limited data suggest that harriers prefer larger fields. In Massachusetts, harriers only used fields over 11 ha (27.5 ac) (Serrentino 1992), whereas blueberry barrens in Maine needed to be at least 100 ha (250 ac) (Vickery et al. 1994). Wetlands used for foraging need not be as large, with areas as small as 1 ha (2.5 ac) being used in Maine (Gibbs et al. 1991).

1.2 Justification

Harriers were believed common in New Hampshire following extensive forest clearing in the 1800s. Beginning in the early 1900s, however, populations began to decline, probably a result of reforestation, wetland loss, persecution, and pesticide contamination (Foss 1994). By the 1970s, the species had become restricted to its current range and abundance in New Hampshire.

Harrier populations over the entire North American breeding range are declining at a rate of 1% per year (Sauer et al. 2004). In the East and Northeast, harriers are infrequently detected during the Breeding Bird Survey. According to detailed statewide accounts, the species has declined in New York (Andrle and Carroll 1988), Vermont (Laughlin and Kibbe 1985), Connecticut (Zeransky and Baptist 1990), and Massachusetts (Viet and Petersen 1993), and is of conservation concern in most northeastern states (Serrentino 1992). In 2001 and 2002, harriers nested in Essex County, Massachusetts for the first time in over 30 years (Berry 2003). These records, in conjunction with increased breeding season sightings in southern New Hampshire (NHBR), suggest the possibility of a partial recovery of coastal populations in the Gulf of Maine.

1.3 Protection and Regulatory Status

This species is protected at the federal level by the Migratory Bird Treaty Act, which prevents the killing of most non-game birds and collection of their nests

or eggs. In New Hampshire it is protected by the New Hampshire Endangered Species Conservation Act (RSA 212).

1.4 Population and Habitat Distribution

Scant data exist on the distribution of northern harriers in New Hampshire prior to the 1800s. Historically, the species was probably restricted to bogs, fens, and similar wetlands (e.g., beaver meadows), and perhaps isolated agricultural clearings along major river valleys. The species may have benefited from extensive forest clearing in the 1800s, and by the early 1900s it was nesting in small numbers over most of the state, with the possible exception of the southwest (Foss 1994).

By the 1960s, Coos County was the stronghold for New Hampshire's harrier population (NHBR). This distribution was largely unchanged during The Breeding Bird Atlas surveys in the early 1980s (figure 1a), documented roughly 16 territories in the state (Foss 1994, NHBR), not all of which were breeding territories. Over the next 15 years, there were between 19 and 21 territories, of which 8 to 13 were active breeding territories. Recent data are scarce because the annual "harrier day" surveys in northern Coos County were discontinued in 1997. Between 1998 and 2003, breeding season harriers were reported at 15 locations, and only 6 of these were in the species' traditional stronghold in the northern Connecticut River valley (NHBR).

Statewide, harrier distributions did not change appreciably from the 1980s to the 1990s (figure 1). The range included 3 areas: Coos County, the Connecticut River valley between Piermont and Lyman, and a complex of wetlands (Danbury Bog) in west-central New Hampshire. Except for Danbury Bog, no site supported harriers for more than 2 years between 1981 and 2003. Harriers bred at Danbury Bog 3 times between 1985 and 1991, and a single individual was observed in June 2001.

The Coos County portion of the range can be further divided into the upper Connecticut valley from Columbia north, the Androscoggin valley between Errol and Shelburne, and the Lancaster/Whitefield/Jefferson area. Harrier activity has been traditionally concentrated in the former, which contains 58% (11 of 19) of the regularly occupied territories in the county (and 50% of the entire state). All but one of the Connecticut Valley territories (91%) were occupied for at least 7 years between 1981 and 2000, while only 3 territories in the Androscoggin Valley or Lancaster/Whitefield/Jefferson area met this same criteria.

Harriers are rare during the breeding season away of the core areas discussed above (figure 1b). Since 1990, reports have come from Tamworth, Dover, Derry, and Brookline. In addition, from 1998 to 2001, single harriers were seen during August in the Hampton/Seabrook salt marshes. Because of the later dates of these sightings, the birds in question could be early southbound migrants or dispersers from the new breeding location in northeast Massachusetts (see section 1.2). However, the regularity of coastal sightings indicates the potential for current or future nesting in this portion of New Hampshire.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

Harrier habitat modeling is complicated by the fact that the species can use 2 very different habitats (grassland and emergent marsh). Given that extensive grasslands and wetland complexes have already been identified as part of this strategy, a first step would be to identify all large parcels of these habitats. Although data on habitat size needs are sparse, there is some indication that harriers are more likely to use a site if it is over 100 ha (Vickery et al. 1994). A model with such a cut-off, though it would overlook some suitable areas, would be guaranteed to recognize the better habitat. In addition, sites north of the White Mountains should have greater weight than those south of the mountains, based on historic and current use. The resulting model is perhaps simplistic, but no data on landscape features exist that would allow for finer resolution.

1.7 Sources of Information

Basic natural history information in this profile was largely gathered from the literature cited in element 5. Habitat modeling was informed by the Gulf of Maine Program (Banner and Schaller 2001). Data on harrier distribution in New Hampshire were compiled from NHBR and observations collected during NHA's "harrier days" between 1983 and 1997.

1.8 Extent and Quality of Data

Because harriers have not been consistently surveyed in northern Coos County since 1997, data are lacking on the species' current distribution in this former stronghold. Harriers continue in the Androscoggin and Lancaster/Jefferson areas, which are visited more frequently.

1.9 Distribution Research

If harrier distribution is to be understood, regular surveys in the northern Connecticut Valley must be reestablished. Likewise, searches of historic locations south of the White Mountains would determine if any breeding pairs persist in these peripheral areas. Given the coarse nature of the habitat model described above, research into patch size, landscape configuration, and habitat juxtaposition would be valuable in future efforts to identify suitable habitat.

Element 2: Species Condition

2.1 Scale

As discussed in section 1.4, there are 5 appropriate planning units for harriers in New Hampshire:

1. Northern Connecticut River grasslands: This area includes the towns from Stratford north to Pittsburg.
2. Androscoggin Valley: This area includes marshes and agricultural lands from Lake Umbagog south to Shelburne, and extends west to the Upper Ammonoosuc valley in Stark.
3. Lancaster/Whitefield/Jefferson
4. Central Connecticut River valley: This area includes wetlands and agricultural lands from Lyman south to Haverhill and Benton.
5. West-central wetlands: This area includes sites from Enfield in the northwest to Danbury in the northeast, and south to Sutton and Newbury.

2.2 Relative Health of Populations

Of the 5 units outlined above, only the northern 3 have consistently supported harriers for the last 25 years (table 1). Sites in the central Connecticut River Valley appear to have been used primarily during the early 1980s (Breeding Bird Atlas), and recent records are scarce. There are also fewer sightings in the west-central wetlands. Collectively, data suggest that harriers have declined in areas peripheral to their core range in Coos County. Yet without recent data, it is difficult to evaluate the species' status in the north.

2.3 Population Management Status

Harrier populations are not managed in New Hampshire (but see section 2.6).

2.4 Relative Quality of Habitat Patches

Data are insufficient to evaluate the condition of harrier territories in New Hampshire. Anecdotal information suggests that agriculture continues to decline in the northern Connecticut River valley, which would imply that some harrier territories may be affected by habitat change through succession. Many areas that include harrier territories appear stable in the Androscoggin and Lancaster areas, and some are protected.

2.5 Habitat Patch Protection Status

In the northern and central Connecticut River valley, essentially no harrier habitat is currently protected. In the Androscoggin Valley, harrier territories at Lake Umbagog and Pontook Reservoir are protected, while potential areas (including foraging habitat) outside of Umbagog and Pontook are not. In the Lancaster area, habitat around the Whitefield Airport is protected in the Pondicherry Division of the Silvio Conte National Fish and Wildlife Refuge, but other grassland areas remain privately owned. To the south, most historic harrier areas (including Cascade Marsh and part of Danbury Bog) are protected as state wildlife management areas.

2.6 Habitat Management Status

Other than at the Whitefield Airport, habitat management is not occurring. The airport has a Memorandum of Agreement with NHFG that defines a Northern Harrier Management Area and requires the following:

- Brush removal only between 1 September and 30 March
- Consultation with NHFG prior to any brush removal
- No use of herbicides, insecticides, or rodenticides without prior approval
- If nesting habitat is modified because of airport activities, the equivalent amount of suitable habitat must be provided elsewhere on the property

2.7 Sources of Information

Data on habitat condition for northern harriers were compiled from the literature or through discussion with observers familiar with local conditions in New Hampshire.

2.8 Extent and Quality of Data

Because regular surveys of the state's primary harrier areas were discontinued in 1997, there is no information on the current condition of over half of the state's historic territories. More regular coverage in the Androscoggin and Lancaster areas suggests that the species' population has not changed in the central and southern portions of Coos County.

2.9 Condition Assessment Research:

A thorough assessment of northern harrier status in New Hampshire will require revisiting core habitat in northern Coos County and historic sites in west-central New Hampshire, including the central Connecticut Valley.

Element 5: References

5.1 Literature

Andrle, R.F., and J.R. Carroll. 1988. The Atlas of Breeding Birds in New York State. Cornell University Press, Ithaca, New York, USA.

Banner, A., and S. Schaller. 2001. USFWS Gulf of Maine Watershed Habitat Analysis. USFWS Gulf of Maine Program, Falmouth, Maine, USA. (http://r5gomp.fws.gov/gom/habitatstudy/Gulf_of_Maine_Watershed_Habitat_Analysis.htm)

Berry, J. 2003. Significant Essex County nest records, 2002-2003. Bird Observer 31:337-355.

Foss, C.R. 1994. Atlas of Breeding Birds of New Hampshire. New Hampshire Audubon. Concord, New Hampshire, USA.

Laughlin, S.B., and D.P. Kibbe. 1985. The Atlas of Breeding Birds of Vermont. University Press of New England, Hanover, New Hampshire, USA.

MacWhirter, R.B., and K.L. Bildstein. 1996. Northern Harrier (*Circus cyaneus*). *In* The Birds of North America, No. 210, A. Poole and F. Gill, editors. The Birds of North America, Inc., Philadelphia, Pennsylvania, USA.

Sauer, J.R., J.E. Hines, and J. Fallon. 2004. The North American Breeding Bird Survey, Results and Analysis 1966-2003. Version 2004.1, USGS Patuxent Wildlife Research Center, Laurel, MD.

Serrentino, P. 1992. Northern Harrier, *Circus cyaneus*. Pp. 89-117 *in* Migratory nongame birds of management concern in the Northeast, K. J. Schnieder and D. M. Pence, editors. U.S. Dept. Interior, Fish and Wildlife Service, Newton Corner, MA.

Serrentino, P. 1998. A survey and habitat evaluation of northern harriers (*Circus cyaneus*) in northwest Coos County, New Hampshire. Report to Silvio O. Conte National Fish and Wildlife Refuge (U.S. Fish and Wildlife Service).

Veit, R.R., and W.R. Petersen. 1993. Birds of Massachusetts. Massachusetts Audubon Society, Lincoln, Massachusetts, USA.

Vickery, P.D., M.L. Hunter, Jr., and S.M. Melvin. 1994. Effects of habitat area on the distribution of grassland birds in Maine. Conservation Biology 8: 1087-1097.

Zeranski, J.D., and T.R. Baptist. 1990. Connecticut Birds. University Press of New England, Hanover, New Hampshire, USA.

5.2 Data Sources

NHBR. New Hampshire Bird Records, New Hampshire Audubon, Concord, New Hampshire, USA.

Element 6: List of Figures

Figure 1. Distribution of breeding season records of northern harrier in New Hampshire 1981-2000. Towns are coded according to the number of years in each period when harriers were reported: yellow = 1, red = 2-5, black = > 5. Figure 1a does not include peripheral sightings outside of the three principal breeding areas discussed in the text.

SPECIES PROFILE

Osprey
Pandion haliaetus

Federal Listing: Not listed
State Listing: Threatened
Global Rank: G5
State Rank: S2B
Author: Christian Martin, New Hampshire Audubon

Element 1: Distribution and Habitat

1.1 Habitat Description

The osprey has a cosmopolitan distribution, occurring nearly everywhere in the world except Polar Regions during various portions of their annual cycle (Poole et al. 2002). Most ospreys in North America are long-distance migrants, traveling up to 5,000 mi (8,000 km) to and from their wintering areas in the Caribbean, Central America, and South America (Henny and Van Velzen 1972, Environment Canada 2001). Satellite tracking studies (Martell et al. 2001) show that ospreys that breed on the east coast of the United States winter primarily in northern South America and sometimes in Cuba and in Florida. Ospreys breeding in Florida, California, and other southern U. S. locations are essentially non-migratory (Poole et al. 2002). Female ospreys from most North American breeding populations usually winter farther south than do their male counterparts, and individuals of both sexes display strong fidelity to wintering and breeding sites.

Osprey do not make their first northward spring migrations from the tropics until they are nearly 2 years old, and generally do not establish breeding territories until they are at least 3 years old (Poole et al. 2002). When attempting to establish a breeding territory, young ospreys often settle within 32 mi (50 km) of natal areas, which contributes to the species' slow rate of colonizing vacant territory.

When ospreys return to New Hampshire from the tropics, they usually arrive in coastal areas first. Dispersal inland often involves travel upstream on the Connecticut, Merrimack, Piscataqua, Saco, and Androscoggin rivers. Local breeding territories are reoccupied beginning in late March and early April; early arrival dates reported for New Hampshire nest sites include March 24 at Great Bay, March 26 in the lower Merrimack River valley, March 29 in the Lakes Region, and April 6 in Pittsburg (Evans 1994, Martin et al. 2004). From April to mid-May, many individuals pass through the state en route to breeding areas far north of the state's border with Canada. During this spring migratory interval, ospreys are seen on all of the state's major rivers and lakes, as well as on many smaller streams and minor ponds, where they are able to obtain prey to fuel their migration.

Ospreys breed from Newfoundland across to Alaska up to and even beyond the tree limit, and they occur in every province in Canada and across the entire U. S. In northern New England and the Canadian Maritimes, ospreys typically establish breeding territories near large lakes, major rivers, and coastal estuaries. For example, a habitat model developed for the Gulf of Maine watershed (USFWS 2000) found that 90% of 200 osprey nests examined in Maine were located within 0.6 miles of major rivers or lakes of greater than 100 acres in size. Another key breeding habitat is wetland ponds, where flooding by beavers produces dead snags for nesting and shallow waters for fishing. Shallow water is preferred because it offers better access to aquatic prey. Suitable breeding habitat (Poole et al. 2002) included the following:

- Areas with dependable fishing sources located within 2 to 3 miles (Poole 1989), but occasionally as far as 8 miles (Prevost 1979, Hagan and Walters 1990) from potential nesting sites,
- Standing trees or other structures located in wetlands,

- An ice-free period of no less than 20 weeks, long enough to permit egg-laying (3 weeks), incubation (5 weeks), raising young (8 weeks), and post-fledging foraging skill development (4 weeks).

Breeding ospreys generally defend their nest site only (typically a perimeter of 50 to 100 m), rather than a much larger feeding territory. Spacing between adjacent nesting pairs is highly variable and is dependant upon regional prey abundance and distribution and upon availability and type of nest substrate (Poole et al. 2002). For example, mean distance reported between neighboring nests for a tree-nesting population in New York State averaged 410 m, whereas a platform-nesting population in salt marshes in southeastern Massachusetts nests averaged only 140 m apart. A boreal forest population in New Brunswick averaged a much more diffuse one pair per 51 ha (Stocek and Pearce 1983).

1.2 Justification

Ospreys have been closely monitored in the United States ever since severe population declines were first documented both in North America and elsewhere between the 1950s and the 1970s (Henny and Ogden 1970, Poole et al. 2002). The number of pairs nesting in coastal areas of southern New England declined about 90% during this period, Chesapeake Bay area pairs declined by about 50%, and populations in the Great Lakes region also dropped significantly. Research demonstrated that population losses during that period resulted primarily from presence of high levels of DDT and other persistent organochlorine pesticides in the aquatic food web, which caused severe eggshell thinning and extremely poor hatching success (Spitzer et al. 1978, Wiemeyer et al. 1988).

Ospreys can serve as valuable bio-indicators of general environmental quality in aquatic systems because they rapidly accumulate chemical contaminants, such as the organochlorine pesticide DDT and its metabolite DDE, contained in fish. A dramatic osprey population decline, caused by DDT contamination, occurred across much of North America beginning in the 1940s and continued until 1970 (Ogden 1977). Osprey populations have rebounded strongly since the banning of the use of DDT, with the most dramatic increases occurring in traditional or historical nesting areas rather than in newly colonized areas (Houghton and Rymon 1997).

1.3 Protection and Regulatory Status

Ospreys are protected in the United States under the Migratory Bird Treaty Act of 1918, which prohibits the possession or killing of most non-game birds and the collection of their eggs or nests. The species was first listed as threatened by the State of New Hampshire in 1979 (R.S.A. 212-A: 1 et seq.), and is still so classified. Other federal measures that indirectly provide protection include the Federal Insecticide, Fungicide, and Rodenticide Act (7 U.S.C. 136) for new and existing pesticide registration and use, the National Forest Management Act (16 U.S.C. 1600), and the Federal Land Management and Policy Act (43 U.S.C. 1701). Ospreys are also protected from unregulated international trade by an agreement of the 1975 Convention on International Trade in Endangered Species of Wild Flora and Fauna.

1.4 Population and Habitat Distribution

Osprey populations across much of North America have rebounded strongly since the banning of the use of DDT. Estimates in the mid-1980s indicated that North America then supported about 18,000 to 20,000 pairs of breeding ospreys (about 57 to 84% of the world population) and that about two thirds of those bred in Canada and Alaska (Poole 1989). Recent population estimates suggest that about one third of the world's breeding ospreys nest in Canada (Environment Canada 2001). There were an estimated 8,000 breeding pairs in the contiguous U. S. in 1981, but 14,200 pairs in 1994 (Houghton and Rymon 1997), an estimate that increased further to 16,000 to 19,000 pairs by 2001 (Poole et al. 2002). Annual population growth rates ranging from 6 to 15% have generally been reported across North America over the past 30 years (Ewins 1997). Specifically, average annual rates of population increase in northern Michigan, Wisconsin, southern Ontario, and upper New York State have been 7%, 8%, 10-15%, and 10%, respectively (Environment Canada 2001).

A summary of the recent population status of breeding ospreys in states adjacent to New Hampshire is summarized in Table 1. In New Hampshire, ospreys have been reported as migrants for more than a century, though they were historically documented

as common summer residents only in the Umbagog Lake area (Maynard 1871, Brewster 1925).

Aerial surveys of Coos County, New Hampshire, conducted by the USFWS in 1970 and 1971, located a total of 7 and 12 osprey nests, respectively, and the Umbagog area breeding population was believed to number only 3 or 4 pairs by 1977 (Smith 1979). There are relatively few historical references about ospreys breeding in other parts of the state (see Allen 1902, Dearborn 1898, Scott 1921), and there are no comprehensive estimates of statewide historical distribution or population size prior to fieldwork initiated by the New Hampshire Audubon (NHA) and New Hampshire Fish and Game (NHFG) beginning in 1980 (Smith and Ricardi 1983). Since 1980, these two organizations have partnered to conduct extensive annual field monitoring of the state's breeding osprey population (Martin et al. 2004).

Surprisingly, there is only one historical reference to nesting ospreys in New Hampshire's Great Bay area (Scott 1921). Early population declines in New Hampshire may have resulted in part from removal, by loggers, of large pines for nest sites, especially those located on river and lake shorelines and in wetlands. Logging-related population declines have been documented elsewhere in North America (Ewins 1997).

New Hampshire classified the osprey as state threatened in 1980 and soon began to conduct field monitoring and management of the breeding population. During the 1980s, nest sites were limited almost completely to the Androscoggin River watershed. The first nesting in New Hampshire's coastal watershed was documented near Great Bay in 1989, followed by first nesting in the Connecticut River watershed in 1993, and in the Merrimack River watershed in 1996. New Hampshire osprey productivity for the 25-year period from 1980 to 2004 is shown in Table 2. Known available, active, and successful osprey nests in New Hampshire from 1980 to 2002 are shown in figure 2. Osprey fledglings produced at successful nests in New Hampshire from 1980 to 2002 are shown in figure 3.

1.5 Distribution Map

1.6 Habitat Map

Several habitats were mapped that are relevant to ospreys, including marsh and shrub wetlands and known great-blue heron rookeries. This information, along with new and available (e.g., rivers, lakes) data, will be used to map potential osprey habitat.

1.7 Sources of Information

General natural history information and some sources of original research discussed in this document were obtained primarily from The Birds of North America, No. 683: Osprey (Poole et al. 2002). Unless otherwise noted, New Hampshire specific data have been acquired by field monitoring and management activities conducted by NHA from 1980 to 2004 under several cooperative and/or contractual agreements and grants received from NHFG, Public Service Company of New Hampshire, and other funding sources (Martin et al. 2004).

1.8 Extent and Quality of Data

Since 1980, the osprey has been one of the most intensively monitored and managed species in New Hampshire. Breeding site and productivity data are derived from field monitoring conducted for 25 years by NHA staff and trained volunteer observers who use standardized monitoring techniques (Martin et al. 2004).

1.9 Distribution Research

The future distribution and abundance of ospreys in New Hampshire should be monitored by spring breeding surveys of recently active and potential breeding sites. Active breeding territories should be checked annually to determine nest occupancy status and reproductive outcome, and surveys of potential breeding territories should be conducted on a rotating basis, with annual survey intensity determined by available funding and human resources. For example, sites could be checked on a biennial or triennial rotating basis, covering 50% or 33% of potential sites annually.

Element 2: Species/Habitat Condition

2.1 Scale

New Hampshire's 5 major watersheds (Androscoggin, Coastal, Connecticut, Merrimack, and Saco wa-

tersheds) will be considered as separate conservation planning units because there are significant differences between watersheds in the physical characteristics, human land use patterns, population distribution, and nest sites utilized by ospreys (see figure 1).

2.2 Relative Health of Populations

2.1.1 Androscoggin River watershed

The Androscoggin River watershed is one of the most pristine and undeveloped major drainages in the state. Umbagog Lake at the Androscoggin's headwaters was the only part of the state that maintained breeding pairs of osprey through the region-wide period of decline in the 1950s through 1970s. The Umbagog Lake population may have been the source for the recolonization of much of the Androscoggin River watershed during early stages of population recovery in the 1980s and early 1990s. Presently, osprey pairs are clustered around two major water bodies, Umbagog Lake and Pontook Reservoir.

During the 2004 breeding season, the Androscoggin River watershed had the highest number of active nests of any major watershed; 14 young fledged from 12 active nests. The 14 young fledged represent 26% of the statewide number of young produced in 2004. Recently, there has been a shift in the distribution of the breeding population, with fewer pairs breeding near Umbagog Lake and more pairs breeding near Pontook Reservoir. The reasons for this shift are unclear, but may be influenced by changing availability of nest trees, forage base, interactions with aerial predators such as bald eagles, or other factors.

The population in this area should remain stable or continue to expand as long as nest tree availability remains high and the forage base remains in good condition. This area is characterized by spruce and fir forests and has high aquatic productivity. Many of the streams and lakes have good fish producing characteristics, such as high oxygen content and suitable substrate. Most of the lakes and streams are stocked annually and there are a high percentage of water bodies that contain warm water species. Land conservation initiatives, such as the establishment and expansion of the Lake Umbagog National Wildlife Refuge, and protection of shoreline by the State of New Hampshire, should protect foraging and nesting habitat in the long-term.

2.2.2 Coastal Watershed

The Coastal watershed in southeastern New Hampshire includes Great Bay and its tributary rivers and streams. Also included within this watershed are extensive coastal salt marshes along the state's immediate coastline and many isolated beaver ponds and wetlands in the headwaters of many of the river drainages mentioned above.

This area has been highly productive for ospreys since breeding pairs began to recolonize the area in 1989. Since the 2000 breeding season, more than 90% of all active nests located in this watershed have been successful. During the 2004 breeding season, this watershed had the highest number of successful nests of any major watershed; 14 young fledged from 9 active nests, 8 of which were successful. The 14 young fledged represent 26% of the statewide total number of young produced in 2004. Ospreys show an affinity for nests within great blue heron rookeries in this watershed. Nesting platforms erected in the coastal watershed have also been successful.

There is high potential for further breeding population expansion in the Coastal watershed due to the numerous lakes and ponds, an abundance of heron rookeries, and a focused effort to install additional platforms and replica nests. Currently there are 4 unoccupied platforms and 1 unoccupied replica nest in the coastal watershed.

2.2.3 Connecticut River Watershed

The Connecticut River watershed extends from the northernmost tip of New Hampshire to the state's southern border with Massachusetts. The Connecticut River flows through several ecoregions and includes several diverse habitats. Northern New Hampshire, characterized by soft and hardwood forests, has a long history of industrial ownership and uses. Agricultural uses are common within the drainage, especially in northern and central sections.

The osprey population in the Connecticut River watershed is in the early stages of recovery. During the 2004 nesting season, 8 young fledged from 5 active nests. The 8 young fledged represent 15% of the statewide total number of young produced in 2004. No active nesting attempts have been documented in the southern two thirds of this watershed, though there are 6 unoccupied platforms available along the

southern two thirds of the Connecticut River in New Hampshire.

Foraging areas are plentiful in the northern Connecticut River watershed. The area is a popular destination for fishermen, and NHFG heavily stocks local water bodies with trout. The area also has a high number of low-lying shallow ponds oxbows and streams ideal for osprey hunting. The Connecticut River watershed contains some of the more rural areas left in New Hampshire. Recently, industrial landowners have sold large parcels of land in the northern region, including lands comprising the headwaters of the Connecticut River. As a result, a large portion of the watershed will be conservation land. Incentives are also being provided to farm owners throughout the watershed in an attempt to conserve some of New Hampshire's open field habitats and farms.

Nest site availability is potentially a limiting factor for osprey population expansion in the Connecticut River watershed. In northern areas, supercanopy pines are uncommon due in part to historical logging practices and due to elevation and predominating soil characteristics. The practice of retaining snags during timber harvests is a relatively new management consideration; snag retention became common only within the past 20 years. Therefore, the lack of larger diameter snags in the Pittsburg area may be a result of harvesting that occurred prior to their identification as desired wildlife retention species. Furthermore, soils in the northern extent of the state are not especially suited for white pine production, and spruce and fir characterize much of this area. Agricultural areas found within the northern, central, and southern sections of the Connecticut Watershed contain very few large diameter trees and are managed as fields.

2.2.4 Merrimack River Watershed

The Merrimack River watershed, including the Lakes Region, the upper Merrimack valley, and the lower Merrimack valley, drains an extensive portion of central and southern New Hampshire. Starting at Franconia Notch, the drainage continues south to the Massachusetts border. Water bodies within this area range from deep, cold lakes and ponds to shallow marshes. The Merrimack River is large, includes many oxbow ponds, and provides a substantial amount of potential osprey foraging and nesting habitat.

During the 2004 breeding season, this watershed had the highest number of young fledged; 17 young fledged from 8 active nests. The 17 young fledged represent 32% of the statewide total number of young produced in 2004. A majority of these active nests was located within heron rookeries, which are commonly found in beaver ponds throughout the watershed. There is high potential for ospreys to establish new nesting sites in heron rookeries scattered throughout the watershed, especially within the Lakes Region.

2.2.5 Saco River Watershed

The Saco River watershed located in the east-central portion of New Hampshire is mountainous. Water bodies within this area are typically clear, cold, and deep. Each of these characteristics is less than ideal foraging habitat for ospreys. Warmer, shallow water bodies tend to produce more foraging opportunities for ospreys. However, the sandy soils of the region are also characterized by an abundance of white pine, which are preferred by osprey as nesting trees. Through the 2004 breeding season, there were no known osprey nests located within this watershed.

The Saco River watershed has an abundant growth of supercanopy pine, yet the lack of white pine snags may be a limiting factor. Shallow water bodies and areas historically selected by great blue herons may offer potential osprey nest areas. Deep, oligotrophic lakes in the watershed have limited productivity due to the high abundance of granite and sand and, as a result, these water bodies are deficient in the correct characteristics to produce preferred forage species such as perch and pickerel.

2.3 Population Management Status

Management strategies for ospreys in New Hampshire fall into 3 categories:

1) Locate territorial pairs
From 1980 to 2004, NHA staff biologists solicited and evaluated public reports of ospreys in areas of potential breeding habitat and followed up with field surveys by staff or trained volunteer observers to identify occupied territories. The number of occupied nest sites has risen from 6 in 1980 to a recent high of 44 in 2003, and from presence in only 1 major watershed in 1988 to 4 of the state's 5 major watersheds by

1996 (Martin et al. 2004).

2) Monitor and manage nesting attempts
Nesting attempts have been monitored by trained volunteers observers and NHA staff biologists from 1980 to 2004, resulting in the documentation of 472 active nesting attempts, 296 successful nesting attempts, 613 young fledged (1.30 young/nesting attempt), and 176 nest failures (37% failure rate). The NHA staff installed sheet metal predator guards around the bases of nest trees to deter tree-climbing mammalian nest predators.

3) Augment natural nest sites by installing nesting platforms and replica nests
The NHA and NHFG began installing nest structures in 1977 around Umbagog Lake, but such activity did not begin in earnest until 1994 in the coastal watershed, when cooperation with Public Service Company of New Hampshire began. The primary objectives were to hasten colonization by ospreys of unoccupied areas of the state and to provide additional nesting opportunities for new osprey pairs within already occupied areas. As of the end of 2004, there were a total of 28 human-built structures (22 platforms and 6 replica nests) in place in New Hampshire for ospreys.

4) Public outreach and education
Information on the goals and status of osprey conservation efforts in New Hampshire has been disseminated in a variety of ways and has involved many different audiences. Extensive efforts have been made to educate the public on accurate identification and reporting of osprey. Articles and media news releases on the state's osprey recovery efforts and opportunities for direct public volunteer involvement appear annually in newspapers, on radio, and in newsletters of various natural resource agencies and conservation groups. The NHA staff offers public lectures and conduct volunteer training sessions annually to effective public participation in osprey conservation. Outreach to landowners, developers, and recreationists concerning osprey habitat needs are ongoing and essential.

2.4 Relative Quality of Habitat Patches

Currently occupied breeding habitat appears to provide the key ecological attributes required to support a healthy, expanding breeding population. Ospreys are generalist feeders that catch fish that linger near the water's surface (Poole et al 2002). The state's lakes and ponds, reservoirs, and rivers are well stocked and will likely provide foraging resources to support additional breeding pairs over the coming decade. The state's beaver and great blue heron population are at healthy levels; thus, the future development of new nest site habitat appears secure. Suitable nesting substrate does not appear to be a limiting factor, except perhaps in the Connecticut Lakes area where there are very few supercanopy pines available. The greatest ongoing habitat quality concerns include the following:

- Additional shoreline development near wetlands and on rivers and lakes, especially in the Merrimack River and the Coastal watersheds
- Increasing use of motorized watercraft and growing popularity of kayaks and canoes, especially in the Androscoggin River watershed
- Additional wetland losses, especially in the Merrimack River and the Coastal watersheds

2.5 Habitat Patch Protection Status

Of the 73 known osprey nests and human-built nest sites in 2004, 33 (45%) were located on public lands (16 federal, 12 state, 5 county or municipal government) and 40 (55%) were located on private land. Conservation easements or other formal conservation measures applied to 40 (55%) of the state's nest sites.

2.6 Habitat Management Status

Nest sites on public land are generally managed to promote productive breeding attempts, but few actual zone closures are in effect. Nest sites on private land are subject to landowner decisions, but outreach and education with landowners have usually resulted in land use practices that benefit osprey nesting success. No formal management agreements are currently in effect in the state.

2.7 Sources of Information

Information on the state's breeding osprey population is derived directly from summary reports and

field data on monitoring and management activities conducted by ANSH from 1980 to 2004 under annual contracts and grants received from the NHFG, from Public Service Company of New Hampshire and other funding sources (Martin et al. 2004).

2.8 Extent and Quality of Data

Because ospreys have been state-listed as threatened since the late 1970s, few New Hampshire wildlife species have a more complete data set on occurrence, productivity, and nest site condition. Annual summaries of this information are on file at NHA.

2.9 Condition Assessment Research

Long-term baseline monitoring of breeding ospreys in New Hampshire remains an important task in order to detect future threats to a stable or growing population in the state. Formal adoption of the existing draft recovery plan, including specific targets for delisting, should be a priority. Additional research to determine contaminant loads present in New Hampshire osprey chicks should be encouraged and facilitated by NHFG in order to determine the potential impact on statewide productivity and population recovery.

Element 3: Species and Habitat Threat Assessment

3.1.1 Mercury and Non-point Source Pollution

(A) Exposure Pathway
There are many types of anthropogenic pollutants whose toxic residues are known to biomagnify, particularly in aquatic systems, as they reach species that occupy higher trophic levels, such as ospreys. While only infrequently resulting in direct mortality, these pollutants have a range of more common sub-lethal effects, especially in long-lived predators such as ospreys that accumulate toxins over a long period. These various neurotoxins produce reproductive, behavioral, neurological, and physiological changes that can result in reduced vigor and breeding success (Wiemeyer et al. 1988, Steidl et al. 1991, Evers 2005).

Ospreys continue to be exposed to toxic contaminants through the fish they eat. Although industrial discharge to surface waters has been significantly curtailed, toxic chemicals are transported long distances by air currents, and these chemicals enter aquatic systems via atmospheric deposition. Although the use of PCBs and dioxins has received much attention in North America, mercury has become an increasing problem in aquatic systems. One recent study conducted in Ontario and New Jersey found that mercury levels did not reach a level associated with toxic effects (Hughes et al. 1997), though another determined that high levels of mercury are present in adult and nestling ospreys in northern Quebec (Desgranges et al. 1998). Additionally, new pesticides continue to be developed that may have undetermined impacts on osprey and other wildlife.

(B) Evidence
Mercury levels are high and pervasive in northeastern North America in aquatic food webs (Hughes et al. 1997, Desgranges et al. 1998, Evers 2005). Brominated fire retardants, commonly known as PBDEs, are similar in chemical structure to PCBs, and are used in a wide range of synthetic household and consumer products. PBDEs have recently been shown to be accumulating in wildlife populations worldwide, including in raptors (Sharp and Lunder 2004). PCBs and many other organic compounds are also commonly detected in ospreys (Wiemeyer et al. 1998).

3.1.2 Recreation (Lead shot and sinkers)

(A) Exposure Pathway:
In a manner similar to what has been well documented in bald eagles, ospreys may be subject to lead poisoning by consuming lead sinkers associated within living or dead fish that they consume. This could potentially be an important source of anthropogenic morbidity and mortality. Continued use of lead fishing tackle (in violation of state laws) could threaten ospreys in certain areas.

(B) Evidence:
Lead poisoning of bald eagles has been documented in at least 34 states (Buehler 2000). Similar exposure in ospreys is far less well documented, however ospreys utilize a similar prey base of living and dead fish, and therefore would be expected to experience similar exposure. One difference is that ospreys are likely not exposed to lead shot because they do not typically feed on non-piscivorous prey and carrion (Poole et al. 2002).

3.1.3 Recreation (Boats and Jet Skis)

(A) Exposure Pathway
Recreational boating can modify osprey foraging patterns by reducing use of perching and foraging areas, potentially altering food delivery and productivity.

(B) Evidence
Motorized boat traffic on New Hampshire water bodies is increasing, as are the size of vessels and their top speed. Improved access to public waters has the potential to further increase the number of boats on the water. The growing popularity of small personal watercraft (motorized jet skis as well as self-propelled canoes and kayaks) has the added effect of bringing increased human traffic volume into the shallow coves and other areas where ospreys feed, perch, and rest.

3.1.4 Development (Shoreline Development)

(A) Exposure Pathway
Shoreline development and increased recreational on water bodies may disturb nesting adults and reduce availability of perching and feeding sites. Development can limit the future expansion of a recovering population and act to reduce future carrying capacity. New Hampshire is among the fastest growing states in the northeastern U.S. Shoreline real estate development contributes to secondary problems such as increased pollution and water-based recreation, which also have the potential to negatively impact ospreys.

(B) Evidence
Some osprey pairs have been documented to acclimate to frequent human activity at nesting sites, especially where the presence of human activity precedes nest establishment (Ewins 1996, Poole et al. 2002). However, many New Hampshire pairs do not appear to exhibited this high degree of tolerance. Shoreline development affects perching and foraging by ospreys, with possible direct and indirect effects on reproductive success. In Ontario, shoreline development has been suggested as a leading source of reduction in nest site availability (Ewins 1997).

3.1.5 Energy and Communication Infrastructure

(A) Exposure Pathway
Ospreys are attracted to high-tension electricity transmission towers and to smaller wooden utility poles as potential nest sites, and this exposes ospreys to the risk of electrocution (Ewins 1995). Although this is not considered the most significant risk to the state's osprey population, it can be managed through monitoring and collaboration with utility companies.

(B) Evidence
During the past decade, the number of power line osprey nests in New Hampshire has increased from 1 to 7 sites. Although there are no documented instances of electrocution of ospreys in the state, there have been cases where power interruptions have been caused by nest structures.

3.1.6 Development (Habitat Loss and Conversion

(A) Exposure Pathway
Availability of suitable nest sites appears frequently to limit some local breeding populations of osprey (Ewins 1997). Supercanopy pines near wetland edges and dead standing trees located in flooded beaver ponds are both highly attractive to ospreys as nesting sites. Flooded areas reduce the vulnerability of osprey nests to mammalian predators (Poole et al. 2002), and draining or filling of wetlands reduces the ability of these areas to support viable osprey nests.

(B) Evidence
Researchers working in certain parts of Europe have reported that some forestry practices have severely reduced or eliminated suitable supercanopy nesting trees, which resulted in fewer available nest sites for ospreys (Meyburg et al. 1996). In Ontario, timber extraction has been suggested as a leading cause of reduction in nest site availability (Ewins 1997).

3.1.7 Non-point Source Pollution (Pesticides and Herbicides)

(A) Exposure Pathway
Ospreys are exposed to DDT and other organochlorines in the fish they consume. These chemicals may be transported long distances by air and may enter aquatic systems via atmospheric deposition and precipitation. Although the use of DDT and other organochlorines has been much reduced in North America, ospreys may still be exposed on the wintering grounds and in migration.

(B) Evidence
The use of DDT has been greatly reduced in North America, but ospreys are long-distance migrants and are exposed to DDT and other organochlorine compounds in prey species on the wintering grounds and in migration (Elliott et al. 2000).

3.2 Sources of Information

Information on various threats to ospreys was obtained from literature review, from NHA field data, and from consultation with specialists employed by the USFWS, NHFG, and the NHA, all located in Concord, New Hampshire, and from BioDiversity Research Institute in Gorham, Maine.

3.3 Extent and Quality of Data

Most of the threats described above have been examined carefully by researchers working outside of New Hampshire. The negative effects of mercury, PBDEs, PCBs, and DDT on aquatic species are well known and are well documented by researchers nationwide. There are sufficient data on the threat posed by lead to piscivorous bird species in New Hampshire that legislation has recently been passed that prohibits the use of certain size lead sinkers and jigs. There is no substantial New Hampshire specific data set on effects on ospreys of motorized and self-propelled boating activity. There is sufficient concern about shoreline and wetland habitat loss to justify strengthening land use policies and investing in more land protection efforts by federal and state agencies, and by non-profit conservation groups. Electrocution issues are currently being addressed in collaboration with local utility companies.

3.4 Threat Assessment Research

There are several areas where additional threat assessment research is warranted, including:

- Investigation into the likely future extent of wetland and shoreline development on water bodies in New Hampshire, and development of a pro-active plan that would better protect wildlife values associated with shorelines and wetlands.
- Investigation of the tolerance of osprey for recreational boating activity in the vicinity of nest sites and foraging areas
- Additional investigation of current levels of mercury, PCBEs, DDE, and other bioaccumulative pollutants in New Hampshire ospreys.

Element 4: Conservation Actions

4.1.1 Document breeding status, Restoration and Management

To determine occupancy status and reproductive outcome, distribution and abundance of breeding ospreys should be documented by nest site visits. Data on annual osprey productivity are needed to determine when recovery goals are achieved. This can be accomplished largely by training and coordinating a statewide network of volunteer nest site monitors. Direct threats addressed under this conservation action include mercury, PBDEs, PCBs, lead, motorized and self-propelled watercraft, shoreline development, electrocution, wetland loss, DDT, and organochlorines.

4.1.2 Finalize and adopt state recovery plan for ospreys, Regulation and Policy

Formally adopt an existing draft state recovery plan for ospreys (Martin et al. 2004) that includes specific targets for delisting. This conservation action builds on 25 years of ongoing management activities to insure population viability and establish clear targets for population recovery. Direct threats addressed under this conservation action include mercury, PBDEs, PCBs, lead, motorized and self-propelled watercraft, shoreline development, electrocution, wetland loss, DDT, and organochlorines.

4.1.3 Determine contaminant loads, Restoration and Management

Conduct more extensive monitoring of contaminant loads present in New Hampshire osprey chicks to determine the potential impact of toxics on statewide productivity and population recovery. This conservation action builds on 25 years of ongoing management activities to insure population viability and understand the effects of environmental contaminants. Direct threats addressed under this conservation ac-

tion include mercury, PBDEs, PCBs, lead, DDT, and organochlorines.

4.1.4 Nest site management, Restoration and Management

Install predator guards on nest sites and selectively place additional nesting platforms to disperse the breeding population. To minimize predation by mammalian predators such as raccoons and to increase productivity rates, the NHA and NHFG have installed predator guards on all new nest poles since 1994 and have installed predator guards on a majority of existing natural nest trees since 1985. Consult with local landowners and collaborate with utility companies to install additional nest poles and platforms to encourage colonization by ospreys of unoccupied areas of the state and to provide additional nesting opportunities for new osprey pairs in already occupied parts of the state. Direct threats addressed under this conservation action include motorized and self-propelled watercraft, shoreline development, electrocution, and wetland loss.

4.1.5 Encourage cooperative research, Restoration and Management

There is a need for more information on the effects of certain contaminants, osprey migration, and nest site fidelity. Migration should be studied using satellite tracking of a subset of the New Hampshire population. Current and proposed blood sampling will provide information on environmental contamination of New Hampshire osprey. Banding studies should also be conducted to assess nest site fidelity. In total, this research will improve our understanding of risk factors and will guide future conservation efforts. Direct threats addressed under this conservation action include mercury, PBDEs, PCBs, DDT, and organochlorines.

4.1.6 Provide public outreach materials, Education and Outreach

Enhance educational efforts about osprey biology, habitat, and land conservation issues to promote better local stewardship, reduce nest disturbance, and provide public support for wildlife protection efforts in general. Direct threats addressed under this conservation action include mercury, PBDEs, PCBs, lead, motorized and self-propelled watercraft, shoreline development, electrocution, wetland loss, DDT, and organochlorines.

4.1.7 Promote conservation of great blue heron colonies and healthy beaver populations, Restoration and Management

Particularly in the southern part of New Hampshire, ospreys commonly select great blue heron rookeries located in flooded wetlands as nest sites. To maintain and encourage a self-sustaining population of osprey, heron rookeries, and the beaver populations that produce dead standing trees in wetlands, should be maintained and protected from disturbance. Direct threats addressed under this conservation action include shoreline development and wetland loss.

Element 5: References

5.1 Literature

Allen, G. M. 1902. A list of the birds of New Hampshire. Proceedings of the Manchester Institute of Arts and Sciences 4. Manchester, NH.

Buehler, D. A. 2000. Bald eagle (*Haliaeetus leucocephalus*). *In* The Birds of North America, No. 683 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Brewster, W. 1925. The birds of Lake Umbagog region of Maine, Pt. 2. Bulletin of Comparative Zoology 66. Harvard College, Cambridge, Mass.

Dearborn, N. 1898. A preliminary list of the birds of Belknap and Merrimack counties, New Hampshire, with notes. M.S. thesis, New Hampshire College of Agricultural and Mechanical Arts, Durham, New Hampshire.

Desgranges, J.L., J. Rodrigue, B. Tardif, and M. Laperle. 1998. Mercury accumulation and biomagnification in ospreys (*Pandion haliaetus*) in James Bay and Hudson Bay regions of Quebec. Archives of Environmental Contaminants and Toxicology 35:330-341.

Elliott, J. E., M. M. Machmer, L. K.Wilson, and C. J.Henny. 2000. Contaminants in ospreys from the Pacific northwest; organochlorine pesticides, polychlorinated biphenyls, and mercury, 1991-1997. Archives of Environmental Contaminants and

Toxicology 38:93-106.

Environment Canada. 2001. The fall and rise of osprey populations in the Great Lakes basin. Environment Canada web site (www.on.ec.gc.ca/glimr/data/osprey-glbasin/).

Evans, D. 1994. Osprey. Pp. 42-43 *in* Atlas of breeding birds in New Hampshire. (C. R. Foss (ed.). Arcadia Press, Dover, NH.

Evers, D. C. 2005. Mercury connections: The extent and effects of mercury pollution in northeastern North America. BioDiversity Research Institute. Gorham, ME. 28 pp.

Ewins, P. J. 1995. The use of artificial nest sites by an increasing population of ospreys in the Canadian Great Lakes basin. Pp. 3-13 *in* Raptors in human landscapes (D. M. Bird, D. E. Varlan, and J. J. Negro, eds.). Academic Press, London, U.K.).

Ewins, P.J. 1996. The use of artificial nest sites by an increasing population of ospreys in the Canadian Great Lakes basin. Pp. 109-123, *in* D.M. Bird, D.E. Varland, and J.J. Negro. Raptors in human landscapes: adaptations to built and cultivated environments. Academic Press. 396 pp.

Ewins, P. J. 1997. Osprey (*Pandion haliaetus*) populations in forested areas of North America: changes, their causes, and management recommendations. Journal of Raptor Research 31:138-150.

Gibson, L. 2003. Return of Rhode Island osprey. Osprey newsletter, No. 74. Rhode Island Division of Fish and Wildlife. 4 pp.

Gibson, L. 2005. Return of Rhode Island osprey. Osprey newsletter, No. 78. Rhode Island Division of Fish and Wildlife. 4 pp.

Gobeille, J. 2004. 2003 Vermont osprey nest report. Vermont Agency of Natural Resources. 4 pp.

Green Mountain Audubon Society (GMAS). 2001. Osprey. Green Mountain Audubon Society web site (www.thecompass.org/audubon/conservation/osprey.html) .

Hagan, J. M. and J. R. Walters. 1990. Foraging behavior, reproductive success, and colonial nesting in ospreys. Auk 107:506-521.

Henny, C.J. and J.C. Ogden. 1970. Estimated status of osprey populations in the United States. Journal of Wildlife Management 34:214-217.

Henny, C. J. and W. Van Velzen. 1972. Migration patterns and wintering localities of American ospreys. Journal of Wildlife Management 36:1133-1141.

Houghton, L. M. and L. M. Rymon. 1997. Nesting distribution and population status of U.S. ospreys 1994. Journal of Raptor Research 31:44-53.

Hughes, K.D., P.J. Ewins, and K.E. Clark. 1997. A comparison of mercury levels in feathers and eggs of osprey (*Pandion haliaetus*) in the North American Great lakes. Archives of Environmental Contaminants and Toxicology 33:441-452.

Martell, M. S., C. J. Henny, P. E. Nye, and M. J. Solensky. 2001. Fall migration routes, timing, and wintering sites of North American ospreys as determined by satellite telemetry. Condor 103: 715-724.

Martin, C. J., M. N. Marchand, J. R. Kelly, T. L. Tarr, and J. J. Kanter. 2004. Draft edition of New Hampshire Osprey Recovery Plan. 26 pp.

Maynard, C. J. 1871. A catalogue of the birds of Coos County, New Hampshire, and Oxford County, Maine. Proceedings of the Boston Society of Natural History 14:357-395.

Meyburg, B.-U., O. Manowsky, and C. Meyburg. 1996. The osprey in Germany: its adaptation to environments altered by man. Pp. 125-135, *in* D.M. Bird, D.E. Varland, and J.J. Negro. Raptors in human landscapes: adaptations to built and cultivated environments. Academic Press. 396 pp.

New York State Department of Environmental Conservation (NYSDEC). 2001. Osprey fact sheet. New York State DEC web site (www.dec.state.ny.us/website/dfwmr/wildlife/endspec/osprfs.html) .

Ogden, J. C.(ed.). 1977. Transactions of the North American osprey research conference, College of William and Mary, Williamsburg, VA, 10-12 February 1972. U.S.D.I., National Park Service, Transactions and Proceedings Series, No. 2.

Palmer, R. S. 1988. Handbook of North American birds, Vol. 4. Yale University Press, New Haven, Connecticut. 433 pp.

Parren, S.G. 1997. Vermont osprey recovery plan. Vermont Fish & Wildlife Department. 10 pp. plus appendices.

Poole, A. F. 1989. Ospreys: a natural and unnatural history. Cambridge University Press.

Poole, A. F., R. O. Bierregaard, and M. S. Martell. 2002. Osprey (*Pandion haliaetus*). *In* The Birds of North America, No. 683 (A. Poole and F. Gill, eds.). The Birds of North America, Inc. Philadelphia, PA.

Prevost, Y. 1979. Osprey-bald eagle interactions at a

common foraging site. Auk 96:413-414.

Scott, C. F. 1921. Notes on land birds of southern New Hampshire. M.S. thesis, University of New Hampshire, Durham, NH.

Sharp, R. and S. Lunder. 2004. In the dust: Toxic fire retardants in American homes. Environmental Working Group. Washington, DC and Oakland, CA. Document available at www.ewg.org. 57 pp.

Smith, C. F. 1979. Proceedings of the [New Hampshire] endangered species conference. U.S. Fish and Wildlife Service, Newton Corner, MA.

Smith, C. F. and C. Ricardi. 1983. Ospreys and bald eagles in New Hampshire: status, habitat, and nest site characteristics. Pp. 149-156, *in* Biology and management of bald eagles and ospreys (D. M. Bird, ed.). Harpell Press. Ste. Anne de Bellevue, Quebec. 325 pp.

Spitzer, P.R., R.W. Riseborough, W. Walker, R. Hernandez, A. Poole, D. Puleston, and I.C.T. Nisbet. 1978. Productivity of ospreys in Connecticut-Long Island increases as DDE residues decline. Science 202:333-335.

Steidl, R.J., C.R. Griffin, and L.J. Niles. 1991. Contaminant levels of osprey eggs and prey reflect regional differences in reproductive success. Journal of Wildlife Management 55:601-608.

Stocek, R. F. and P. A. Pearce. 1983. Distribution and reproductive success of ospreys in New Brunswick, 1974-1980. Pp. 215-221, *in* Biology and management of bald eagles and ospreys. (D. M. Bird, ed.). Harpell Press. Ste. Anne de Bellevue, Quebec. 325 pp.

U. S. Fish and Wildlife Service. 2000. Osprey habitat model. Gulf of Maine Coastal Program web site (http://r5gomp.fws.gov).

Vermont Agency of Natural Resources (VANR). 2001. Vermont's osprey population is on the increase. Vermont ANR web site (www.anr.state.vt.us/bridge/fall00/osprey.htm).

Wiemeyer, S. N., C. M. Bunck, and A. J. Krynitsky. 1988. Organochlorine pesticides, polychlorinated biphenyls, and mercury in osprey eggs – 1970-79 – and their relationships to shell thinning and productivity. Archives of Environmental Contaminants and Toxicology 17:767-787.

5.2 Data Sources:

Osprey nest and productivity surveys from 1981-2004, MS Access database, New Hampshire Audubon, Concord, NH.

Element 6: List of Figures

Figure 1. Number of known available, active, and successful osprey nests in New Hampshire from 1980-2002.

Figure 2. Number of osprey fledglings produced at successful nests in New Hampshire from 1980 to 2002.

Figure 3. Distribution of known active osprey nests within five major watersheds in New Hampshire during 1980-1989, 1990-1994, 1995-1999, and 2000-2003.

Figure 4. Number of known active osprey nests within four major watersheds of New Hampshire from 1980-2003.

Table 1. New Hampshire osprey productivity summary: 1980-2004.

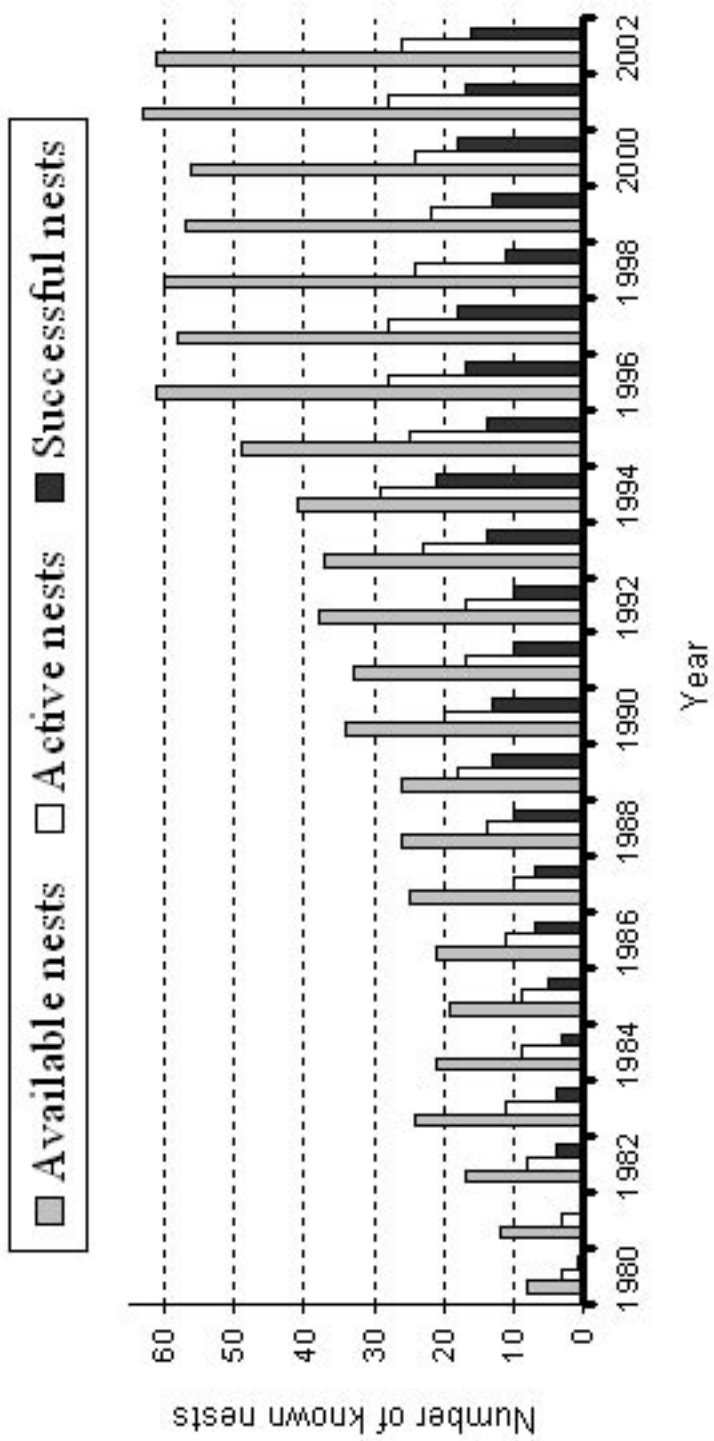


Figure 1. Number of known available, active, and successful osprey nests in New Hampshire from 1980-2002.

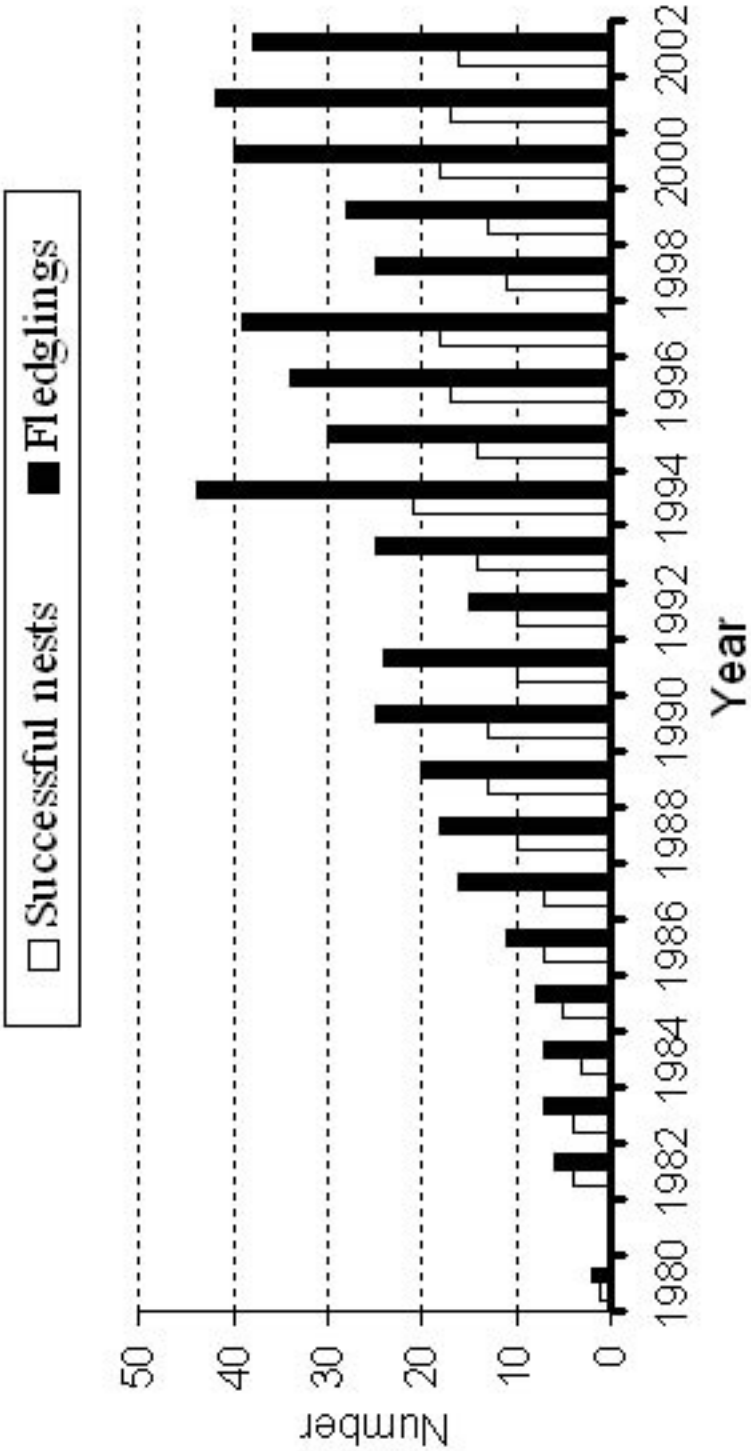


Figure 2. Number of osprey fledglings produced at successful nests in New Hampshire from 1980 to 2002.

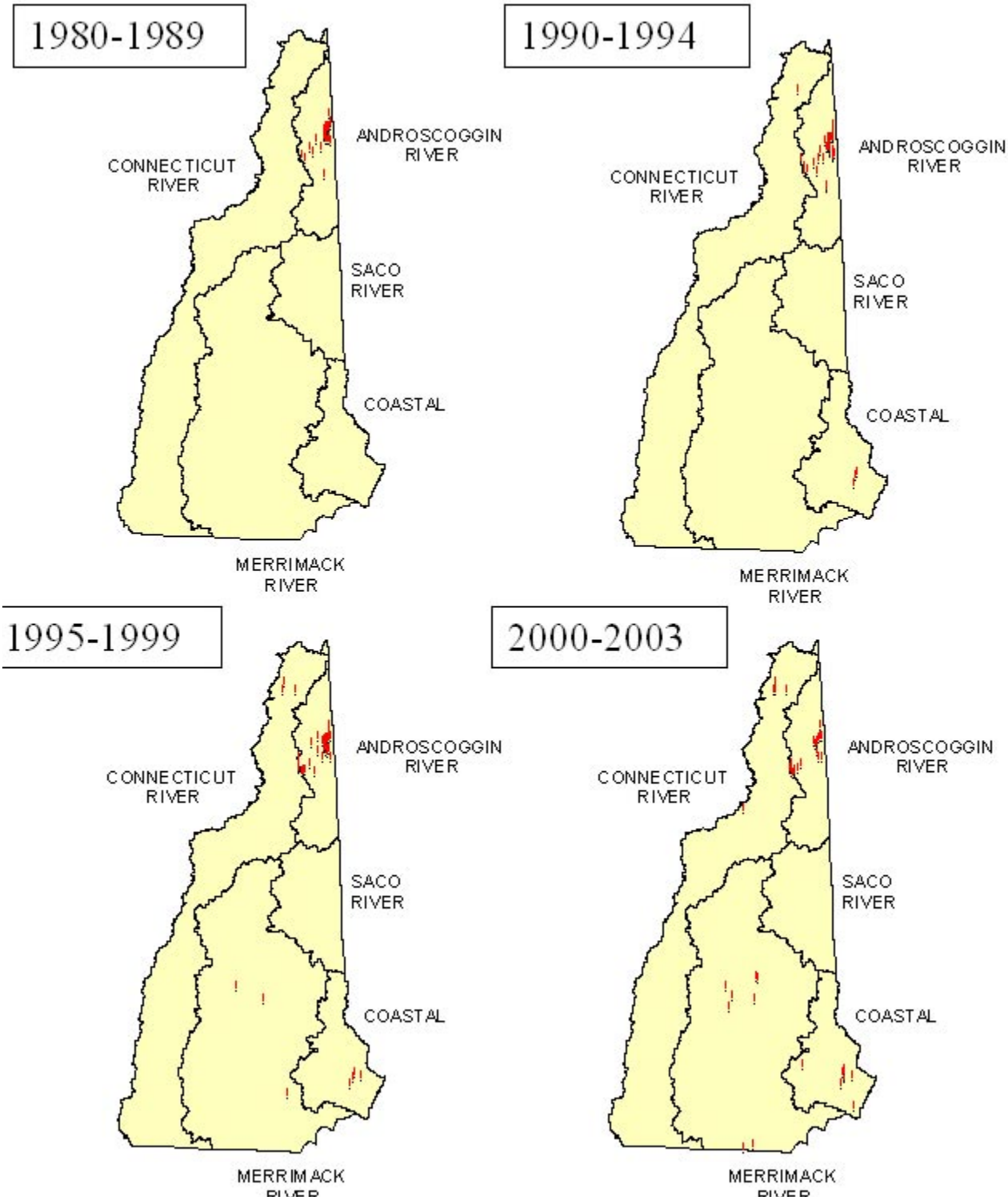


Figure 3. Distribution of known active osprey nests within five major watersheds in New Hampshire during 1980-1989, 1990-1994, 1995-1999, and 2000-2003.

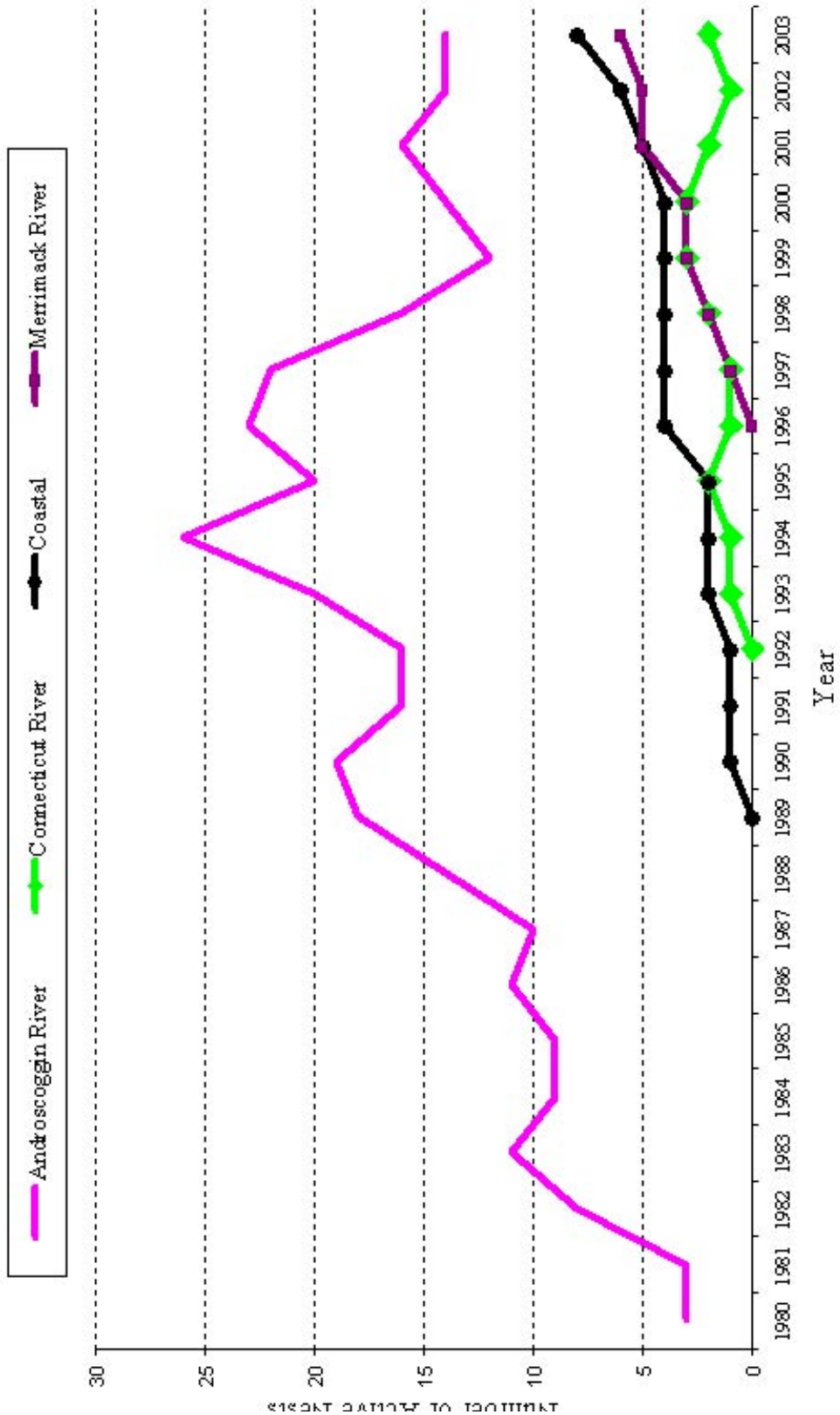


Figure 4. Number of known active osprey nests within four major watersheds of New Hampshire from 1980-2003.

Year	Occupied Nests	Active Nests	Successful Fledged	Young	Young per Nesting Pair
1980	6	3	1	2	0.67
1981	9	3	0	0	0
1982	14	8	4	6	0.75
1983	20	11	4	7	0.64
1984	15	9	3	7	0.77
1985	14	9	5	8	0.89
1986	15	11	7	11	1
1987	18	10	7	16	1.6
1988	21	14	10	18	1.29
1989	23	18	13	20	1.11
1990	26	20	13	25	1.25
1991	21	17	10	24	1.49
1992	33	17	10	15	0.88
1993	37	23	14	25	1.09
1994	32	29	21	44	1.52
1995	33	25	14	30	1.2
1996	43	28	17	34	1.21
1997	39	28	18	39	1.39
1998	36	24	11	25	1.04
1999	34	22	13	28	1.27
2000	39	24	18	40	1.67
2001	39	28	17	42	1.5
2002	32	27	17	40	1.48
2003	44**	30	23	54**	1.80**
2004	43	34**	26**	53	1.56
Totals for 1980-2004	**472**	**296**	**613**		**1.3**

Table 1. New Hampshire osprey productivity summary: 1980-2004.

SPECIES PROFILE

Palm Warbler

Dendroica palmarum

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S3B
Author: Kim A. Tuttle, New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

Palm warblers nest in bogs and fens in boreal forests, usually on the ground beneath a short conifer (Richards 1994, Wilson 1996). Shrub openings, sphagnum, and a spruce or tamarack canopy are key habitat characteristics (Welsh in Richards 1994).

1.2 Justification

The palm warbler reaches the southern extent of its nesting range in northern New Hampshire, which may explain its absence from several apparently suitable nesting habitats. Peatlands are rarely altered and palm warblers are less likely to be affected by habitat fragmentation than are forest dwelling birds in the northeastern and central United States (Wilson 1996). However, the fragmentation of forested uplands adjacent to peatlands may provide egg and nest predators, such as common grackles (Quisculus quiscula) and raccoons (Procyon lotor), with greater access to palm warbler nests (Wilson 1996).

Palm warblers are nocturnal migrants. They are one of the most frequently killed migrants in collisions with television towers and other tall and lighted buildings and structures. Over a 25-year period, a single television tower in Florida was responsible for 2,305 palm warbler deaths, mostly during the fall migration. This number represents 5.4% of all birds killed by the tower (Wilson 1996).

1.3 Protection and Regulatory Status

Palm warblers are protected under the Federal Migratory Bird Treaty Act (1918).

1.4 Population and Habitat Distribution

Palm warblers are among the most northerly of the Dendroica warblers, nesting mostly in bogs and fens in boreal forests across much of Canada and the northern United States (Wilson 1996). In New England, palm warblers nest in central and northern Maine and in northern New Hampshire (Richards 1994). Richards documented the first likely breeding record for New Hampshire in 1957 by observing 2 palm warblers, one of which was carrying food to Floating Island Bog at Harper's Meadow in Errol. In August 1980, Richards recorded the first observation of a juvenile with remnant down at the same bog as an adult (Richards 1994). Richards (1994) identified no 'confirmed' or 'probable' breeding records for palm warblers in New Hampshire, although single birds were seen in a stand of northern white cedar on a low ridge near Floating Island Bog in Errol and Dummer.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

See Peatlands Habitat Mapping (element 1.6)

1.7 Sources of Information

NatureServe (2005) was used for status and ranking information. Recent distribution data are from the NHBR database, maintained by NHA, and from Richards (1994). Distribution, habitat, and life his-

tory information were taken from published literature including Richards (1994).

1.8 Extent and Quality of Data

Palm warblers appear to be limited to a few semi-open bogs in northern New Hampshire, mostly because the species reaches the southeastern edge of its breeding range here. Much of the preferred bog habitat is barely accessible to observers and the species may occur more often than records indicate (Richards 1994). In addition, palm warblers are difficult to relocate even if they are close to previous nesting sites (Richards 1994).

1.9 Distribution Research

Since palm warbler records are few in New Hampshire, known breeding locations can be checked annually. Palm warblers can be included in comprehensive peatland habitat inventories and monitoring.

Element 4: Conservation Actions

See Peatlands profile for conservation actions. Maintaining intact uplands around peatlands may prevent increased nest mortality from predators associated with fragmentation.

Element 5: References

5.1 Literature

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: 17 March 2005).

Richards, T. 1994. Palm warbler. Page 385 in Atlas of breeding birds in New Hampshire, C.S. Foss, editor. Arcadia, Dover, New Hampshire, USA.

Wilson, W.H., Jr. 1996. Palm warbler (Dendroica palmarum). In The Birds of North America,

No. 238, A. Poole and F. Gill, editors. The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C. USA.

5.2 Data Sources

New Hampshire Bird Records database. Maintained by New Hampshire Audubon, Concord, New Hampshire, USA. (Accessed 30 March 2005)

SPECIES PROFILE

Peregrine Falcon

Falco peregrinus

Federal Listing: Not listed
State Listing: Endangered
Global Rank: G4
State Rank: S1
Author: Christian J. Martin, New Hampshire Audubon

Element 1: Distribution and Habitat

Habitat Description

The peregrine falcon is a wide-ranging species that uses many different habitats across the United States for breeding, wintering, and migration. Open landscapes and air spaces, where peregrine falcons can locate and attack their prey in the air, are important components of most habitat types. Peregrine falcons in cliff habitats are often generalist feeders, preying on medium-sized birds roughly in proportion to their local abundance. Peregrine falcons sometimes travel several miles from cliffs to obtain prey. Preferred habitats include mountainous terrain, agricultural land, wide river valleys, lake shorelines, ocean coastlines, and islands (White et al. 2002). The urban environment, with high-rise buildings, major bridges, and tall smokestacks, has become an increasingly important habitat for peregrine falcons within the past quarter century (Cade et al. 1996b).

The home range of a territorial individual can be relatively small (100 km^2) when prey populations are abundant, but may be much larger (350 to 1,500 km^2) when prey populations are more dispersed (White et al. 2002). Peregrine falcons prefer to raise young on vertical cliffs or on man-made structures that possess physical characteristics similar to cliffs. Peregrine falcons can potentially establish breeding territories anywhere in the United States provided that areas with suitable nest sites and sufficient prey base occur in close proximity.

1.2 Justification

Peregrine falcons historically established breeding territories in relatively low densities in suitable cliff habitats throughout the United States. Between the late 1800s and the early 1940s, many cliff breeding sites in the eastern half of the country were identified and documented (Hickey 1942). Extensive reproductive failure caused by increasing levels of persistent synthetic chlorinated hydrocarbons (DDT and others) in their avian prey caused a dramatic population decline and range reduction starting in the late 1940s and continuing through 1970 (Hickey 1969, Enderson et al. 1995). In New Hampshire, peregrine falcons ceased to breed productively by the late 1950s and all known nesting areas in the state became vacant by the mid-1960s (Spofford 1975). By the late 1960s, peregrine falcons no longer occupied any historical breeding sites in states east of the Rocky Mountains (Cade et al. 1988). A massive restoration program began in the mid-1970s and was unprecedented in scope and scale. This effort resulted in the gradual recovery and re-occupancy of vacant historical territories in New Hampshire and across the United States starting in the early 1980s and continuing to the present day (Cade and Burnham 2003).

1.3 Protection and Regulatory Status

The peregrine falcon is protected in the United States under the Migratory Bird Treaty Act of 1918, which prohibits the possession or killing of most non-game birds and the collection of their eggs or nests. The American peregrine falcon, (F. p. anatum), the subspecies which formerly occupied the eastern United States, was first listed as Endangered by the federal government in 1970 under the Endangered Species Conservation Act of 1969 (Public Law 91-135, 83

Stat. 275). This authority was later transferred to the Endangered Species Act (ESA) of 1973 (16 U.S.C. 1531 et seq.). Since 1979, the species has been listed as Endangered by the State of New Hampshire (R.S.A. 212-A:1 et seq.).

As a result of the population recovery throughout the United States during the 1980s and 1990s, the American peregrine falcon was removed from the federal Endangered Species List in 1999 (Mesta 1999). As required for any delisting under the ESA, the United States Fish and Wildlife Service (USFWS), in cooperation with state wildlife agencies, developed and implemented a post-delisting monitoring plan to track the post-delisting status of peregrine breeding populations in the United States through 2015 (Green et al. 2003).

Other federal protective measures that continue after delisting under ESA include those offered by the Federal Insecticide, Fungicide, and Rodenticide Act (7 U.S.C. 136) for new and existing pesticide registration and use, the National Forest Management Act (16 U.S.C. 1600), and the Federal Land Management and Policy Act (43 U.S.C. 1701) (Green et al. 2003). Peregrine falcons are protected from unregulated international trade by an agreement of the 1975 Convention on International Trade in Endangered Species of Wild Flora and Fauna.

1.4 Population and Habitat Distribution

Cliffs are abundant in New Hampshire. Suitable nesting substrate does not appear to be a limiting factor in peregrine falcon distribution. Prior to the mid-1940s, at least 350 peregrine falcon pairs were estimated to breed at sites in the eastern United States (Hickey 1942). Following extirpation of the original F. p. anatum population in the region, biologists released approximately 2500 captive-produced young (consisting of at least seven F. peregrinus subspecies) to the eastern United States starting in 1974 (Tordoff and Redig 2001). The Eastern Peregrine Falcon Recovery Plan, first developed in 1979, designated northern New York and northern New England (i.e., the Adirondacks and most of Maine, New Hampshire, and Vermont) as Recovery Region 2 (USFWS 1987). Recovery Region 2 contained about 85 territorial pairs prior to the early 1940s (Hickey 1942), but no pairs from the mid-1960s through 1980 (Berger et al. 1969).

Through the mid-1950s, all documented peregrine falcon territories in New Hampshire were associated with cliffs. Most sites were scattered throughout the White Mountains from the west central to the far northeastern parts of the state (Table 1). The now recovering population occupies territories in a similar pattern, occurring mostly in the White Mountains with a few additional occupied cliffs in the far north and one urban site in southern New Hampshire (Table 1 and Figure 1). Recovery data for individually marked peregrine falcons clearly show that individuals breeding in New Hampshire are not isolated from those breeding in other New England states, but instead are part of an interconnected regional population (Barclay 1995, M. Amaral, USFWS, personal communication).

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

See Cliff habitat profile.

1.7 Sources of Information

General natural history information and some sources of original research were obtained primarily from White et al. (2002). Unless otherwise noted, the source for New Hampshire species data is field monitoring and management activities conducted by the New Hampshire Audubon (NHA) from 1983 though 2004 under annual contracts and/or grants received from the New Hampshire Fish and Game Department (NHFG) and/or the USFWS (e.g., Martin 1993, Martin 2004).

1.8 Extent and Quality of Data

Since the early 1980s, the peregrine falcon has been one of the most intensively monitored and managed species in New Hampshire (see Appendix 1 for example of detailed data available for each documented breeding site). Breeding site data are derived from 2 decades of field monitoring by NHA staff and trained volunteers. These observers employ standardized monitoring techniques at historical, active, and other potential sites throughout the state (see Cade et al. 1996a). Remote sites and sites located close to roads and trails are surveyed, although remote sites are vis-

ited less frequently.

1.9 Distribution Research

Spring surveys of recently active and potential breeding sites should be used to monitor the distribution and abundance of peregrine falcons in New Hampshire. Recently active sites should be checked annually to determine occupancy status and reproductive outcome. Surveys of potential sites should be conducted on a rotating basis, with annual survey intensity determined by funding and available human resources. For example, sites could be checked on a 3-year rotation covering 33% of sites annually, on a 5-year rotation covering 20% annually, or on a 10-year rotation covering 10% annually. New Hampshire should continue to participate in the federal post-delisting monitoring program established by the USFWS to track the status of a subset of the breeding population across the United States in 2006, 2009, 2012, and 2015 (Green et al. 2003).

Element 2: Species/Habitat Condition

2.1 Scale

See Cliff Habitat Profile.

2.2 Relative Health of Populations

New Hampshire's 17 documented historical breeding territories and 18 recently occupied breeding territories are listed in Table 1. Of the 17 historical territories documented in the state, 5 (29%) have been reoccupied while 12 (71%) were unoccupied between 1970 and 2004. Thirteen recently occupied territories have no documented record of historical use, suggesting that the number of territories in the state prior to 1950 was underestimated. Table 2 documents the temporal pattern of territory occupancy in New Hampshire beginning in 1981. During the 10-year period from 1985 to 1994, the breeding population expanded at an annual rate of 15.9%. From 1995 to 2004, the population continued to expand, but at a less vigorous annual rate of 3.6%. The population is continuing to grow. The highest numbers of occupied territories, territorial pairs, nesting pairs, successful pairs, and number of young fledged in the post-DDT era have all been attained within the past three breeding seasons.

2.3 Population Management Status

Volunteers from NHA conduct productivity monitoring and presence/absence surveys of approximately 30 potential peregrine falcon breeding sites. Other activities include salvage of eggs and chicks, evaluation and management of human (i.e., recreational) influences, internet broadcasting of nesting activity, and extensive outreach and education to the public and rock-climbing community.

2.4 Relative Quality of Habitat Patches

All peregrine falcon breeding sites are cliffs except the site on the New Hampshire Tower in the City of Manchester. Potential and currently occupied cliff sites in New Hampshire appear to provide the key ecological attributes required to support a healthy breeding population. Of 172 documented incubation attempts on cliffs in New Hampshire from 1981 to 2004, 134 (78%) took place directly on rock ledges, 34 (20%) were in former common raven nests, and 4 (2%) occurred on undetermined substrates. The greatest concern for habitat quality at cliff sites is the growing popularity of recreational climbing and its potential to suppress nesting success and productivity.

Each of the four known urban nesting attempts occurred in a human-built nesting box. The number of potential urban nesting sites is expected to increase (10-20 currently exist) with increasing development. Peregrine falcons use tall office buildings, church steeples (e.g., in Nashua, Manchester, Concord, and Berlin), major industrial buildings, tall smokestacks, large dams (e.g., Seabrook Station, Merrimack Station, Newington Station, Nexfor Paper Mill, Moore Dam, and Comerford Dam), and substructures of the state's largest bridges (e.g., Interstate 95 at Piscataqua River, Route 16/4 at Little Bay mouth, Route 9 at Connecticut River, Route 101/293 at Merrimack River). The most serious habitat quality concerns at urban sites are pigeon abundance, the potential risk of secondary poisoning due to pigeon control efforts, the limited availability of suitable nesting substrates, and the highly variable maintenance schedules of urban structures.

2.5 Habitat Patch Protection Status

Of 15 occupied peregrine falcon breeding territories in New Hampshire in 2004, 11 sites (73%) were on public land, 3 (20%) were on private land, and one (7%) was on a mix of public and private land. Of the 11 sites on public land, 6 sites were managed by the United States Forest Service, 4 were on state land managed by the New Hampshire Division of Resources and Economic Development, and one was on municipal land managed by the Town of Woodstock. Of the 3 sites on private land, one was protected by a conservation easement, while 2 were not. Fifteen sites were cliff habitat, and one was urban habitat.

2.6 Habitat Management Status

Cliff habitats in New Hampshire are subject to very little direct habitat management. There are no efforts to promote or discourage any particular vegetation type or density on cliffs. Establishing temporary restrictions for the recreational use of cliffs is the only current management action. Urban habitat management consists of voluntary adjustments in building maintenance to avoid potentially disruptive activities such as window washing or antenna construction during the breeding season.

2.7 Sources of Information

Information on New Hampshire's peregrine falcon population and habitat is derived directly from summary reports and field data on monitoring and management activities conducted by NHA from 1983 though 2004 under annual contracts and/or grants from the NHFG and/or the USFWS (e.g., Martin 1993, Martin 2004).

2.8 Extent and Quality of Data

Peregrine falcons have been listed as Endangered on both federal and state lists for much of the past four decades, and so there is a relatively complete data set on occurrence, productivity, and habitat condition. Annual summaries of this information are on file at the NHFG.

2.9 Condition Ranking

2.10 Condition Assessment Research

The population of peregrine falcons in northern New England has been individually marked. Band resighting helps collect critically important and hard-to-acquire data on dispersal patterns and population demography, individual longevity, and nest site fidelity. It links contaminant data from eggs to individual female peregrine falcons of known age and reproductive history.

Element 3: Species and Habitat Threat Assessment

3.1.1 Recreation

(A) Exposure Pathway
Human presence near nest sites provokes aggressive defensive behaviors, limiting incubation, brooding, or feeding, and increasing chick exposure to temperature fluctuations and predation. These factors may also result in higher mortality and reduced productivity due to premature fledging of young.

(B) Evidence
Peregrine falcons nesting in remote areas are intolerant of human encroachment (Cade et al. 1996a). Recreational rock climbing activity and hiking on or near cliffs can produce aggressive nest defense behaviors (Lanier and Joseph 1989, Pyke 1997). The popularity of recreational rock climbing has grown exponentially in northern New England during the post-DDT era and is becoming a serious problem for land managers trying to protect nesting peregrine falcons (Mesta 1999). Few cliffs in New Hampshire are free from fixed climbing hardware, including cliffs in federally designated wilderness areas that are located as far as 4 miles from the nearest roadside trailhead.

3.1.2 Non-point Source Pollution

(A) Exposure Pathway
Various neurotoxins accumulate in animal tissues and are magnified in predatorial trophic webs, with ingestion by top predators producing reproductive, behavioral, neurological, and physiological stresses. These changes lead to reduced vigor and breeding

success (Evers 2005, Sharp and Lunder 2004). Organochlorine pesticides, most notably DDT, accumulate in animal tissue and are magnified in predatorial trophic webs, causing lethal and sub-lethal effects in peregrine falcons.

(B) Evidence
Brominated fire retardants, commonly known as PBDEs, are similar in chemical structure to PCBs. They are used in a wide range of synthetic household and consumer products. PBDEs have been shown to be accumulating in wildlife populations worldwide, and some of the highest concentrations yet documented occur in peregrine falcon populations in the United Kingdom (European Union 2003).

Elevated levels of organochlorine pesticides are still being detected in some North American peregrine falcon populations and pose a possible risk to sustained recovery (Mesta 1999). Even though these chemicals have been banned for sale and use in North America, their use continues to be largely unrestricted in Latin America. DDT residues continue to be detected in some migratory songbird populations and toxic residues in avian prey species can cause lethal and sub-lethal effects in peregrine falcons, including eggshell thinning that results in a loss of productivity (Cade et al. 1988, White et al. 2002). There are direct correlations between concentrations of DDE residues in egg contents and eggshell thickness (Peakall and Kiff 1988).

3.1.3 Mercury

(A) Exposure Pathway
Mercury bioaccumulates in much the same way as other persistent toxins. See 3.1.2 above.

(B) Evidence
Mercury levels are high and pervasive in the aquatic food webs and terrestrial systems of northeastern North America (Evers 2005). Current research shows that even forest songbird populations have elevated mercury burdens (Rimmer et al. 2005).

3.1.4 Energy and Communication Infrastructure

(A) Exposure Pathway
Construction associated with the building of cellular towers and wind turbines may limit incubation, brooding, or feeding, and increase chick exposure to temperature fluctuations and predation. These factors may lead to higher mortality and reduced productivity due to premature fledging of young. Death or serious injury may result when peregrine falcons collide with towers, supporting wires, and/or wind turbine blades.

(B) Evidence
Activities on the tops of nesting cliffs tend to be more disruptive than similar activities below cliffs (Cade et al. 1996a). Construction that involves road building, logging, and blasting is potentially disruptive to nesting peregrine falcons and needs to be controlled roughly one half mile from nest sites (Cade et al. 1996a). Collisions with structures and support wires are a known source of mortality for fledglings and after hatch-year peregrine falcons (White et al. 2002).

3.2 Sources of Information

Information on threats to peregrine falcons was obtained from a literature review, from NHA field data, and from consultation with specialists from the USFWS and NHA in Concord, New Hampshire, and from BioDiversity Research Institute in Gorham, Maine.

3.3 Extent and Quality of Data

Researchers working outside of New Hampshire examined most of the threats to peregrine falcons described above. There are sufficient data on the climbing and hiking threat in New Hampshire to justify concern and warrant management actions. The potential effects of mercury and PBDEs on terrestrial species are just now gaining the attention of researchers nationwide. Egg samples in the archives of the USFWS could potentially produce New Hampshire data to assess this issue. Threats related to exposure to DDT and other organochlorine pesticides are well documented, including data from New Hampshire. There is no data specific to New Hampshire on the effects of cellular tower/wind turbine construction or operation. With relatively little data nationwide, this topic warrants further field investigation.

3.4 Threat Assessment Research

Investigate the tolerance thresholds of peregrine falcons for recreational rock climbing activity in the vicinity of nest sites, and examine the impacts of climbing activity on the cliff habitat in general. Analyze archived peregrine falcon egg and prey remains to produce data specific to New Hampshire on current levels of mercury, PCBEs, DDE, and other bio-accumulative pollutants. Investigate the likely future extent of cellular tower/wind turbine construction and operation in New Hampshire to determine their potential impact on peregrine falcons and other cliff-dwelling wildlife. Develop guidelines for the location, construction, and operation of these facilities.

Element 4: Conservation Actions

4.1.1 Monitor Threatened and Endangered Breeding Status, Monitoring

4.1.2 Develop State Recovery Plan, Regulation and Policy (see Strategies, Agency Regulation and Policy)

4.1.3 Advise ESA Recovery Efforts, Regulation and Policy (see Strategies, Inter-Agency Regulation and Policy)

4.1.4 Cultivate Recreational User Stewardship, Education and Outreach (see Cliff Habitat, see also Strategies, Education and Outreach)

4.1.5 Advise Land Managers on Mitigation of Recreational Impacts, Regulation and Policy (see Cliff Habitat, see also Strategies, Inter-Agency Regulation and Policy)

4.1.6 Identify High Risk Areas for Recreation, Wind Energy, and Pollutants, Conservation Planning see Strategies, Conservation Planning)

4.1.7 Engage in Inter-Agency Risk Assessments for Recreation, Wind Energy, and Pollutants, Regulation and Policy (see Strategies, Inter-Agency Regulation and Policy)

4.1.8 Restrict Access to High Risk Areas, Regulation and Policy (see also Strategies, Inter-Agency Regulation and Policy)

4.1.9 Advise Wind Energy Developers on Best Management Practices for Construction, Regulation and Policy (see Strategies, Inter-Agency Regulation and Policy)

4.1.10 Prioritize Cliffs for Protection, Land Protection (see Strategies, Conservation Planning)

4.1.11 Protect Unfragmented Blocks, Land Protection (see Strategies, Land Protection)

4.1.12 Monitor as an Indicator of Bio-Accumulation of Contaminants, Monitoring (see Strategies, Monitoring)

Element 5: References

5.1 Literature

Barclay, J. 1995. Patterns of dispersal and survival of eastern peregrine falcons derived from banding data. Unpublished report. BioSystems Analysis, Inc.

Berger, D. D., C. R. Sindelar, and K. E. Gamble. 1969. The status of the breeding peregrines of the eastern United States. Pp. 165-173 in J. J. Hickey (ed.). Peregrine falcons populations: their biology and decline. University of Wisconsin Press, Madison, Wisconsin, USA.

Cade, T. J. and W. Burnham (eds.). 2003. Return of the peregrine: a North American saga of tenacity and teamwork. The Peregrine Fund, Inc., Boise, Idaho, USA.

Cade, T. J., J. H. Enderson, and J. Linthicum. 1996a. Guide to Management of Peregrine Falcons at the Eyrie. The Peregrine Fund, Boise, Idaho, USA.

Cade, T. J., J. H. Enderson, C. G. Thelander, and C. M. White (eds.). 1988. Peregrine falcon populations: their management and recovery. The Peregrine Fund, Inc. Boise, Idaho, USA.

Cade, T. J., M. Martell, P. Redig, G. Septon, and H. B. Tordoff. 1996b. Peregrine falcons in urban North America. Pp. 3-13 in Raptors in human landscapes (D. M. Bird, D. E. Varlan, and J. J. Negro, eds.). Academic Press, London, U.K.).

Corser, J. D., M. Amaral, C. J. Martin, and C. C. Rimmer. 1999. Recovery of a cliff-nesting per-

egrine falcon, Falco peregrinus, population in northern New York and New England, 1984-1996. Canadian Field-Naturalist 113:472-480.

Enderson, J. H., W. Heinrich, L. Kiff, and C. M. White. 1995. Population changes in North American peregrines. Transactions 60th North American Wildlife and Natural Resources Conference.

European Union. 2003. Update risk assessment of bis (pentabromophenyl) ether (decabromodiphenyl ether). Environmental draft of November 2003. CAS Number 1163-19-5.

Evers, D. C. 2005. Mercury connections: The extent and effects of mercury pollution in northeastern North America. BioDiversity Research Institute. Gorham, Maine, USA.

Foss, C. R. 1994. Atlas of Breeding Birds in New Hampshire. New Hampshire Audubon. Arcadia Press. Dover, New Hampshire, USA.

Fowle, M. R., K. A. Wohlfort, S. D. Faccio, and D. W. Blodgett. 2004. The 2004 breeding status and population dynamics of peregrine falcons in Vermont. Unpublished report. National Wildlife Federation, Montpelier, Vermont, USA.

Green, M., R. Mesta, M. Morin, M. Amaral, R. Currie, P. Delphey, R. Hazelwood, K. Hollar, M. Klee, A. Matz, M. Miller, and T. Swem. 2003. Monitoring plan for the American peregrine falcon, a species recovered under the Endangered Species Act. United States. Fish and Wildlife Service, Division of Migratory Birds and State programs, Pacific region. Portland, Oregon, USA.

Hickey, J. J. 1942. Eastern population of the duck hawk. Auk 59:176-204.

Hickey, J. J. (ed.). 1969. Peregrine falcons populations: their biology and decline. University of Wisconsin Press, Madison, Wisconsin, USA.

Lanier, J. W., and R. A. Joseph. 1989. Managing human recreational impacts on hacked or free-ranging peregrines. Pp 149-153 in Proceedings of the Northeast Raptor Management Symposium and Workshop. (B. G. Pendleton, ed.). National Wildlife Federation Scientific and Technical Series No. 13. Washington, DC.

Martin, C. J. 1993. The 1993 breeding status of peregrine falcons in New Hampshire. Unpublished report. New Hampshire Audubon, Concord, New Hampshire, USA.

Martin, C. J. 2004. New Hampshire Nongame and Endangered Wildlife Program Status and Management Report, July 1, 2003-June 30, 2004. New Hampshire Fish and Game Department Federal Aid Project EW-1-22.

Martin, C.J., and D. J. North. 1993. Peregrine falcons incubate clutch of eggs for minimum of 73 days. Journal of Raptor Research 27:173.

Mesta, R. 1999. Endangered and threatened wildlife and plants; final rule to remove the American peregrine falcon from the federal list of endangered and threatened wildlife, and to remove the similarity of appearance provision for free-flying peregrines in the coterminous United States (Federal Register 64(164):46542-46558.

Peakall, D. B., and L. F. Kiff. 1988. DDE contamination in peregrines and American kestrels and its effect on reproduction. Pages 337-350 in Peregrine falcon populations: their management and recovery. T. J. Cade, J. H. Enderson, C. G. Thelander, and C. M. White (eds.). The Peregrine Fund, Inc. Boise, Idaho, USA.

Pyke, K. 1997. Raptors and climbers: Guidance for managing technical climbing to protect raptor nest sites. Access Fund, Boulder, Colorado, USA.

Rimmer, C. C., K. P. McFarland, D. C. Evers, E. K. Miller, Y. Aubry, D. Busby, and R. J. Taylor. 2005. Mercury levels in Bicknell's thrush and other insectivorous passerine birds in montane forests of the northeastern United States and Canada. Ecotoxicology 14.

Sharp, R., and S. Lunder. 2004. In the dust: Toxic fire retardants in American homes. Environmental Working Group. Washington, DC and Oakland, CA. Document available at www.ewg.org. 57 pp.

Spofford, W. R. 1975. New Hampshire peregrine falcon site assessment information. Unpublished manuscript. New Hampshire Audubon, Concord, New Hampshire.

Tordoff, H. B., and P. T. Redig. 2001. Role of genetic background in the success of reintroduced peregrine falcons. Conservation Biology 15:528-532.

United States. Fish and Wildlife Service. 1987. Revised peregrine falcon, eastern population, recovery plan. United States Fish and Wildlife Service, Newton Corner, Massachusetts, USA.

United States Fish and Wildlife Service. 1991. First update of peregrine falcon (Falco peregrinus), eastern population, revised recovery plan. United States Fish and Wildlife Service, Newton Corner, Massachusetts, USA.

White, C. M., N. J. Clum, T. J. Cade, and W. G. Hunt. 2002. Peregrine Falcon (Falco peregrinus). In The Birds of North America, No. 660 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

5.2 Data Sources

Peregrine falcon cliff watch surveys, breeding site surveys, and productivity data from 1981-2004, New Hampshire Audubon, Concord, New Hampshire.

Peregrine falcon banding database, United States Fish and Wildlife Service, New England Field Office, Concord, New Hampshire.

Element 6: List of Figures

Figure 1. Distribution of peregrine falcon breeding territories in New Hampshire in 2004.

Table 1. Historical and recent peregrine falcon breeding sites in New Hampshire.

Table 2. New Hampshire peregrine falcon productivity summary: 1981-2004.

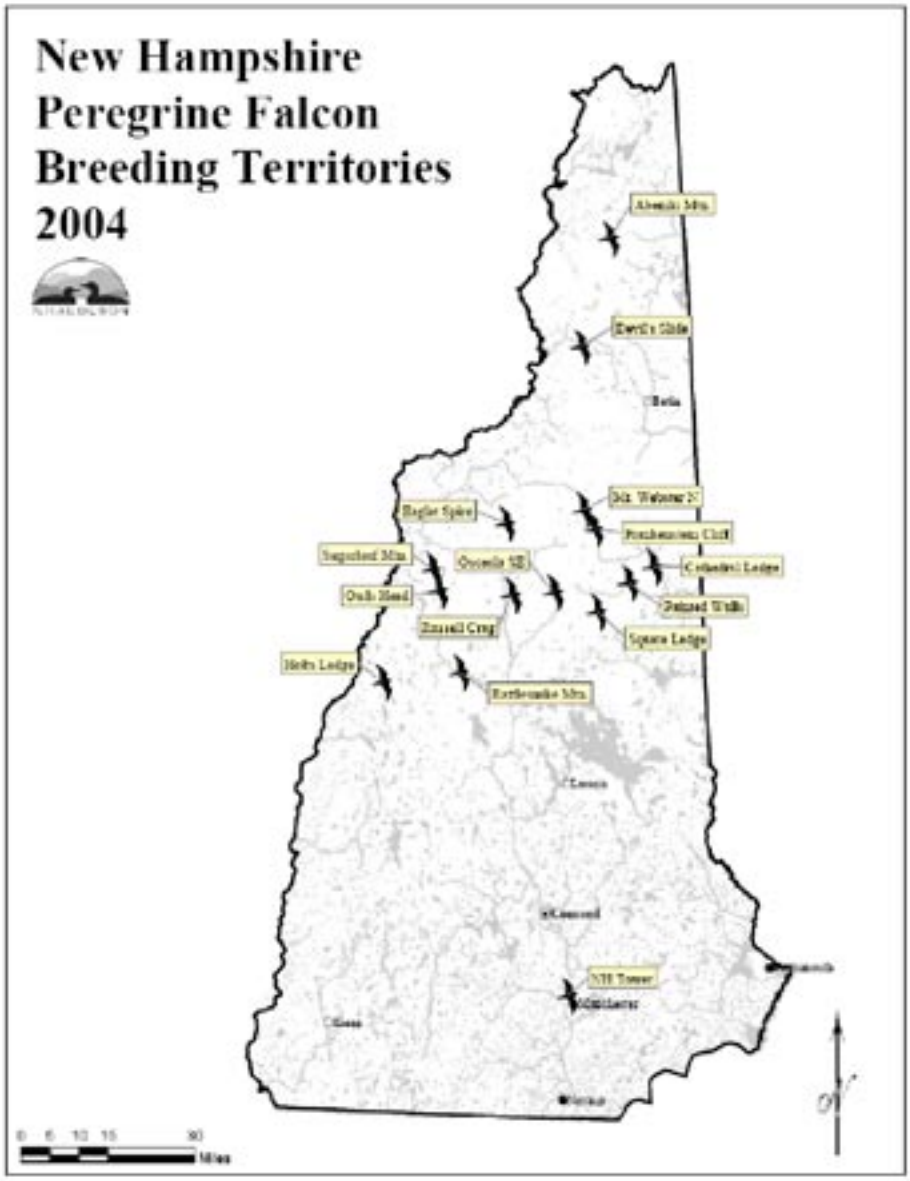


Figure 1. Distribution of peregrine falcon breeding territories in New Hampshire in 2004.

Breeding site	NH Township	Most recent documented occupancy
Unoccupied since 1970, but with documented prior historical use		
Baldface	Beans Purchase/Chatham	no specific date given
Black Mtn.	Benton	no specific date given
Percy Peaks	Stratford	no specific date given
Moat Mtn.	Albany	1870
Humphreys Ledge	Bartlett	1902
Sugarloaf	Alexandria	1927
Mt. Monadnock	Jaffrey	1938
Ragged Mtn. Bulkhead	Andover	1939
Pond Ledge	Haverhill	1940
Polar Caves	Rumney	1949
Peaked Mtn.	Piermont	1954
Mt. Kilburn	Walpole	1955
Occupied since 1970 with documented prior historical use		
Cathedral/White Horse	Bartlett	1986-89, 1997-2004
Holts Ledge	Lyme	1987-2004
Owls Head	Benton	1993-2004
Rattlesnake Mtn.	Rumney	1994-2004
Diamond Peaks	2nd College Grant	1997-1999
Occupied since 1970, but with no documented prior historical use		
Eagle/Eaglet/Cannon	Franconia	1981-2004
Square Mtn.	Kilkenny	1984-1998
Frankenstein Cliff	Harts Location	1985-2004
Willard/Webster	Harts Location	1985-1995, 1997-1998, 2001-2004
Abeniki Mtn.	Dixville	1988-2004
Painted Walls	Albany	1989-1990, 1993-2004
Square Ledge	Albany	1991-1992, 1995-2004
Devils Slide	Stark	1994-2004
Osceola East/South	Livermore	1995, 1999-2004
Beaver Pond Cliff	Benton	1998
New Hampshire Tower	Manchester	2000-2004
Russell Crag	Woodstock	2002-2004
Sugarloaf Mtn.	Benton	2004

Table 1. Historical and recent peregrine falcon breeding sites in New Hampshire.

Year	Occupied Territories	Territorial Pairs	Nesting Pairs	Successful Pairs	Young Fledged	Young fledged/ nesting pair
1981	1	1	1	1	2	2
1982	1	1	1	0	0	0
1983	1	1	1	0	0	0
1984	2	0	0	0	0	0
1985	4	4	3	2	5	1.67
1986	5	5	4	4	9	2.25
1987	6	6	5	1	2	0.4
1988	7	7	4	2	3	0.75
1989	8	7	7	5	10	1.43
1990	7	7	7	4	11	1.57
1991	7	6	6	3	7	1.17
1992	7	7	7	3	5	0.71
1993	8	8	7	5	11	1.57
1994	10	9	8	5	10	1.25
1995	11	11	10	8	15	1.5
1996	9	9	8	5	13	1.63
1997	12	11	10	6	16	1.6
1998	12	10	10	7	16	1.6
1999	12	11	9	8	25	2.78
2000	11	10	10	10	25	2.5
2001	13	12	12	10	22	1.83
2002	14	14	14	9	27	1.93
2003	14	14	14	10	21	1.5
2004	15	13	11	8	15	1.36
24 yrs	**197**	**184**	**169**	**116**	**270**	**1.6**

Table 2. New Hampshire peregrine falcon productivity summary: 1981-2004.

SPECIES PROFILE

Piping Plover
Charadrius melodus

Federal Listing: Threatened
State Listing: Endangered
Global Rank: G3
State Rank: S1
Author: Allison M. Briggaman, New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

"Piping plovers nest above the high tide line on coastal beaches, sandflats at the ends of sandspits and barrier islands, gently sloping foredunes, blowout areas behind primary dunes, sparsely vegetated dunes, and washover areas cut into or between dunes. Feeding areas include intertidal portions of ocean beaches, washover areas, mudflats, sandflats, wrack lines, and shorelines of coastal ponds, lagoons, or salt marshes" (United States Fish and Wildlife Service (USFWS) 1996).

1.2 Justification

Before the Migratory Bird Treaty Act of 1918, unregulated hunting caused the decline of the Atlantic coast piping plover population (USFWS 1996). Since the 1940s, the piping plover population has steadily declined due to increased development along the Atlantic coast. This development boom has increased habitat loss and degradation, human disturbance, and predation, all of which have contributed to species decline. These factors have affected the piping plover along the entire Atlantic coast, from Nova Scotia to North Carolina (USFWS 1985, Haig 1992). Though the piping plover was absent for several years along the New Hampshire coast, it was discovered nesting again in 1996.

The Atlantic coast piping plover population is the aggregate of many small groups with many breeding sites, with each site having fewer than 10 breeding pairs (A. Hecht, USFWS, personal communication). Therefore, even protecting breeding locations with only a few pairs is crucial to maintaining the integrity of the overall population.

1.3 Protection and Regulatory Status

- Federal Endangered Species Act (ESA) of 1973
- Federal Migratory Bird Treaty Act of 1918
- New Hampshire RSA 212-A:6 IV(a) Endangered Species Conservation Act

1.4 Population and Habitat Distribution

The Atlantic coast piping plover population breeds from Nova Scotia south to North Carolina. They are monogamous and territorial during the breeding season with pairs staying together to help raise their young.

New Hampshire Fish and Game (NHFG) began a piping plover protection effort in 1997. Since then, piping plovers have consistently nested on the beaches and dunes along the Atlantic coast in the towns of Hampton and Seabrook. One to 2 pairs have consistently nested north of Hampton Harbor Inlet and 1 to 5 pairs have consistently nested south of Hampton Harbor Inlet (NHFG data).

1.5 Town Distribution Map
Not completed for this species.

1.6 Habitat Map
See Dune habitat profile

1.7 Sources of Information

Information on piping plover habitat, population distribution and status was collected from recovery plans, USFWS data, NHFG data, scientific journals and the Coastal Sand Dune Systems map produced for this process.

1.8 Extent and Quality of Data

Piping plovers have been intensively managed throughout their breeding range along the East coast since their listing under the Endangered Species Act (ESA) in 1986. In New Hampshire, breeding habitat has been managed and piping plovers have been monitored annually since 1997.

1.9 Distribution Research

Continue monitoring efforts during the breeding season and continue to participate in the Atlantic Coast annual census.

Element 2: Species/Habitat Condition

2.1 Scale

The Coastal Sand Dunes map produced for this process identified 13 habitat patches along the New Hampshire coast. Two of these patches provide suitable piping plover breeding habitat and span approximately 2 miles of the New Hampshire coast. These areas fall within two towns: Hampton and Seabrook. In Hampton, piping plovers have been observed to nest with varying success at Hampton Beach State Park since the Piping Plover Protection Effort began in 1997. Birds have tried to nest on town land but have been unsuccessful.

In Seabrook, suitable habitat occurs along Seabrook Town Beach where plovers have nested consistently since 1997. Although plovers have historically nested in the Seabrook Harbor, no nesting has been documented since 1997.

Sand dunes likely comprised a much greater amount of the immediate coast before the increased development of recent decades. The remaining 10 habitat patches identified by the Coastal Sand Dunes mapping process are primarily state owned areas (i.e. State Parks). These areas provide potential locations for dune habitat restoration.

2.2 Relative Health of Populations

Piping plovers that breed along the New Hampshire coast are part of the greater Atlantic Coast population. The Atlantic Coast population will be considered recovered when 2,000 breeding pairs are maintained for 5 years and are distributed throughout 4 recovery units, as delineated by the USFWS Piping Plover Atlantic Coast Population Revised Recovery Plan (1996). As of 2003, the Atlantic coast population was 324 pairs short of that goal (USFWS 2004a).

New Hampshire falls within the New England recovery unit that must achieve and maintain 625 breeding pairs to meet the recovery goal (USFWS 1996). This goal was attained in 1998 when 627 breeding pairs were recorded. Each year since, the goal has been met or exceeded, except for 1999 and 2000 when the total count dropped by 3 and 4 pairs respectively (see table 1) (USFWS 2004a). Preliminary estimates for 2004 indicate 659 pairs for the New England recovery unit (USFWS 2004b).

According to population monitoring by S.M. Melvin and J.P. Gibbs (1994), a minimum of 1.24 chicks fledged per pair is necessary to maintain a stationary population. However, the USFWS Piping Plover Atlantic Coast Population Revised Recovery Plan states that a higher productivity rate of 1.50 chicks fledged per pair is necessary to prevent extinction and maintain a population of 2000 breeding pairs (USFWS 1996).

Since 1997, when the Piping Plover Protection Effort began in New Hampshire, between 5 and 7 pairs have nested annually along the coast and have fledged a total of 72 chicks. Productivity for piping plovers in New Hampshire has varied between 0.1 and 2.7 chicks fledged per pair each year with the average productivity totaling 1.5 between 1997 and 2004.

2.3 Population Management Status

Piping plovers are monitored each year throughout the breeding season. Nest sites are located and protected from trampling and predation with fenced exclosures. Chicks are monitored daily from hatching to fledging, and recreational activities are managed in breeding areas to prevent disturbance. Beach management activities such as beach raking and boardwalk

maintenance are coordinated with local, town, state and federal officials.

2.4 Relative Quality of Habitat Patches

Thirteen habitat patches are identified in the Coastal Sand Dunes map produced for this process. Of these, 3 are known to provide suitable habitat and to be occupied by breeding piping plovers. The remaining 10 habitat patches either provide potential habitat or feeding areas or are potential dune habitat restoration locations.

2.5 Habitat Patch Protection Status

Three of the habitat patches identified in the Coastal Sand Dunes map created for this process are known piping plover breeding areas and are protected under Federal and State Threatened and Endangered Species Laws (see element 1.3 above). The remaining 10 habitat patches identified are state owned lands, primarily State Parks, and are open to the public for recreational uses. Coastal sand dune systems are protected under the Federal Coastal Zone Management Act (1972) and NH RSA 482-A pertaining to Fill and Dredge in Wetlands. Refer to the Dune habitat profile for more information.

2.6 Habitat Management Status

In areas where piping plovers are known to occur, habitat management protects nesting areas during the breeding season. Management activities include fencing suitable habitat areas during the breeding season, restricting motorized vehicle use and coordinating beach management activities, such as beach raking and boardwalk maintenance. Habitat management is conducted by NHFG according to USFWS Atlantic Coast Piping Plover Population Revised Recovery Plan guidelines and in cooperation with town officials.

Coastal sand dune systems are managed by local towns and New Hampshire State Parks, and are managed primarily for recreation. For more information on coastal sanddune system habitat management, refer to the Dune habitat profile.

2.7 Sources of Information

Information on habitat protection and management was obtained from NHFG piping plover monitoring data and annual reports, personal communication, and the Dune habitat maps created for this process.

2.8 Extent and Quality of Data

Piping plovers have been intensively managed throughout their breeding range along the East coast since their listing under the Endangered Species Act (ESA) in 1986. In New Hampshire, occupied breeding habitat has been managed, and piping plovers have been monitored annually since 1997.

Information on the location of coastal sand dunes and associated natural plant communities is available from New Hampshire Natural Heritage Inventory (NHNHI) . However, there is a lack of information available about the overall health and condition of coastal sand dune systems and piping plover breeding habitat.

2.9 Condition Assessment Research

Continue monitoring to determine annual productivity.

Element 3: Species and Habitat Threat Assessment

3.1.1 Recreation

A) Exposure Pathway

Coastal sand dune systems comprise less than 2 miles of the State's 18.57 miles of shoreline (New Hampshire DES 2004, Coastal Sand Dune Systems habitat map). These limited dune areas not only provide suitable habitat for breeding piping plovers, but they also receive severe pressure from human recreational activities, including sunbathing, swimming, jogging, dog walking, kite flying, volleyball, jet skiing, surfing and fishing. Human presence in coastal sand dunes leads to increased disturbance, increased stress, reduced productivity and direct mortality of breeding piping plovers and their chicks. Human disturbance causes plovers to flush from nests, which results in less incubation time and exposes eggs to extreme temperatures. When this happens, eggs may no lon-

ger be viable, or they may not develop fully, and this can lead to the adults abandoning the nest. Human presence can also cause direct mortality, as when nests or chicks are trampled. Furthermore, human refuse attracts predators, causing increased disturbance, increased stress, reduced productivity and direct mortality of breeding piping plovers.

(B) Evidence:
During summer 2003, Hampton Beach State Park reported 122,890 visitors (J. Lyons, New Hampshire Department of Resource and Economic Development, personal communication). Such intense usage is clearly problematic, since disturbance of piping plovers by humans and their pets is one of the primary reasons for their listing under the Endangered Species Act. Nor are visitor numbers likely to fall. Beach walking is the second most popular recreational activity, and as populations rise, beach usage will increase proportionately (NSRE 1994). Thus, if human recreational activities are not effectively managed in piping plover breeding areas, it is unlikely that piping plovers will successfully breed.

3.1.2 Recreation (Off Road Vehicles)

(A) Exposure Pathway
Although only beach cleaning equipment and essential vehicles are allowed on New Hampshire beaches, these vehicles can crush piping plover eggs, chicks and adults. Removal of human-created trash on the beach is desirable to reduce predation threats, but the indiscriminate nature of mechanized beach cleaning adversely affects piping plovers and their habitat. In addition to the danger of direct crushing of piping plover nests and chicks and the prolonged disturbance from the machine's noise, this method of beach cleaning removes the birds' natural wrackline feeding habitat (Eddings and Melvin 1991, Howard et al. 1993).

(B) Evidence:
The USFWS (1996) has identified unrestricted motorized vehicles as a serious threat to piping plovers and their habitats. Piping plover mortality due to motorized vehicles has been well documented throughout its breeding range. In New Hampshire, there is one documented instance and several suspected instances of piping plover mortality due to motorized vehicles (New Hampshire Fish and Game unpublished data).
Soon after hatching, chicks are very mobile, moving between intertidal zones and dunes and along the length of beaches. This errant nature, combined with the chicks' inability to fly, leaves them particularly vulnerable to injury by motor vehicles. Vehicles also significantly degrade piping plover habitat or disrupt normal behavior patterns. They may harm or harass plovers by crushing wrack into the sand and making it unavailable as cover or a foraging substrate (Hoopes et al. 1992, Goldin 1993), by creating ruts that can trap or impede movements of chicks (USFWS 1996).

3.1.3 Predation and Herbivory (Subsidized or Introduced Predators)

(A) Exposure Pathway:
Piping plovers face a variety of predators, both natural and domesticated. Known predators of piping plovers, their eggs, and chicks along the New Hampshire coast include fox, striped skunk, crows, ravens, gulls, common grackles, and domestic and feral dogs and cats. Domestic dogs in particular pose significant threats to breeding plovers in New Hampshire. Although dogs are prohibited on Town beaches and State Park beaches between Memorial Day and Labor Day, a lack of enforcement allows dogs to be walked daily. Additionally, many property owners along Seabrook Town Beach are summer residents who bring their cats and leave them outside for the summer to roam freely. Some property owners in both Seabrook and Hampton even provide feeding stations for feral cats, thus increasing the risk of predation in piping plover breeding areas. Meanwhile, other birds such as the herring, great black backed and ring billed gulls encroach on piping plover territory and may cause them to abandon their nests (USFWS 1996).

(B) Evidence
Predation is a major and well-documented threat to piping plover reproductive success along the Atlantic coast (Burger 1987, MacIvor 1990, Patterson et al. 1991, Cross 1991, Elias-Gerken 1994). Likewise, evidence is plentiful that human activity has caused predation pressures to increase (USFWS 1996).

In New Hampshire, gulls, cats, and dogs are the most commonly observed predators, with feral cats

and domestic dogs posing the most significant threats to piping plover productivity and survival. Cats have been documented in piping plover breeding areas at both Hampton and Seabrook, and cats are the suspected cause of the death of several chicks and at least 1 adult. Dogs have been observed running freely through areas restricted for piping plovers, defecating and flushing piping plovers along the beaches. (NHFG, unpublished data). Similarly, large flocks of gulls have been observed feeding in piping plover breeding habitat, thus preventing plovers and their chicks from foraging.

3.1.4 Development

(A) Exposure Pathway
See Dune habitat profile, Element 3 section 3.1.2 Development (Habitat Loss and Conversion)

(B) Evidence
See Dune habitat profile, Element 3 section 3.1.2 Development (Habitat Loss and Conversion)

3.2 Sources of Information
Information on piping plover threats was taken from the USFWS Atlantic Coast Piping Plover Population Revised Recovery Plan, NHFG data, scientific journal articles, and personal communications and observations.

3.3 Extent and Quality of Data

Threats to breeding piping plovers along the Atlantic Coast have been cited as reasons for the species listing under the Endangered Species Act and have been well documented throughout their breeding range.

3.4 Threat Assessment Research

Potential threat assessment research would accomplish the following:

- Evaluate different management practices to determine the most effective human use management strategies in piping plover breeding areas
- Investigate different predator control methods and implement a predator control management protocol
- Identify and obtain funding to support a part time animal control officer to patrol beaches and enforce animal control laws and possibly carry out predator control management protocol
- Work with town officials to determine necessary actions and begin enforcing town regulations regarding use of unofficial pathways over dunes/town property during piping plover breeding season

Element 4: Conservation Actions

4.1.1 Improve enforcement of existing laws and regulations, Regulation and Policy

(A) Human disturbance

(B) Justification

- Enforcement of existing laws will reduce human disturbance to breeding piping plovers by reducing the number of dogs in the breeding areas and reducing human foot-traffic on unofficial paths over the dunes.
- Reducing human disturbance to breeding piping plovers will reduce the amount of time incubating birds are disrupted from the nests, reduce the occurrences of nest abandonment, reduce the risk of eggs/chicks being trod on by humans and their pets and thus foster increased productivity.
- Improving enforcement of existing laws and regulations should be focused on the breeding areas.
- Improving enforcement of existing laws and regulations should be maintained year round for consistency. Enforcement should increase during the breeding season, which corresponds with peak human recreational activities.

(C) Conservation Performance Objective
Improve enforcement of existing laws and regulations to increase annual productivity among breeding piping plovers by reducing disturbance from humans and their pets. Successful reduction of human disturbance will be indicated by a reduction of the number of people walking dogs on the beaches, a reduction of the number of unofficial paths leading from private residences over the dunes and into breeding areas and a reduction in the frequency of use of fireworks on the

beaches at night.

(D) Performance Monitoring
Daily monitoring of piping plovers during the breeding season will continue, and will include information about the number, location, and activities of the birds as well as documentation of human disturbance and its effect on breeding piping plovers.

(E) Ecological Response Objective
The desired ecological response to improved enforcement of existing laws and regulations is to maintain productivity at 1.50 or more chicks fledged per pair each year. This level of productivity will sustain a population of 625 breeding pairs in the New England region and will contribute to the desired 2000 breeding pairs in the Atlantic Coast piping plover population, as outlined in the Atlantic Coast Piping Plover Revised Recovery Plan of 1997, by the USFWS.

(F) Response Monitoring
See section D above.

(G) Implementation
The New Hampshire Fish and Game, together with the USFWS and local officials at the town level should find funding for additional personnel to enforce existing town regulations and state and federal endangered species laws. Enforcement should be carried out year-round with an increase in enforcement during the summer months to correspond with piping plover breeding and the peak of recreational beach use.

(H) Feasibility
The expertise to improve enforcement of existing laws and regulations exists at the town, state and federal levels. However, lack of personnel and funding to support additional personnel has prevented adequate enforcement of town laws and state and federal endangered species laws.

4.1.2 Education and Outreach to residents, day visitors, community and town officials, Education and Outreach

(A) Human disturbance and Predation

(B) Justification

- Education and outreach to residents, day visitors, community and town officials will help to reduce human disturbance of breeding piping plovers by raising awareness. It will also reduce predation by reducing the number of feral cats, domestic cats and dogs and the number of people who feed gulls on the beach.
- Reducing human disturbance will increase productivity and survivorship among piping plovers by reducing the amount of time incubating birds are disrupted from the nests and reducing the occurrence of nest abandonment.
- Reducing the number of predators on beaches will reduce the risk of eggs and chicks being stepped on by humans and their pets and reduce the number of chicks that are lost to predation.
- Education and outreach should be targeted to town officials, members of the local communities, and day visitors to beaches to raise awareness, understanding, and support.
- Education and outreach should be conducted year round. Education programs with the local schools and meetings with town officials should be conducted in the off-season to raise awareness and support among the community. Outreach to residents who live directly along the beaches should be conducted just before the start of each breeding season to raise awareness. Education and outreach to day visitors should be conducted during the summer months when plovers are breeding and most people visit beaches.
- Education and outreach efforts will consist of direct contact and involvement with members of the local communities and those who use New Hampshire beaches for recreation. Public attitudes towards piping plovers will be learned, and this information will be used to guide management activities. Furthermore, education and outreach efforts should lead to greater community involvement in the management of piping plovers and their breeding areas.

(C) Conservation Performance Objective
To support breeding piping plovers by increasing community awareness of, and involvement in, the protection and management of this endangered species that occurs in their back yard.

(D) Performance Monitoring
Observe use of beaches for a decrease in human and animal activity during breeding plover breeding season. Increase the number of people from local areas volunteering to monitor plovers.

(E) Ecological Response Objective
The desired ecological response is greater productivity for each breeding season.

(F) Response Monitoring

- Observe and record the number of volunteers from the local communities for an increase in involvement.
- Observe use of beaches and plover breeding areas for a decrease in the number of domestic pets observed.
- Monitor breeding piping plovers and recording productivity for increases in productivity.

(G) Implementation

- Continue posting signs along areas closed for piping plover breeding areas.
- Create and install educational displays at all main beach entrances.
- Give an informative presentation to town officials, local conservation commissions, community groups involved in beach management, local police departments, state parks personnel and feral cat feeding program coordinators.
- Create mini-presentations for day visitors at beaches, including a guided walk to observe piping plovers.
- Create and distribute an informational packet mailing to all residents who live along piping plover breeding areas.
- Create an educational program to be used in local schools and organize student involvement in monitoring and management on the beaches.
- Recruit, train, and maintain piping plover volunteer monitors.

(H) Feasibility
NHFG has been constrained by limited funds for plover monitoring and management and the creation of education and outreach programs. To date, funding has been used to hire one temporary seasonal piping plover monitor. This position involves carrying out the logistics of monitoring plovers, managing breeding areas, coordinating volunteer efforts and coordinating beach management activities between local, town, state and federal groups.

4.1.3 Institute temporary closures of piping plover breeding areas, Restoration and Management, Habitat Protection, Regulation and Policy.

(A) Human disturbance, Motorized vehicles and Predation

(B) Justification

- Closing piping plover breeding areas will eliminate all forms of human disturbance and predation by domestic dogs and will eliminate all use of motorized vehicles in the breeding areas, thus fostering a more productive breeding environment.
- Eliminating human disturbance and motorized vehicles and reducing the number of predators present in the breeding areas will have a direct positive impact on the survivorship and productivity of breeding piping plovers.
- Areas targeted for closure during the breeding season should include the NHFG property on the south side of the Seabrook-Hampton Bridge on Seabrook Harbor and the southernmost dune at the south end of Hampton Beach State Park near the jetty. Areas of Seabrook Town Beach should be considered as well.
- Closures of piping plover breeding areas should be in place between 15 March and 31 August. Areas may be reopened sooner than 31 August, as determined by observations of fledging by the piping plover monitor.
- Areas designated for closure during the breeding season will be monitored. If no birds use 1 or more of the designated areas, then those areas may be opened.

(C) Conservation Performance Objective
Eliminate disturbance by humans, their pets and motorized vehicles to allow this federally endangered and state threatened species space to perform courtship, nest and raise its young through complete closures of designated piping plover breeding areas on an annual basis

(D) Performance Monitoring
Monitoring will continue as outlined in the USFWS guidelines in both areas designated as closed for plover breeding and areas left open to human uses where piping plovers breed.

(E) Ecological Response Objective
The desired ecological response to closure of piping plover breeding areas is the maintenance of between 1.24 and 1.50 chicks fledged per pair each year. When this is achieved, New Hampshire will be contributing to the population of 2,000 breeding pairs along the Atlantic Coast , as outlined in the USFWS revised recovery plan.

(F) Response Monitoring
Areas closed for piping plover breeding will be monitored, as will areas left open to human use. Productivity will be compared between the two areas and calculated for the entire New Hampshire coast to determine whether productivity goals are being met and maintained.

(G) Implementation
NHFG, together with the USFWS, New Hampshire Audubon and other conservation organizations should decide on a plan of action for habitat restoration at the New Hampshire Fish and Game owned land on Seabrook Harbor. This coalition should begin to identify steps and strategies to work with other state agencies (i.e. Division of Resource and Economic Development – State Parks Department) and town officials to determine what actions need to be taken to institute temporary closures of piping plover breeding areas on State and Town owned lands.

(H) Feasibility
NHFG-owned land on Seabrook Harbor is the most feasible area for closure. However, this area requires habitat restoration work to make it suitable breeding habitat and therefore would not be the most appropriate for immediate consideration. Closure of the southernmost section of Hampton Beach State Park is the most appropriate area for immediate consideration because it is state-owned land that has supported breeding piping plovers consistently since 1997. This area also would be appropriate because of its minimum impact on human recreational uses. Closure of the breeding areas at Seabrook beach may be appropriate because these areas have supported breeding piping plovers since 1997. However, these areas will be more difficult to close because of their proximity to towns and the potential negative repercussions from disgruntled beach-goers.

4.1.4 Institute predator control protocol, Regulation and Policy

(A) Predation

(B) Justification
- Instituting a predator management protocol will enable action to be taken during the breeding season to control predators in piping plover breeding areas.
- Controlling predators in piping plover breeding areas will help to reduce the number of eggs, chicks and adults lost to predation and will increase productivity.
- Predator control should be instituted in piping plover breeding areas.
- Predator control should be conducted year round. Removal of predators from the breeding areas prior to and throughout the breeding season are crucial to plover nesting success.
- Predator control will only be carried out if evidence of predators is observed in the breeding areas and control will be targeted to the areas where predators are present.

(C) Conservation Performance Objective
The objective of instituting predator control protocol is to increase productivity among breeding piping plovers.

(D) Performance Monitoring
Monitoring of breeding piping plovers and management of breeding areas will continue as outlined in the USFWS Atlantic Coast Piping Plover Population Revised Recovery Plan.

(E) Ecological Response Objective
Reduce the number of eggs, chicks and adults lost to predation and observe an increase in New Hampshire's piping plover productivity each breeding season.

(F) Response Monitoring
Piping plovers and their breeding areas will con-

tinue to be monitored. The number and frequency of predators and the number of eggs, chicks, and adults lost to predation will continue to be observed and recorded. Piping plover productivity will continue to be determined each breeding season.

(G) Implementation
NHFGt must take action immediately to implement the most appropriate predator control in piping plover breeding areas. Options to consider include acquiring funding to provide for animal control in piping plover breeding areas, acquiring funding to hire a Departmental part time animal control person, contracting with a private wildlife control operator, or entering into an agreement with the U.S. Department of Agriculture, Wildlife Services.

(H) Feasibility
On town-owned lands, predator management has been the responsibility of local police departments' animal control officers and has been conducted as requested by the piping plover monitor. However, due to lack of funding, equipment, personnel, and animal control requests, local police departments do not effectively control predators in piping plover breeding areas. On state-owned lands where piping plovers nest, no predator control has taken place.

Despite these shortcomings, NHFG has the authority and the connections with USDA Wildlife Services to enter into agreements for instituting predator control in piping plover breeding areas. Although Wildlife Services has the personnel, the equipment, and the expertise to carry out effective predator control in piping plover breeding areas, controversy among local community members has kept New Hampshire Fish and Game from entering into any agreement with Wildlife Services.

4.1.5 Manage motorized vehicle use, Habitat Protection, Regulation and Policy.

(A) Motorized vehicles

(B) Justification

- Managing motorized vehicle use in piping plover breeding areas will reduce mortality of eggs, chicks and adults during the breeding season and will help to protect piping plover breeding habitat year round.
- Successful management of motorized vehicle use will be evident in the survivorship and productivity of breeding piping plovers and in the overall health of the coastal sand dune habitat.
- Management of motorized vehicles should be targeted at coastal sand dune systems, including known and potential piping plover breeding areas.
- Motorized vehicles should continue to be managed as outlined in the USFWS Atlantic Coast Piping Plover Population Revised Recovery Plan.
- Daily monitoring of breeding piping plovers and management of breeding areas, combined with partnerships between town, state and federal officials in beach management will allow for adjustments to be made to vehicle use on beaches as necessary.

(C) Conservation Performance Objective
The objective of managing motorized vehicles is to increase productivity of breeding piping plovers along the New Hampshire coast.

(D) Performance Monitoring
Observation of motorized vehicles use will continue as part of the daily monitoring of breeding piping plovers and the management of breeding areas. NHFG will continue to work with town, state and federal officials involved in beach management activities to coordinate motorized vehicle use on beaches and in piping plover breeding areas.

(E) Ecological Response Objective
Increase piping plover productivity and protect breeding habitat areas.

(F) Response Monitoring
Daily observation and monitoring of breeding piping plovers and their habitat will result in documented occurrences of motorized vehicle use in breeding areas. NHFG will continue to coordinate beach management activities in piping plover breeding areas between town, state, and federal officials.

(G) Implementation
NHFG should continue to carry out monitoring and management as outlined in the USFWS Atlantic Coast Piping Plover Population Revised Recovery Plan. In addition, NHFG should revise existing

wording on lobster regulations. Currently, licensed lobstermen are allowed to drive on New Hampshire beaches to look for and retrieve lobster traps that wash ashore after storms. This regulation should be reworded to enact a restriction on all vehicle use, including licensed lobstermen, during the piping plover breeding season.

(H) Feasibility:
NHFG has been working since 1997 with all public employees and officials in order to manage motorized vehicle use in piping plover breeding areas. These efforts have been carried out under the USFWS guidelines and should continue. NHFG has the authority, the staff and the expertise to change wording of regulations affecting fish and wildlife management in the state. Action should be taken as soon as possible to make the necessary revision permitting licensed lobstermen to drive on beaches.

4.2 Conservation Action Research
Due to growing human populations and increasing recreation and development pressures, effective management of piping plovers and their breeding areas is vital to their existence. Research should be conducted to consider different approaches for managing piping plover breeding areas.

Element 5: References

5.1 Literature:

Burger, J. 1987. Physical and social determinants of nest site selection in piping plover in New Jersey. Condor 98: 811-818.

Cross, R.R. 1991. Monitoring, management, and research of the piping plover at Chincoteague National Wildlife Refuge. Unpublished report. Virginia Department of Game and Inland Fisheries, Richmond, Virginia. 76 pp.

Eddings, K.J., and S.M. Melvin. 1991. Biology and conservation of piping plovers at Breezy Point, New York, 1991. Unpublished report submitted to the U.S. Fish and Wildlife Service, Newton Corner, Massachusetts. 38 pp.

Elias-Gerken, S.P. 1994. Piping plover habitat suitability on central Long Island, New York barrier islands. M.S. Thesis. Virginia Polytechnic Institute and State University, Blacksburg, Virginia. 48 pp.

Goldin, M.R. 1993. Effects of human disturbance and off-road vehicles on piping plover reproductive success and behavior at Breezy Point, Gateway National Recreation Area, New York. M.S. Thesis. University of Massachusetts, Amherst, Massachusetts. 128 pp.

Haig, S.M. 1992. Piping Plover. *In* The Birds of North America, No. 2 (A.Poole, Pl Stettenheim, and F. Gill, Eds.). Philadelphia: The Academy of Natural Sciences; Washington, DC: The American Ornithologists' Union.

Hoopes, E.M., C.R. Griffin, and S.M. Melvin. 1992. Relationships between human recreation and piping plover foraging ecology and chick survival. Unpublished report. University of Massachusetts, Amherst, Massachusetts. 77 pp.

Howard, J.M., R.J. Safran, and S.M. Melvin. 1993. Biology and conservation of piping plovers at Breezy Point, New York. Unpublished report. Department of Forestry and Wildlife Management, University of Massachusetts, Amherst. 34 pp.

MacIvor, L.H. 1990. Population dynamics, breeding ecology, and management of piping plovers on outer Cape Cod, Massachusetts. M.S. Thesis. University of Massachusetts, Amherst, Massachusetts. 100 pp.

Melvin, S.M. and J.P. Gibbs. 1994. Viability analysis for the Atlantic Coast Population of piping plovers. Unpublished report to the USFWS, Sudbury, Massachusetts. 16 pp.

National Survey on Recreation and the Environment (NSRE): 1994. The Interagency National Survey Consortium, Coordinated by the USDA Forest Service, Recreation, Wilderness, and Demographics Trends Research Group, Athens, GA and the Human Dimensions Research Laboratory, University of Tennessee, Knoxville, TN.

New Hampshire Department of Environmental Services. 2004. Watershed Management Bureau, Coastal Management Program, New Hampshire Tidal Shoreline Mileages By Waterbody page. <http://www.des.state.nh.us/coastal/pdf/tidal_shoreline.pdf>. Accessed 2005 January 11.

New Hampshire Office of State Planning. 2003. Department of Resources and Economic

Development. New Hampshire Outdoors, Statewide Comprehensive Outdoor Recreation Plan, 2003-2007. Concord, NH. 122 pp.

Patterson, M.E., J.D. Fraser, and J.W. Roggenbuck. 1991. Factors affecting piping plover productivity on Assateague Island. Journal of Wildlife Management 55(3): 525-531.

Tull, C.E. 1984. A study of nesting piping plovers of Kouchibouguac National Park 1983. Unpublished report. Parks Canada, Kouchibouguac National Park, Kouchibouguac, New Brunswick. 85 pp.

USFWS. 1985. Endangered and threatened wildlife and plants: Determination of endangered and threatened status for the piping plover: Final rule. Federal Register 50 (238): 50726-50734.

USFWS. 1996. Piping Plover (*Charadrius melodus*), Atlantic Coast Population, Revised Recovery Plan. Hadley, Massachusetts. 258 pp.

USFWS. 2004a. 2002-2003 status update: U.S. Atlantic Coast piping plover population. Sudbury, Massachusetts. 8pp.

USFWS. 2004b. Preliminary 2004 Atlantic Coast Piping Plover Abundance and Productivity Estimates. <http://www.fws.gov/northeast/pipingplover/status/preliminary.04.pdf>. Accessed 2005 March 26.

5.2 Data Sources:

Table 1. USFWS. Piping Plover Atlantic Coast Population, Annual Status Report 2002-2003 accessed 3.21.05 http://www.fws.gov/northeast/pipingplover/status/index.html

Element 6: List of Figures

Table 1. Summary of Atlantic Coast Piping Plover Population Estimates, 1989 to 2003

STATE/REGION	PAIRS															
	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Goal
Maine	16	17	18	24	32	35	40	60	47	60	56	50	55	65	61	
New Hampshire									5	5	6	6	7	7	7	
Massachusetts[e]	137	140	160	213	289	352	441	454	483	495	501	496	495	538	511	
Rhode Island	19	28	26	20	31	32	40	50	51	46	39	49	52	58	71	
Connecticut	34	43	36	40	24	30	31	26	26	21	22	22	32	31	37	
NEW ENGLAND	206	228	240	297	376	449	552	590	612	627	624	623	641	699	687	625
New York[d]	191	197	191	187	193	209	249	256	256	245	243	289	309	369	386	
New Jersey	128	126	126	134	127	124	132	127	115	93	107	112	122	138	144	
NY-NJ REGION	319	323	317	321	320	333	381	383	371	338	350	401	431	507	530	575
Delaware	3	6	5	2	2	4	5	6	4	6	4	3	6	6	6	
Maryland	20	14	17	24	19	32	44	61	60	56	58	60	60	60	59	
Virginia	121	125	131	97	106	96	118	87	88	95	89	96	119	120	114	
North Carolina	55	55	40	49	53	54	50	35	52	46	31	24	23	23	24	
South Carolina		1	1		1			0					0			
SOUTHERN REGION	199	201	194	172	181	186	217	189	204	203	182	183	208	209	203	400
U.S. TOTAL	724	752	751	790	877	968	1150	1162	1187	1168	1156	1207	1280	1415	1420	1600
ATLANTIC CANADA	233	229	234	234	234	181	208	186	197	212	240	231	245	275	256	400
ATLANTIC COAST	957	981	985	1024	1111	1149	1358	1348	1384	1380	1396	1438	1525	1690	1676	2000

Table 1. Summary of Atlantic Coast Piping Plover Population Estimates, 1989 to 2003

SPECIES PROFILE

Purple Finch

Caprodacus purpureus

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S5
Author: John J. Kanter, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Purple finch nest in cool coniferous forests and a variety of other cover types (Wooton 1996) where conifers are present. During winter, purple finch are likely to be distributed by food resources rather than habitat structure or vegetative composition (Wooton 1996). In a New York study area, higher breeding densities were strongly correlated with the ratio of forest edge to forest area and with the density of understory vegetation (Keller 1990, as cited in Wooton 1996). Purple finch also nest in orchards, conifer plantations, and suburbs. Purple finch ability to adapt to these anthropogenic habitats has likely expanded its range.

1.2 Justification

Purple finch populations have declined 1.7% annually ($p<0.05$) throughout its range from 1966 to 2003 (Sauer et al. 2004). In the Atlantic Northern Forest (Bird Conservation Region 14), a conservation-planning unit that includes most of New Hampshire, the 2.43% ($p<0.001$) annual rate of decline has been more severe. Analysis of annual Christmas Bird Count data demonstrates a similar declining trend based on purple finch observation rates in primary wintering range (Bolgiano 2004).

1.3 Protection and Regulatory Status

- Migratory Bird Treaty Act of 1918
- Bird Conservation Region (BCR) 14 high priority species

1.4 Population and Habitat Distribution

BCR 14 supports 11.4% of the purple finch breeding population and some of the highest densities known for the species. The purple finch is found in all 3 of the state's ecoregion sections and was documented in 172 out of 179 priority breeding bird atlas survey blocks (McDermott 1994).

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

N/A

1.7 Sources of Information

Primary sources of information included peer-reviewed literature, Breeding Bird Survey Database, New Hampshire's Breeding Bird Atlas, and expert consultation.

1.8 Extent and Quality of Data

The annual breeding bird survey, New Hampshire's Breeding Bird Atlas, and numerous local surveys (e.g., White Mountain National Forest Monitoring) provide extensive information on purple finch distribution and abundance. Purple finch habitat associations are poorly described.

1.9 Distribution Research

- Continue annual breeding bird survey routes
- Update New Hampshire's Breeding Bird atlas at 20-year intervals

Element 2: Species/Habitat Condition

2.1 Scale

New Hampshire's 3 ecoregion sections are appropriate for scale because conifer composition, especially spruce fir, differs among them: White Mountains = 120,344 ha, Vermont/New Hampshire uplands = 44,441 ha, and Lower New England = 7,136 ha.

2.2 Relative Health of Populations

Purple finch densities, represented by average number per breeding bird survey route (1966 to 2003), are highest in the White Mountain Section, intermediate in Vermont /New Hampshire Uplands, and lowest in the Lower New England Section (Sauer et al. 2004)

2.3 Population Management Status

No population management is conducted for purple finch.

2.4 Relative Quality of Habitat Patches

The White Mountain Section's greater composition of conifers, especially spruce and fir, provides habitat that likely supports New Hampshire's highest purple finch densities. The Vermont-New Hampshire Upland has the next highest composition of spruce-fir habitat and is intermediate in its purple finch habitat quality. The Lower New England Section's combination of urbanization and lack of spruce and fir provides the lowest habitat quality.

2.5 Habitat Patch Protection Status

Fifty percent of the White Mountain section is in conservation ownership.

2.6 Habitat Management Status

Because large areas of the White Mountain section are in public ownership, management opportunities are significant. Purple finch habitat associations need to be more clearly defined in order to prescribe forest management practices that benefit this species.

2.7 Sources of Information

Peer-reviewed literature, Breeding Bird Survey Data, and New Hampshire Fish and Game GIS

2.8 Extent and Quality of Data

The loss of breeding spruce fir habitat from 1970 to 1983 due to Eastern budworm outbreak (Bolgiano 2004) and interspecific competition with house finch (*Caprodacus mexicanus*) that was introduced to eastern North America in 1930 (Wooton 1996), are offered as explanations for the purple finch's regional decline. Both hypotheses rely on correlation of these events with purple finch population declines without providing evidence of any direct causes.

Purple finch numbers reported for the Christmas Bird Count were twice as high during the 1970 to 1983 outbreak of Eastern spruce budworm (*Choristoneura fumiferana*) than during the preceding and subsequent 20-year periods (Bolgiano 2004). Purple finch populations may have risen as nest productivity increased from this abundant food source. Extensive logging operations to salvage wood damaged by budworm subsequently led to modification of millions of hectares of prime breeding habitat. The purple finch population in the region declined in response to the combined loss of food and habitat that resulted from the budworm outbreak.

Wooton (1996) offers an alternative explanation that competition with the house finch is responsible for the decline. The decline in purple finch in eastern North America correlates with the introduction and establishment of the house finch. Nevertheless, competition, hybridization, or other interspecific perturbations are not well documented.

2.9 Condition Assessment Research

Research is needed to identify factors leading to purple finch declines. In addition, research that clearly describes habitat associations of purple finch in Atlantic Northern Forests will better inform foresters and landowners about habitat enhancement practices. Research that links small-scale habitat features with large-scale land cover data sets is needed to predict how population changes are affected by forestry and eastern budworm damage.

Element 5: References

5.1 Literature

Bolgiano, N.C. 2004. Changes in boreal bird irruptions in eastern North America relative to the 1970s spruce budworm infestation. American Birds 54: 26-33.

Keller, J.K. 1990. Using aerial photography to model species-habitat relationships: the importance of habitat size and shape. New York State Museum Bulletin 471: 34-46.

McDermott, J. 1994. Purple Finch. Pp. 354-355 in Foss, C.R., ed. The Atlas of Breeding Birds in New Hampshire. Arcadia, an imprint of The Chalford Publishing Corporation, Dover, New Hampshire, and the New Hampshire Audubon, Concord, New Hampshire, USA.

Sauer, J.R., J.E. Hines, and J. Fallon. 2004. The North American breeding bird survey, results and analysis 1966-2003. Version 2004.1, U.S. Geological Survey Patuxent Wildlife Research Center, Laurel, Maryland, USA.

Wootton, J.T. 1996. Purple Finch (*Carpodacus purpureus*). In The Birds of North America No. 208 (A. Poole and G. Gill, eds.) The Academy of Natural Sciences, Philadelphia, PA and The American Ornithologists' Union, Washington, D.C.

SPECIES PROFILE

Purple Martin

Progne subis

Federal Listing: Not listed
State Listing: Endangered
Global Rank: G5
State Rank: S1
Author: Pamela D. Hunt, New Hampshire Audubon

Element 1: Distribution and Habitat

1.1 Habitat Description

In New Hampshire, purple martin (hereafter called martins) colonies are located in open areas with a relatively unobstructed view of the horizon. Such areas include golf courses, lakeshore residential areas, open fields, and low-density residential areas. Many colonies are near water (lakes or rivers), although a water feature does not appear to be critical to the species. Martins prefer nest poles that are not vegetated at the base and that are within 100 feet of human habitation (presumably to avoid predation) (Purple Martin Conservation Association, Hill 1990).

1.2 Justification

Martins have been declining over most of their range in New England for at least 2 decades (Laughlin and Kibbe 1985, Zeranski and Baptist 1990, Veit and Petersen 1993, Hunt 2003). Breeding Bird Survey data indicate a range wide decline of 0.6% per year, with the decline concentrated in eastern North America (0.9% per year, Sauer et al. 2004). In the East, declines appear most dramatic in the northern United States and along the Gulf Coast.

Martin distribution within New Hampshire has contracted significantly over the last 50 years (figure 1). Whereas the Lakes Region and other areas of east-central New Hampshire have apparently always contained several colonies, other regions such as the Contoocook Valley and Western Highlands appear to have completely lost their colonies since broad surveys were first conducted in the late 1950s. Small colonies on the Seacoast (Great Bay and in Rye) barely survive, and were unoccupied in 2004 despite regular management and monitoring activity at both sites.

1.3 Protection and Regulatory Status

This species is protected at the federal level by the Migratory Bird Treaty Act, which prevents the killing of most non-game birds and collection of their nests or eggs. In New Hampshire, it is protected by the New Hampshire Endangered Species Conservation Act (RSA 212).

1.4 Population and Habitat Distribution

Martins were recorded in New Hampshire in the late 1700s and sporadic records exist for the 1800s, but it was not until roughly the 1880s that consistent records were kept. In the early 1900s, martins were locally common over most of the lowlands in southern and central New Hampshire, with scattered populations in the Connecticut River Valley as far north as Colebrook and Lancaster (Allen 1903, Wright 1911).

Forbush (1929) reported a significant die-off due to cold weather in June 1903, with a smaller die-off in the summer of 1914. In the aftermath of these die-offs, the first statewide colony survey in 1920-21 found only 17 colonies in 10 towns, with half of the colonies in southeastern New Hampshire (Hebert 1960, see Hunt 2003).

A second major decline occurred in June 1959, when cold wet weather in mid-June caused martins to desert many colonies, and even resulted in some adult mortality (Hebert 1959). A statewide survey was repeated in 1959-60 and found only five of the

previous colonies still active; none of the southeastern colonies from 1920-21 were still active. However, several new colonies were located, resulting in a net increase to 22 colonies in 18 towns (Hebert 1960). Additional colonies reported during in the three years prior to this survey bring the total for the late 1950s up to at least 30 (Figure 1a).

The next statewide martin survey was the Breeding Bird Atlas surveys (1980-85). Martins were confirmed breeding in 17 atlas blocks and recorded as "probable" in five more. These blocks were distributed across 21 towns, primarily in Carroll, Belknap, and Merrimack counties (Figure 1b). In addition, NHBR data from this period show five additional colonies apparently not reported to the Atlas.

A dramatic decline beginning in the mid-1980s (figure 2) may be at least partially attributable to the cessation of intensive surveys, although other data seem to indicate a real decline. Data from the Breeding Bird Survey (BBS) indicate a drop in martin numbers over most of the eastern United States in 1983 (Sauer et al. 2003). Martins disappeared from the Hopkinton BBS route after 1985.

Starting in the late 1980s, almost all the available data on purple martin distribution in the state come from NHBR. There are consistent records for only 7 sites, and single-year records for 2-4 more. Three additional historic sites were reported as active to the Purple Martin Conservation Association (PMCA), but none more recently than 1987. Martins were also reported to the PMCA at 4 additional locations, but none of these was confirmed.

1.5 Town Distribution Map

See Figure 1.

1.6 Habitat Map

N/A

1.7 Sources of Information

Information on purple martin colony locations was obtained from New Hampshire Bird Records, Foss (1994), the PMCA, and local bird publications. Regional information was collected from state bird publications and the Breeding Bird Survey.

1.8 Extent and Quality of Data

When martin surveys were promoted and coordinated at the statewide level (1959 to 1960, early 1980s, and early 2000s), data on martin distribution in New Hampshire were probably very accurate. The species' colonies are highly visible and the species is easily identified. However, the local nature of most colonies makes them less likely to be discovered between surveys. For example, 3 of the 10 colonies active between 2002 and 2004 were previously undocumented. Ironically, martins' penchant for nesting in residential areas and on golf courses probably decreases the chances of colonies being sighted, because lay birders do not frequent these areas.

1.9 Distribution Research

Much is known about the distribution of the purple martin in New Hampshire. Where historic town records exist, however, the exact habitat should be identified for future restoration projects.

Element 2: Species Condition

2.1 Scale

Each colony is treated as a conservation-planning unit, even though all colonies inhabit similar artificial housing. Because maintenance and housing conditions vary from place to place, this distinction between colonies is intuitive. Nevertheless, the transient nature of artificial habitat means that historic comparisons must be discarded.

2.2 Relative Health of Populations

In the column "Current Size" in table 1, the current size (2002-2004 average) of the colony is given in number of pairs. The column "Historic Size" reflects the general status of the colony during the 1980s. In general, these data indicate that most colonies are smaller than during the 1980s, which corroborates the statewide population decline discussed in section 1.2.

2.3 Population Management Status

In table 1, colony management is rated as one of the following:

- Poor: the nest boxes are not known to be cleaned annually, and competitors are not discouraged or excluded.
- Fair: the nest boxes are sometimes cleaned (or cleaning has been less frequent in recent years)
- Good: the nest boxes are regularly cleaned and monitored, though competitors are not usually controlled
- Excellent: the nest boxes are regularly cleaned and competitors regularly discouraged. It should be noted that the 2 "excellent" only achieved this rating in 2004, when martins did not use either site. Assuming management continues in the absence of martins, these colonies would retain this rank even if no birds were present.

2.4 Relative Quality of Habitat Patches

Given that colonies are effectively the same as habitat patches for this species, see column "Colony Management" in table 1. The column "Housing Availability" can supplement this, which is the current number of compartments in the available martin housing at a given colony. Data on colony size, potential colony size, and management status have been combined into the final column, "Colony Potential." Colony Potential reflects the possibility of growth in a given colony given existing conditions and historic occupancy levels, as follows:

- Low Growth: small or recently abandoned colony that may reestablish itself, given that management of "good" or better is in place.
- Stability: larger colonies that have maintained a constant population for several years. There is potential for increase if management is elevated to "excellent."
- Uncertain: colonies with limited data, or where declines appear to have occurred in recent years. Declines may be reversed with improved management.

2.5 Habitat Patch Protection Status

All recently active martin colonies are under private ownership.

2.6 Habitat Management Status

See section 2.3.

2.7 Sources of Information

Information on management and condition of active or recently active colonies was obtained through a combination of site visits and discussions with colony owners. Trends in colony size were obtained from NHBR and current site monitoring activity.

2.8 Extent and Quality of Data

The assessment of colony potential described above is necessarily brief. Although much is known about trends in colony size and distribution in the state, little is known about causal factors (see element 3). And although it is known that management can result in colony growth (Brown 1981, Hill 1990), it is not clear how effective these techniques may be in New Hampshire, where there is a limited source of new recruits into the population.

2.9 Condition Assessment Research

Much research has already been conducted to determine the best conditions for purple martin reproduction (Brown 1981; Hill 1990, 1991, 1999; Kostka 1998, 2000), so there is little need for a research program in New Hampshire.

Element 5: References

5.1 Literature

Allen, G.M. 1903. A List of the Birds of New Hampshire. Proceedings of the Manchester Institute of Arts and Sciences: IV (1). Manchester, New Hampshire, USA.

Brown, C.R. 1981. The impact of starlings on purple martin populations in unmanaged colonies. American Birds 35: 266-268.

Brown, C.R. 1997. Purple martin (*Progne subis*). *In* The Birds of North America, No. 287 (A.

Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, DC.

Forbush, E.H. 1929. Birds of Massachusetts and other New England states. Part III. Norwood, Norwood, Massachusetts, USA.

Foss, C.R. 1994. Atlas of Breeding Birds in New Hampshire. New Hampshire Audubon, Concord, New Hampshire, USA.

Hebert, V.H. 1959. 1959 nesting season. New Hampshire Bird News 12: 129-138.

Hebert, V.H. 1960. Purple martins in New Hampshire. New Hampshire Bird News 13: 155.

Hill, J.R.,III. 1990. Top 10 reasons why people fail to attract purple martins. Purple Martin Update 2(3): 28.

Hill, J.R., III. 1991. Gourd homes for martins: The pros and cons. Purple Martin Update 3(2):12-15.

Hill, J.R., III. 1994. Do parasites lower the nesting success of purple martins? Purple Martin Update 5(1): 28-29.

Hill, J.R., III. 1999. Relative breeding success of purple martins nesting in various types of housing. Purple Martin Update 8(4): 2-6.

Hill, J.R., III, P. Kramer, and M. Levy. 2004. The PMCA's 2004 research trip to the purple martin's Brazilian wintering grounds. Purple Martin Update 13(2): 2-7.

Hunt, P.D. 2003. The purple martin in New Hampshire: Historical and current status and proposed conservation measures. Report to the New Hampshire Fish and Game Department, Nongame and Endangered Species Program. New Hampshire Audubon, Concord, New Hampshire, USA.

Kostka, K. 1998. Dawnsong: a powerful tool for attracting purple martins. Purple Martin Update 8(3): 8-10.

Kostka, K. 2000. Social attraction: A new technique for establishing a purple martin colony site. Purple Martin Update 9(3): 26-29.

Laughlin, S.B., and D.P. Kibbe. 1985. The Atlas of Breeding Birds of Vermont. University

Press of New England, Hanover, New Hampshire, USA.

Morton, E.G. 1998. The fatal flaw of martin house designs with continuous porches. Purple Martin Update 3(1): 26-27.

Sauer, J.R., J.E. Hines, and J. Fallon. 2004. The North American Breeding Bird Survey, Results and Analysis 1966-2003. Version 2004.1, USGS Patuxent Wildlife Research Center, Laurel, MD.

Veit, R.R. and W.R. Petersen. 1993. Birds of Massachusetts. Massachusetts Audubon Society, Lincoln, MA.

Wright, H.W. 1911. The Birds of the Jefferson Region in the White Mountains. Manchester

Institute of Arts and Sciences, Manchester, NH. (2000 reprint with an introduction by Tudor Richards, Durand Press, Etna, NH)

Zeranski, J.D., and T.R. Baptist. 1990. Connecticut Birds. University Press of New England, Hanover, New Hampshire, USA.

5.2 Data Sources:

NHBR. New Hampshire Bird Records. New Hampshire Audubon, Concord, NH.

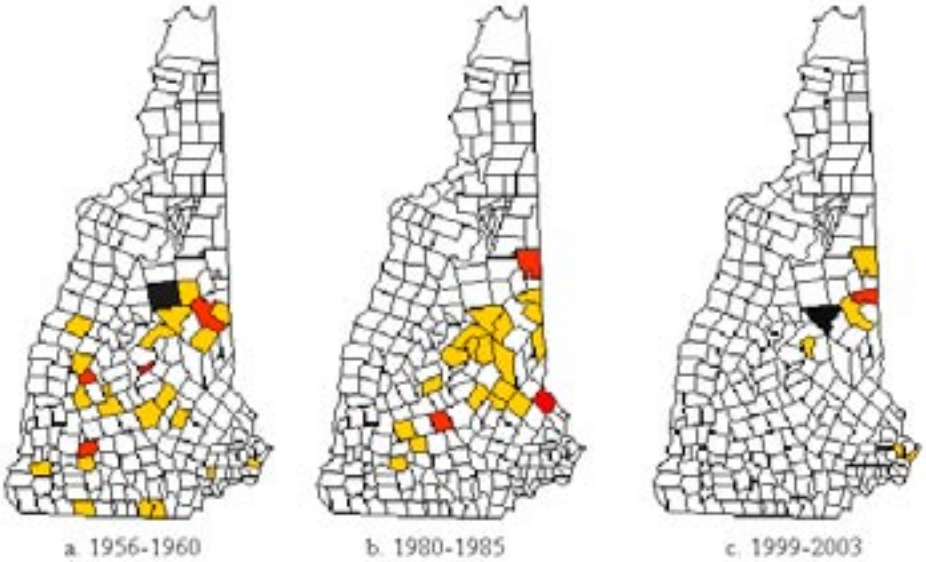
PMCA. Purple Martin Conservation Association – Colony Registration Program, Edinboro, PA.

Element 6: List of Figures

Figure 1. Distribution of Purple martin colonies in New Hampshire for three five-year periods: a. late 1950s (statewide Audubon surveys), b. early 1980s (Breeding Bird Atlas), and c. early 2000s (current monitoring program). Towns shaded to indicate number of colonies: yellow = one, red = two, black = three.

Figure 2. Number of Purple martin colonies in New Hampshire, 1951-2003. Each point represents the total number of colonies reported during the five year period.

Table 1. Overview of purple martin colonies in New Hampshire, 2000 to present. Current size, historic size, and housing availability are expressed in number of pairs. Terms used to describe colony management are defined in section 2.3. Colony potential is based on a combination of population trend and management status for a given colony (see section 2.4).



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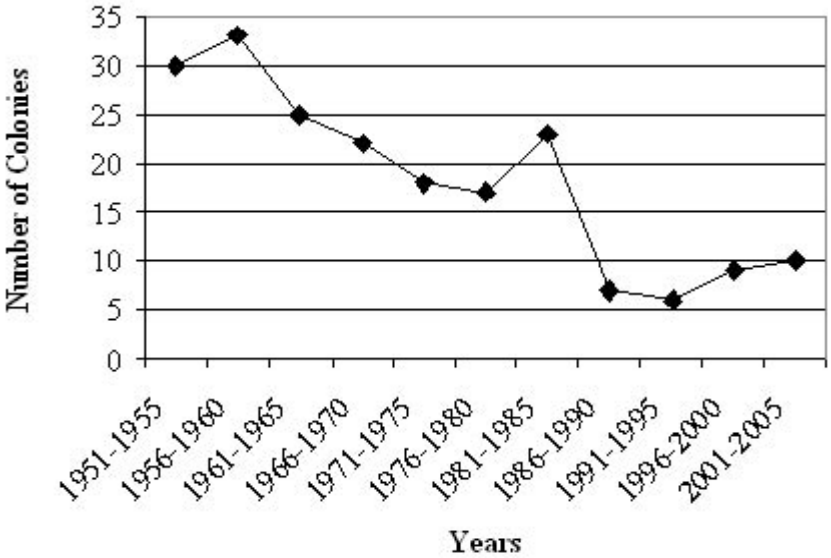


Unit #	Unit Name	Current Size	Historic Size	Colony Management	Housing Availability	Colony Potential
1	Fun Spot	23	10+	Good	82	Stability
2	Conway	22	40	Fair	96	Stability
3	Windward Harbor	9	10	Good	12	Low Growth
4	Lees Mill	8	10	Poor	23	Uncertain
5	Indian Mound	3	Not known	Unknown	24	Uncertain
6	Hodge Farm	3	30+	Good	36	Low growth
7	Totem Pole	2	10+	Fair	48	Uncertain
8	Portsmouth Country Club	2	3	Excellent	30	Low growth
9	Hemlock Point	1	Not known	Good	27	Low growth
10	Wentworth Golf Course	1	Not known	Excellent	12	Low growth

Table 1. Overview of purple martin colonies in New Hampshire, 2000 to present. Current size, historic size, and housing availability are expressed in number of pairs. Terms used to describe colony management are defined in section 2.3. Colony potential is based on a combination of population trend and management status for a given colony (see section 2.4).

SPECIES PROFILE

Purple Sandpiper
Calidris maritima

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: SNA
Author: Alina, J. Pyzikiewicz, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Purple sandpipers breed in tundra and rocky shores and overwinter on coastal islands (Payne and Pierce 2002). Breeding areas include mossy areas near the shoreline and coastal barren flats with abundant insects and seeds (Payne and Pierce 2002). Wintering grounds include rocky coasts and jetties and coastal islands where crustaceans, mollusks, and other invertebrates are plentiful (Payne and Pierce 2002).

1.2 Justification

The North Atlantic coast is one of the heaviest populated areas in the United States and is undergoing rapid development. The purple sandpiper uses New Hampshire's rocky shores and islands as wintering grounds.

1.3 Protection and Regulatory Status

The purple sandpiper is protected under the Migratory Bird Act and various non-government coastal shorebird programs (Bird Conservation Regional plans, The United States Shorebird Conservation Plan, Waterbird Conservation for the Americas).

1.4 Population and Habitat Distribution

In North America, purple sandpipers breed primarily on islands in the Canadian Arctic and overwinter on the coast from Quebec to South Carolina (Payne and Pierce 2002). In New Hampshire, the purple sandpiper winters along the rocky coastlines of Rye, Hampton, and Seabrook, and on the Isles of Shoals (New Hampshire Bird Records (NHBR)). It forages off the mainland coast from October to April, and on the Isles of Shoals as late as August (NHBR). The heaviest concentrations of wintering purple sandpipers in New Hampshire have been observed at Rye Harbor State Park, the rocks at Hampton Harbor, and the Isles of Shoals (NHBR). Population sizes are unknown because access to these areas is limited (Morrison et al. 2001). The United States Shorebird Conservation Plan (2000) estimates populations of wintering purple sandpipers in North America to be around 15,000.

1.5 Town Distribution Map
Not comopleted for this species.

1.6 Habitat Map
Not addressed for this species.

1.7 Sources of Information

Birds of North America, NHBR, and the United States Shorebird Conservation plan.

1.8 Extent and Quality of Data

Little is known about the status of the purple sandpiper in New Hampshire. Published information regarding North American breeding and wintering grounds is minimal, with most research taking place outside North America (Payne and Pierce 2002).

1.9 Distribution Research

- Identify and monitor important wintering areas

- Conduct surveys to estimate wintering population size
- Determine factors limiting population size and habitat use
- Coordinate research and monitoring activities with other countries that support purple sandpipers

Element 4: Conservation Actions

See Coastal Islands Habitat Profile.

Element 5: References

5.1 Literature

Brown, S., C. Hickey, and B. Harrington, editors. 2000. The United States shorebird conservation plan. Manomet Center for Conservation Sciences, Manomet, Massachusetts, USA.

Morrison, R.I.G., R.E. Gill, Jr., B.A. Harrington, S. Skagen, G.W. Page, C.L. Gratto-Trevor, and S.M. Haig. 2001. Estimates of shorebird populations in North America. Occasional Paper No. 104. Canadian Wildlife Service. Ottawa, Ontario, Canada.

Payne, L.X., and E.P. Pierce. 2002. Purple sandpiper (*Calidris maritime*). *In* The Birds of North America, No 706, A. Poole and F. Gill, editors. The Birds of North America, Philadelphia, Pennsylvania, USA.

5.2 Data Sources

New Hampshire Bird Records. New Hampshire Audubon, Concord, New Hampshire, USA.

SPECIES PROFILE

Red Shouldered Hawk

Buteo lineatus

Federal Listing: Not listed
State Listing: Special Concern
Global Rank: G5
State Rank: S3
Author: Carol R. Foss, New Hampshire Audubon

Element 1: Distribution and Habitat

1.1 Habitat Description

Red shouldered hawks in the northeastern portion of their range typically inhabit large contiguous blocks of moist and mature deciduous and mixed forests. They especially prefer bottomland and riparian forests and forested wetlands and will use suburban woodlots if there is adequate foraging habitat nearby (Crocoll 1994).

1.2 Justification

The northeastern red shouldered hawk population experienced a substantial decline during the 1960s (Henny 1972, Palmer 1988). This species was listed as Threatened in New Hampshire between 1980 and 1986, was on the American Birds Blue List throughout its range between 1972 and 1986 (Tate 1986), and was considered a migratory non-game bird of management concern in the northeastern United States in 1987 (Peterson and Crocoll 1992). Population increases led to reduced levels of concern and subsequent downlistings. According to analyses of Breeding Bird Survey data, red shouldered hawk populations are increasing regionally (Sauer et al. 2004).

However, increasing levels of forest fragmentation and recreational activity may justify monitoring, particularly in southern New Hampshire. Clearing of large forest blocks has been implicated in population declines (Brown 1971, Woodrey 1986, Hands et al. 1989, Preston et al. 1989, Peterson and Crocoll 1992), and forest fragmentation favors Great Horned Owls and Red-tailed Hawks over red shouldered hawks (Bednarz and Dinsmore 1981, 1982, Bryant 1986).

1.3 Protection and Regulatory Status

The Red-shouldered hawk is protected in the United States under the Migratory Bird Treaty Act of 1918 (16 U.S.C. 703-712; Ch. 128; July 13, 1918; 40 Stat. 755) as amended by: Chapter 634; June 20, 1936; 49 Stat. 1556; P.L. 86-732; September 8, 1960; 74 Stat. 866; P.L. 90-578; October 17, 1968; 82 Stat. 1118; P.L. 91-135; December 5, 1969; 83 Stat. 282; P.L. 93-300; June 1, 1974; 88 Stat. 190; P.L. 95-616; November 8, 1978; 92 Stat. 3111; P.L. 99-645; November 10, 1986; 100 Stat. 3590 and P.L. 105-312; October 30, 1998; 112 Stat. 2956).

1.4 Population and Habitat Distribution

The New Hampshire population of red shouldered hawks is estimated at 1,400 to 1,600 individuals, based on a cursory examination of topographic maps. Maps were examined for location of potential home ranges based on presence of wetlands or bottomland forests on a town-by-town basis. The combined population estimate for BCRs 14 and 30 is 7,330 individuals (Hunt 2005). The range-wide population is estimated at 830,000 (Rich et al. 2004).

New Hampshire Endangered Species Program and NHBR documented 88 occupied red shouldered hawk territories in southern New Hampshire during the 1981 to 1989 breeding seasons: 41 in Merrimack County, 19 in Hillsborough County, and 28 in Rockingham County. Biologists conducting searches and broadcast surveys at 57 of these sites in 1990, detected red shouldered hawks at 25 of the 57 sites, and rated habitat at 44 as suitable, 11 as marginal, and 2

as no longer suitable (NHA, unpublished data).

Red shouldered hawks are more common in the Sebago-Ossipee Hills, Coastal Plain, and southern New Hampshire Uplands subsections than elsewhere in the state (Foss 1994), where mountainous terrain limits the distribution of suitable wetlands.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

1.7 Sources of Information

The information in this account is based on review of available literature and analysis of data in the NHBR Database from 1991 to 2004.

1.8 Extent and Quality of Data

Searches for red shouldered hawks were conducted under the auspices of the New Hampshire Endangered Species Program during the 1980 and 1981 breeding seasons. Biologists used broadcast surveys to determine occupancy of 57 previously documented territories in 1990. Additional data were obtained during fieldwork for the New Hampshire Breeding Bird Atlas (1981 to 1986) and by serendipitous observations. The absence of documented territories in Sullivan County is more likely the result of a lack of observers than of the absence of red shouldered hawks.

1.9 Distribution Research

The relatively specific habitat needs of this species (mature forest and extensive wetlands) enable identification of potential territory sites from topographic maps. Field surveys of identified potential sites in the rapidly developing southeastern counties would provide an important baseline against which to measure future population change. In addition, field efforts in Sullivan County would clarify the species' distribution in New Hampshire.

Element 2: Species/Habitat Condition

2.1 Scale

Conservation of red shouldered hawks is best addressed at the ecoregional scale. New Hampshire Endangered Species Program data from the 1980 and 1981 field seasons and New Hampshire Breeding Bird Atlas data suggest that red shouldered hawks occur at highest densities in the Southern New England Coastal Hills and Plain Ecoregion. Suitable habitat and documented territories are scarce and widely scattered in the White Mountains and Vermont-New Hampshire Uplands ecoregions. County analyses of potential habitat confirm this assessment (see table 1). Field surveys have high territory densities in Kensington/South Hampton (0.35/sq. mi), Andover (0.15/sq. mi), Dunbarton (0.13/sq. mi), and Canterbury (0.11/sq. mi).

2.2 Relative Health of Populations

Insufficient data exist to assess recent population trends for New Hampshire. Breeding Bird Survey data suggest that red shouldered hawk populations are increasing regionally (Sauer et al. 2004).

2.3 Population Management Status

No population management efforts are under way, and there is no evidence that such efforts are needed.

2.4 Relative Quality of Habitat Patches

Quality of habitat patches varies from sites in large blocks of unfragmented forest with relatively pristine wetlands to sites in highly fragmented forest with wetlands degraded by stormwater runoff from roads and other impervious surfaces. Two of the counties with the highest densities of potential territories experienced New Hampshire's most rapid development from 1990 to 1997; Hillsborough and Rockingham counties each received 27% of the State's new housing units during that period (Sundquist and Stevens 1999).

2.5 Habitat Patch Protection Status

Unknown.

2.6 Habitat Management Status

No active habitat management is currently underway.

2.7 Sources of Information

Cited literature, evaluation and analysis of available data, and consultation with colleagues.

2.8 Extent and Quality of Data

Searches for red shouldered hawks were conducted under the auspices of the New Hampshire Endangered Species Program during the 1980 and 1981 breeding seasons. Biologists used broadcast surveys to determine occupancy of 57 previously documented territories in 1990. Additional data were obtained during fieldwork for the New Hampshire Breeding Bird Atlas (1981 to 1986) and by serendipitous observations. Potential territories were identified roughly from the New Hampshire Atlas and Gazetteer (DeLorme 2002). There has been no recent field survey to determine habitat quality of historical and potential territories.

2.9 Condition Assessment Research

Priority research for this species is the GIS analysis of fragmentation and development metrics for potential habitat.

Element 3: Species and Habitat Threat Assessment

3.1.1. Development (Fragmentation, Habitat Loss and Conversion)

(A) Exposure Pathway
Development and deforestation reduce availability of nesting sites and foraging areas. Remaining habitat exists in patches interspersed among other land uses, and such landscape mosaics provide suitable habitat for Great Horned Owls and Red-tailed Hawks. The relative contributions of reduced foraging area, aggressive interaction, predation, and competition to abandonment of fragmented sites are unknown.

(B) Evidence
Great horned owls are known to prey on red shouldered hawk nestlings (Huey 1913, Wiley 1975, Portnoy and Dodge) and to nest in former red shouldered hawk nests (Palmer 1988). Habitat alteration (e.g., removal of trees) has preceded known cases of red-tailed hawks replacing red shouldered hawks (Palmer 1988). When habitat remains unaltered, red shouldered hawks may occupy specific territories for many years (Bent 1937).

3.2 Sources of Information

Literature review.

3.3 Extent and Quality of Data

Although there is no compelling reason to expect that New Hampshire red shouldered hawks should behave differently than those in other parts of the species' range, none of the primary research on which the threat discussion is based was conducted in northern New England.

3.4 Threat Assessment Research

- Where development in New Hampshire is high, field surveys and GIS analyses should be conducted to determine the nature of threats.
- Documenting territories and nest sites within tracts of protected land would provide insight into the long-term viability of the species in southern New Hampshire.

Element 4: Conservation Actions

4.1 Specific Conservation Action: Protect large unfragmented forest blocks with extensive wetland. Category: Habitat Protection

(A) Direct Threats Affected
Development (Fragmentation, Habitat Loss and Conversion)

(B) Justification
- Evidence cited above strongly suggests that

maintaining red shouldered hawk habitat enables local populations to persist over long periods.

- The threat posed by habitat loss and fragmentation must be confronted on the scale of individual home ranges. However, multiple home ranges in high-density areas should take precedence over single, isolated home ranges.
- Protective measures should be based on urgency of threats.
- The scope and nature of protective measures will reflect new information on red shouldered hawks.

(C) Conservation Performance Objective
Protect habitat for clusters of home ranges throughout the southern New England Coastal Hills and Plain Ecoregion.

(D) Performance Monitoring
Monitor number and location of protected habitat areas.

(E) Ecological Response Objective
Maintain local populations of successfully breeding pairs throughout the Southern New England Coastal Hills and Plain Ecoregion.

(F) Response Monitoring
Monitor protected home ranges with broadcast surveys and searches for nest sites.

(G) Implementation
See profile for unfragmented forest blocks of matrix forest.

(H) Feasibility
See profile for unfragmented forest blocks of matrix forest.

Element 5: References

5.1 Literature

Bednarz, J.C. and J.A. Dinsmore. 1981. Status, habitat use, and management of Red-shouldered Hawks in Iowa. Journal of Wildlife Management 45: 236-241.

Bednarz, J.C. and J.A. Dinsmore. 1982. Nest sites and habitat of Red-shouldered and Red-tailed Hawks in Iowa. Wilson Bulletin 94: 31-45.

Bent, A.C. 1937. Life Histories of North American Birds of Prey. U.S. National Museum Bulletin 167, Washington, DC.

Bosakowski, T. and D.G. Smith. 1989. Survey of the woodland raptor community in the Pequannock watershed. Master's thesis, Rutgers University, Newark, NJ.

Bryant, A.A. 1986. Influence of selective logging on Red-shouldered Hawks, *Buteo lineatus*, in Waterloo Region, Ontario, 1953-1978. Canadian Field-Naturalist 100:520-525.

Crocoll, S.T. 1994.Red-shouldered Hawk. No. 107 *in* A. Poole and F. Gill, eds. *The Birds of North America*. The Academy of Natural Sciences of Philadelphia.

Foss, C.R., ed. 1995. *The Atlas of Breeding Birds in New Hampshire*. Arcadia, an imprint of The Chalford Publishing Corporation, Dover, NH and The New Hampshire Audubon, Concord.

Gavutis, G.W., Jr. 1995.Red-shouldered Hawk. Pp. 52-53 *in* Foss, C.R., ed. *The Atlas of Breeding Birds in New Hampshire*. *in* Foss, C.R., ed. *The Atlas of Breeding Birds in New Hampshire*. Arcadia, an imprint of The Chalford Publishing Corporation, Dover, NH and The New Hampshire Audubon, Concord.

Hands, H.M., R.D. Drobney, and M.R. Ryan. 1989. Status of the Red-shouldered Hawk in the north-central United States. U.S. Department of the Interior, Fish & Wildlife Service.

Henny, C.J. 1972. An analysis of the population dynamics of selected avian species with special reference to changes during the modern pesticide era. U.S. Bureau of Sport Fisheries and Wildlife (Wildlife Research Report no. 1), Washington, D.C.

Huey, L.M. 1913. Nesting notes from San Diego County. Condor 15:228.

Hunt, P.D. 2005. A Regional Perspective on New Hampshire's Birds of Conservation Priority: Objectives, Threats, Research Needs and Conservation Strategies. Report to NH Fish & Game Department, Concord.

Johnsgard, P.A. 1990. *Hawks, Eagles & Falcons of North America: Biology and Natural History*. Smithsonian Institution Press, Washington, DC.

Palmer, R.S. 1988. Red-shouldered Hawk. Pp. 413-429 *in* R.S. Palmer, ed. *Handbook of North American Birds*, vol. 4, Yale University Press, New Haven, CT.

Peterson, J.M.C. and S.T. Crocoll. 1992. Red-shouldered Hawk *Buteo lineatus*. Pp. 333-351 in K.J. Schneider and D.M. Pence, eds. *Migratory Nongame Birds of Management Concern in the Northeast*. USDA Fish and Wildlife Service, Region 5, Newton Corner, MA.

Portnoy, J.W. and W.E. Dodge. 1979. Red-shouldered Hawk nesting ecology and behavior. Wilson Bulletin 91: 104-117.

Preston, C.R., C.S. Harger, and H.E. Harger. 1989. Habitat use and nest-site selection by Red-shouldered Hawks in Arkansas. Southwestern Naturalist 34:72-28.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S.W. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.C. Hunter, E.E. Inigo-Elias, J.A. Kennedy, A.M. Martell, A.O. Panjabi, D.N. Pashley, K.V. Rosenbert, C.M. Rustay, J.S. Wendt, and T.C. Will. 2004. North American Landbird Conservation Plan. Cornell Lab of Ornithology, Ithaca, NY.

Sauer, J. R., J. E. Hines, and J. Fallon. 2004. *The North American Breeding Bird Survey, Results and Analysis 1966 - 2003. Version 2004.1. USGS Patuxent Wildlife Research Center, Laurel, MD (http://www.mbr-pwrc.usgs.gov/bbs/)*

Sundquist, D. and M. Stevens. 1999. New Hampshire's Changing Landscape: Population Growth, Land Use Conversion, and Resource Fragmentation in the Granite State. Society for the Protection of New Hampshire Forests and The Nature Conservancy, Concord, New Hampshire.

Titus, K., M.R. Fuller, D.F. Stauffer, and J.R. Sauer. 1989. Buteos. Pp. 53-64. Proceedings of the Northeast Raptor Management Symposium and Workshop, National Wildlife Federation Scientific and Technical Series No. 13.

Wiley, J.W. 1975. The nesting and reproductive success of Red-tailed Hawks and Red-shouldered Hawks in Orange County, California. 1973. Condor 77: 133-139.

Woodrey, M.S. 1986. Characteristics of Red-shouldered Hawk nests in southeast Ohio. Wilson Bulletin 98: 466-469.

5.2 Data Sources

New Hampshire Bird Records, New Hampshire Audubon, Concord, NH.

Table 1. Estimated red shouldered hawk potential territories for New Hampshire counties.Figure 1. New Hampshire towns with red shouldered hawk observations reported to New Hampshire Bird Records during 1991-2004.

County	Area (sq. mi.)			Estimated potential home ranges	Estimated density
Belknap	467.6			35	0.07
Carroll	978.2			75	0.08
Cheshire	722			116	0.16
Coos	1884.7			34	0.02
Grafton	1746.2			69	0.04
Hillsborough	880.8			124	0.14
Merrimack	961.6			91 87	0.09
Rockingham	705.5			115	0.16
Strafford	378.5			55	0.15
Sullivan	548.7			27	0.05

Table 1. Estimated red shouldered hawk potential territories for New Hampshire counties.Figure 1. New Hampshire towns with red shouldered hawk observations reported to New Hampshire Bird Records during 1991-2004.

SPECIES PROFILE

Roseate Tern

Sterna dougallii

Federal Listing: Endangered
State Listing: Endangered
Global Rank: G4
State Rank: S1
Author: Diane L. De Luca, New Hampshire Audubon

Element 1: Distribution and Habitat

1.1 Habitat Description

Roseate terns nest on small rocky or sandy islands, barrier beaches, salt marshes, and rarely on the mainland (USFWS 1989, Kress and Hall 2004). Most colonies are close to shallow-water foraging areas with sandy bottoms, bars, or shoals (Gochfeld et al. 1998). In the Northeast, roseate terns nest within common tern colonies (Nisbet 1989, USFWS 1998). Within these mixed colonies, roseate terns usually select habitat with dense vegetation or the protection of rocks and driftwood (Burger and Gochfeld 1988). They will also use artificial nest sites (e.g., boxes and half-buried tires) (Spendelow 1982).

Roseate terns forage over shallow sandbars, shoals, inlets, or schools of predatory fish, often in mixed flocks with other terns (Safina 1990, Shealer and Burger 1993, 1995). Roseates feed on at least 15 species of small marine fish but prefer sand lance (*Ammodytes* spp.) (Gochfeld et al.1998, Kress and Hall 2004). Feeding studies at New Hampshire's Seavey Island have documented sand lance (*Ammodytes* spp.), white hake (*Urophycis tenius*), Atlantic herring (*Clupea harengus*), and American Pollock (*Pollachius virens*) as key forage species (NHA and NHFG unpublished data 2003-2004). Foraging distance is variable (300 m^2 to 30 km^2) and depends on local prey availability. Roseate terns will travel farther than common terns to feed (Gochfeld et al. 1998, Kress and Hall 2004).

1.2 Justification

Since records were first taken in 1870, the roseate tern has dwindled somewhat in the region (USFWS 1988). This population nested from Nova Scotia to Virginia in the late nineteenth century but has been lost from all south of Long Island's south shore. The roseate tern was listed under the Endangered Species Act in 1987. At the time of listing, there were approximately 3,000 pairs nesting on 21 islands (10 islands with over 10 pairs) in the Northeast. Since then, restoration efforts have had a limited effect; populations continue to fluctuate around 3,700 pairs between New York and Nova Scotia (Roseate Tern Recovery Team (RTRT) 2004). Currently, the estimated numbers of nesting pairs in this region remains 3,700 on 19 islands (10 islands with over 10 pairs). Trend data from the last ten years show a population decline of 10% in spite of continued management (RTRT minutes 2004).

There have been recent large declines in southern New England and Long Island. Most sites on Long Island's south shore have been lost, and a significant Long Island Sound colony is greatly reduced (USFWS 1998, Kress and Hall 2004). In contrast, the cold water Gulf of Maine roseate population has been steady during this period. The Seavey Island roseate tern colony grew from 1 pair in 2001 to 112 pairs in 2004 (NHFG and NHA unpublished data). Thus, it is important to evaluate these smaller, cold-water populations for their potential to aid in recovery goals. More than 85% of the entire northeastern population currently nests on 4 islands between Buzzard's Bay and Long Island, New York, leaving the entire population increasingly vulnerable. Preservation of populations adapted to variable climates is critical in a time of global climate change.

The concentration of roseate terns in several large colonies, due to predation and loss of nesting sites,

is the primary threat to the species (USFWS Roseate Tern Recovery Plan). Expanding gull populations have taken over many of the offshore islands that once supported terns, and other islands have been lost to erosion. Roseates were forced to nest at inshore islands where the habitat quality was lower and the risk of predation from multiple predators was high.

In the northeastern United States, eggs, chicks and adults are eaten by 11 avian, 10 mammalian, 1 reptile, and 2 ant species (Nisbet 1989). Additional limiting factors may include inadequate foraging resources, competition for nest sites, contaminant impacts, imbalanced sex ratio, and insufficient funds to adequately protect existing colonies. Inclement weather may also harm northeastern roseate tern populations. Little is known about factors affecting the population on its wintering grounds (Gochfeld et al.1998). In managing for roseate terns the needs of other coastal island species including common tern, Arctic Tern, common eider, black guillemot and purple sandpiper are also addressed

1.3 Protection and Regulatory Status

The roseate tern is protected in the United States under the Migratory Bird Treaty Act of 1918, which prohibits the taking of bird, nest, and eggs. The roseate tern is also protected under the United States Endangered Species Act of 1973 and was listed as an endangered species on 2 December 1987. In April 1985, the Canadian population of the roseate tern was designated as threatened by the Committee on the Status of Endangered Wildlife in Canada.

In New Hampshire, the roseate tern is listed as an endangered species and protected under RSA 212. Seavey Island, the only current nesting location for roseate terns in New Hampshire, is managed by NHFG. Seavey Island is posted as an endangered species breeding site and the public is restricted from 1 May to 1 September. Seavey Island is actively managed through the breeding season, and biologists are present at the colony from late April to August.

1.4 Population and Habitat Distribution

In New Hampshire, the only current nesting of roseate terns occurs at Seavey Island, Isles of Shoals. The island has been intensively managed for terns since 1997. One pair of roseate terns successfully nested on Seavey Island in 2001 and the population quickly grew to include 112 pairs in 2004. The Seavey Island colony represents approximately 3% of the entire northeastern population and close to 40% of the roseate terns breeding in the Gulf of Maine.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

The New Hampshire GRANIT System was used to identify coastal islands. Very small islands were grouped to the nearest adjacent neighboring islands. In total, 96 polygons were grouped into 48 islands, which in turn were clustered into 15 conservation units. Each conservation unit was then defined by parameters such as size, shoreline, development, distance from known and potential contaminant sources, and the distances to the nearest aquaculture operations, oil spill response staging areas, recreational fishing areas, marinas and public beaches. New Hampshire Department of Environmental Services provided the locations of known contamination sources, heliports, oil spill response staging areas, recreational fishing, marinas, and aquaculture facilities.

1.7 Sources of Information

Basic natural history information in this profile was largely gathered from the literature cited in element 5. Information on habitat and distribution was gathered from scientific literature, recovery conservation plans, technical field reports, published literature, NHA and NHFG Seavey Island data, New Hampshire Bird Records data, Gulf of Maine Seabird Working Group (GOMSWG) and Roseate Tern Recovery Team (RTRT) discussion and minutes. Information for mapping was provided as cited in 1.6.

1.8 Extent and Quality of Data

Roseate terns have been closely monitored in the region for more than 20 years. The Seavey Island roseate tern population has been intensively studied since recolonization in 2001. In New Hampshire, a census is taken at all current and recently occupied tern-nesting sites during June. Censuses were taken at the Isles of Shoals in 1977, 1985, 1995, and one is

planned for 2005.

In 2004, nesting habitat parameters were measured on Seavey Island to develop habitat and vegetation profiles. This study is part of a habitat management plan to enhance nesting opportunities. Roseate tern foraging habitat is largely unknown in New Hampshire. In 2004, a brief study suggested that some foraging occurs near Seavey Island, but critical foraging areas remain undocumented. Few data exist on staging areas for roseate terns before or after the breeding period, or on migration and wintering habitat.

1.9 Distribution Research

- Continue intensive monitoring of roseate terns on Seavey Island and characterize breeding habitat
- Evaluate other islands at the Isles of Shoals for suitable tern habitat, especially historic sites (Lunging and Duck Islands)
- Identify priority habitats and potential restoration sites
- Document significant foraging and staging areas
- Band Seavey Island roseate tern chicks with field-readable bands to provide information on recruitment and intercolony movement. Develop protocol to systematically re-sight banded birds and coordinate with other islands for data exchange. Understand movement patterns of the roseate tern within the Gulf of Maine using the marked known aged population. Evaluate annual interchange of birds between GOM and "warm water" group.
- Research migration routes
- Research winter habitat use and distribution

Element 2: Species/Habitat Condition

2.1 Scale

Fifteen conservation units have been identified for coastal islands. All 9 islands at the Isles of Shoals are recognized as separate units.

2.2 Relative Health of Populations

The only New Hampshire population of roseate terns occurs on Seavey Island, Isles of Shoals. This population has been intensively monitored since 2001 when the first pair nested; in 2004, 112 pairs nested (table 1). Productivity has averaged 0.93 chicks per pair between 2001 and 2004 (table 2). This remains below the northeastern average of more than 1.1 chicks per pair. Fewer than 1 chick per pair is considered low but can be seen in small or newly formed colonies (Nisbet 1989, Gochfeld et al. 1998).

Seavey Island is now 1 of 2 colonies in the cold waters of the Gulf of Maine that number over 100 pairs; the other is Eastern Egg Rock in Muscongus Bay, Maine, which had 110 pairs in 2004. Seavey Island and Eastern Egg Rock are now the fifth largest colonies in the Northeast.

Roseate terns have not nested on any other islands at the Isles of Shoals since the late 1940s. The last known breeding on Lunging Island was in 1944 (Borror and Holmes 1990). Anecdotal evidence from Duck Island describes tern breeding in the "thousands". Both Lunging and Duck Island are potential breeding habitat but support large herring and great black-backed gull colonies.

The potential for roseate tern recolonization outside the Isles of Shoals is low. Inshore tern colonies contend with predation, disturbance, and the attendant disruptions of nesting habitats. Few inshore islands have the dense vegetation or rocky outcrops that roseates prefer to nest in. In addition, roseates only nest in common tern colonies of significant size. The largest common tern colony outside of Seavey Island rarely supports more than 12 pairs.

The objective for recovery in this species is to increase the Northeast nesting population to a minimum of 5,000 pairs with at least 6 large colonies (over 200 pairs) with high productivity (at least 1.0 fledged young per pair). A secondary objective is to expand the number of roseate tern breeding colonies to 30 or more sites. At present, there are only 4 sites larger than 200 pairs, and they all experience fluctuating productivity. The concentration of nearly all the roseate (100%), Arctic (100%), and common turns (98%) at one site in New Hampshire puts tern populations at great risk.

2.3 Population Management Status

The Seavey Island roseate, common and Arctic tern colony is managed intensively. Biologists live on the island throughout the breeding season, controlling predators, monitoring colony productivity, and implementing public outreach. Visitation is restricted from 1 May to 1 September to minimize disturbance.

Managers encouraged roseate terns to recolonize Seavey Island by using tern attractants and controlling gull populations. Gull control at Seavey Island consisted of dogs (late April), pyrotechnics, regular circumnavigation of the island beginning 30 minutes before sunrise and continuing until 30 minutes after sunrise, and the placement of a large rock in any gull nest cups (NHA and NHFG unpublished reports 1997-2003). Tern attraction techniques included the placement of decoys in suitable habitat along with the broadcast of tern colony sounds (Kress 1983). Common terns nested at this site in the first year of restoration efforts (1997).

Gull predation continues, but is dealt with successfully. Resident tern biologists intervene throughout the breeding season, and specialist predatory gulls are removed from the island. During summer, tern biologists regulate visitation and guide educational visits from Shoals Marine Lab, Star Island, and various other conservation organizations. Lighthouse renovation is scheduled to begin in 2005, and coordination with tern project biologists, New Hampshire Parks and Recreation oversight staff, and construction personnel will be imperative to avoid any disturbance to the terns.

2.4 Relative Quality of Habitat Patches

Seavey Island provides the best habitat for roseate terns in New Hampshire. A survey was initiated in 2004 to develop habitat and vegetation profiles for roseate nest sites. This study will evaluate the capacity of the site to support more roseate tern nesting and to document habitat changes. The quality of foraging habitat and prey availability on Seavey Island is largely unknown.

Duck Island and Lunging Island still have good potential for tern nesting, though the presence of gulls makes colonization problematic. Smuttynose Island once supported one of the largest gull concentrations at the Isles of Shoals, and the presence of raccoons and gulls makes this site unsuitable for tern nesting. A large gull colony exists on Appledore Island, where a research station is operated from April to October. However, rats, muskrats, raccoons, and human disturbance make this island unsuitable for terns.

2.5 Habitat Patch Protection Status

Seavey Island was deeded to the State of New Hampshire after the White Island Light was automated in 1987. White and Seavey Islands have been managed by the Department of Resources and Economic Development (DRED) Parks and Recreation Division as part of Odiorne State Park since 1993. A Memorandum of Agreement on tern restoration exists between DRED – Parks Division and the NHFG. Seavey Island is managed by NHFG as an endangered species nesting area and is afforded both state and federal protection under endangered species law.

The Coastal Islands National Wildlife Refuge purchased Duck Island in July 2003. This island will be managed for its wildlife resources, protected as a seabird colony, posted for closure during the breeding season, and evaluated for habitat management and restoration (B. Benedict, USFWS, personal communication). Privately owned Lunging Island is not protected beyond current shoreline and wetland regulations. Smuttynose Island is privately owned but was protected in August of 2001 by a conservation easement held by the Coastal Islands National Wildlife Refuge. This conservation easement allows the refuge to manage the site for wildlife resources (B. Benedict, USFWS, personal communication). Islands in the Piscataqua River, and Great and Little Bays are not suitable for roseate terns because of their proximity to the mainland.

2.6 Habitat Management Status

Seavey Island is managed for terns through the NHFG and NHA Tern Restoration partnership. Restoration efforts from 1997 to 2004 have focused on intensive management to eliminate gull nesting and to control predation, and have allowed re-colonization by common terns.

There has been a shift in the Seavey Island vegetation from yarrow and seaside goldenrod to tall dense grasses. Although the height of the grass makes the habitat more suitable for roseate terns, the density can cause problems for movement of both adults and chicks as the season progresses. In 2005, approximately 100 feet of boardwalk were laid through the grassy area to give more structure and opening to the nesting habitat, and to allow biologists access to this part of the island.

Other islands identified in section 2.4 as having the potential for tern recolonization need to have baseline habitat assessments. If determined to be suitable for restoration efforts, a habitat restoration plan would need to be developed and implemented.

2.7 Sources of Information

Information on habitat and distribution was gathered from scientific literature, recovery conservation plans, technical field reports, published literature, NHA and NHFG data, GOMSWG, and Roseate Tern Recovery Team (RTRT) discussion and minutes. Information for mapping was provided as cited in 1.6.

2.8 Extent and Quality of Data

Seavey Island has been monitored intensively since 1997. Census and productivity numbers have been determined since roseate terns began nesting in 2001. Chick provisioning data were collected in 2004. Baseline habitat data for roseate tern nesting sites were also collected in 2004. It will be important to expand on these data to determine the habitat parameters in preferred nesting areas.

2.9 Condition Assessment Research

Monitoring

- Continue intensive monitoring of roseate terns on Seavey Island
- Continue to monitor productivity. Use established methods as outlined by the Roseate Tern Recovery Plan to determine productivity on a yearly basis

Research and Assessment

- Characterize roseate tern breeding habitat on Seavey Island. Determine the habitat parameters in preferred nesting habitat. Evaluate the need for vegetation management to maintain and/or increase roseate habitat on Seavey Island.
- Conduct habitat assessments at the other historical Isles of Shoals islands
- Identify and characterize preferred foraging habitat/sites. Evaluate vulnerability of principal foraging sites to human related over-use issues.
- Assess available foraging resources by conducting foraging studies. Establish protocol to study the relationship of prey availability and productivity. Identify prey availability during the courtship and egg-laying stage to determine impacts on clutch size. Identify inter-annual and inter-colony variation in prey and the potential effects on productivity. Develop understanding of how foraging effort affects reproduction.
- Assess potential impacts of an oil spill near Seavey Island

Research and Survey

- Identify important staging areas for Gulf of Maine roseate terns and the proportion of the population aggregating at staging/roosting areas. Conduct staging area counts through re-sighting of banded GOM birds, and determine the proportion of the population aggregating at staging/roosting areas. Build baseline information of the use of staging sites by NH and ME roseate terns. Determine if pre-migratory staging areas are a vulnerable population bottleneck.
- Identification and habitat assessment of important wintering areas

Element 5: References

5.1 Literature

Borror, A.C., and D.W. Holmes. 1990. Breeding Birds of the Isles of Shoals. Shoals Marine Laboratory, New York, New York, USA.

Brody, Samuel D. 1998. Evaluating the role of site selection criteria for Marine Protected Areas in the Gulf of Maine. Gulf of Maine Council on the Marine Environment.

Burger, J., and M. Gochfeld.1988. Nest site selection: comparison of Roseate and Common Terns in a Long Island, New York colony. Bird Behavior 7: 59-66.

Chardine, J.W. 1990. Newfoundland: Crossroads for Marine Birds and Shipping in the North Atlantic. Proceedings: The Effects of Oil on Wildlife. Newfoundland.

Clement, J., and M. Janowicz (Editors). 2003. Aquaculture Physical Remediation: Workshop Proceedings. Gulf of Maine Council on the Marine Environment, www.gulfofmaine.org

Collie, J.S., G.A. Escanero, and P.C. Valentine. 1997. Effects of bottom fishing on the benthic megafauna of Georges Bank. Marine Ecology Progress Series 155: 159-172.

Donehower, C. 2003. Predation rate and predatory behavior of large gulls on Eastern Egg Rock. Unpublished Report. National Audubon Society.

Drury, W.H.1973. Population changes in New England seabirds. Bird-Banding 44: 267-313.

Foss, C. Editor. 1994. Atlas of the Breeding Birds in New Hampshire. New Hampshire Audubon, Dover, New Hampshire, USA.

Gochfeld, M., J. Burger, and I.C.T. Nisbet. 1998. Roseate Tern (*Sterna dougallii*). In The Birds of North America. No. 370 (A. Poole and F. Gill, eds.). The Birds of North America Inc. Philadelphia, Pennsylvania, USA.

Goodale, W. 2000. The importance of lobster bait in Penobscot Bay gull diet. Unpublished Report. College of the Atlantic.

Gulf of Maine Council on the Marine Environment. 2002. Action Plan 2001-2006. Gulf of Maine Council on the Marine Environment.

Gulf of Maine Council Habitat Restoration Subcommittee. 2004. The Gulf of Maine Habitat Restoration Strategy. Gulf of Maine Council on the Marine Environment.

Hays, H., P. Lima, L. Monteiro, J. DiCostanzo, G. Cormons, I.C.T. Nisbet, J.E. Saliva, J.A. Spendelow, J. Burger, J. Pierce, and M. Gochfeld. 1999. A nonbreeding concentration of Roseate and Common Terns in Bahia, Brazil. Journal of Field Ornithology 70:455-464.

Kress, S.W. 1983. The use of decoys, sound recordings, and gull control for re-establishing a tern colony in Maine. Colonial Waterbirds 6:185-196.

Kress, S.W., and C.S. Hall. 2004. Tern Management Handbook – Coastal Northeastern United States and Atlantic Canada. U.S. Department of Interior, Fish and Wildlife Service, Hadley, Massachusetts, USA.

New Hampshire Office of State Planning Coastal Program. 1996. A vision for the New Hampshire coast. National Oceanic and Atmospheric Administration. 61pp.

Nisbet, I.C.T., and J.A. Spendelow. 1999. Contribution of research to management and recovery of the Roseate Tern: Review of a twelve –year project. Waterbirds 22:239-252.

Nisbet, I.C.T. 2000. Disturbance, habituation and management of Waterbird colonies. Waterbirds 23:

Pierce, V. 1991. Pathology of Wildlife following a #2 Fuel Oil Spill. The Effects of Oil on Wildlife: Research, Rehabilitation, and General Concerns. BRRC, TSBR, IWR.

Safina, C., R.H. Wagner, D.A. Witting, and K.J. Smith. 1990. Prey delivered to Roseate and Common Tern chicks; composition and temporal variability. Journal of Field Ornithology 61: 331-338.

Shealer, D.A., and J. Burger. 1993. Effects of interference competition on the foraging activity of tropical Roseate Terns. The Condor 95: 322-329.

Shealer, D.A., and J. Burger. 1995. Comparative foraging success between adult and one-year-old Roseate and Sandwich Terns. Colonial Waterbirds 18: 93-99.

Shealer, D.A., and S.W. Kress. 1994. Postbreeding movements and prey selection of roseate terns at Stratton Island, Maine. Journal of Field Ornithology 65: 349-362

Spendelow, J.A. 1982. An analysis of the temporal variation, and the effects of habitat modification on, the reproductive success of Roseate Terns. Colonial Waterbirds 5:19-31.

Spendelow, J.A., J.D. Nichols, I.C.T. Nisbet, H. Hays, G.D. Cormons, J.Burger, C. Safina, J.E. Hines and M. Gochfeld. 1995. Estimating annual survival and movement rates of adults within a metapopulation of Roseate Terns. Ecology 76: 2415-2428.

Tripp, B., M. Ernst and D. Keeley (Editors) 2004. Establishing research priorities in the Gulf of Maine. Final Report. GOMC-RARGOM Theme Meeting.

Tyrell, M.C. 2005. Gulf of Maine Habitat Primer. Gulf of Maine Council on the Marine Environment, www.gulfofmaine.org. vi+54 pages

USFWS. 1989. Recovery Plan for Roseate Tern (*Sterna dougallii*). Northeast Population. Newton Corner, Massachusetts, USA.

USFWS. 1998. Roseate Tern Recovery Plan – Northeastern Population, First Update. Hadley, Massachusetts, USA.

5.2 Data Sources

New Hampshire Bird Records

New Hampshire Audubon and New Hampshire Fish and Game 1997 – 2004 Seavey Island Summary Reports.

Hunt, P. 2004. A regional perspective on New Hampshire's Birds of Conservation Priority: Objectives, threats, research needs, and conservation strategies. Unpublished report.

Roseate Tern Recovery Team Minutes 2000-2004

Gulf of Maine Seabird Working Group Minutes 1997 – 2004.

SPECIES PROFILE

Ruffed Grouse

Bonasa umbellus

Federal Listing: Not listed
State Listing: Not listed
Global Ranking:
State Ranking:
Author: Julie Robinson, Jim Oehler, and Ellen Snyder, New Hampshire Fish and Game, Consulting Wildlife Biologist

Element 1: Distribution and Habitat

1.1 Habitat Description

The ruffed grouse uses deciduous and coniferous forests in both upland and wetland settings (DeGraaf et al. 1989). Ruffed grouse are early successional forest specialists. Grouse require four different cover types for drumming, brood rearing, nesting, and wintering. In general, they inhabit brushy, mixed-age woodlands, early successional to mature hardwood and mixed forests, often with aspen and birch as a component. Optimal habitat for ruffed grouse include young (6 to 15-year-old), even-age deciduous stands typically supporting 20-25,000 woody stems/ha (Gullion 1984). These habitats are available to grouse for approximately one decade because stem densities decrease rapidly through natural thinning as succession proceeds (Dessecker and McAuley 2001). Although commonly identified as an "edge" species, ruffed grouse association with habitat edges largely reflects their use of various interspersed forest habitats at different times of the year and their use of marginal habitats where quality habitat is lacking. They typically avoid hard-contrast edges (Dessecker and McAuley 2001).

Old orchards are an ideal fall habitat in New England (DeGraaf and Yamasaki 2001). Catkin-bearing trees are also an indicator of grouse habitat. They use logs or stone walls for drumming sites and dense cover for protection (Brooks and Birch 1988). Hens and broods prefer areas with a dense understory and fairly open herbaceous ground cover. Grouse nest and feed in hardwood stands and dust themselves in sunny openings. Ruffed grouse use mature woodlands, especially coniferous forests, during winter. When snow is deep and soft, birds will roost in the snow. Otherwise they will roost on the ground or in trees.

1.2 Justification

Ruffed grouse are found throughout much of the eastern United States, yet are common only where extensive tracts of forest dominate the landscape (Dessecker and McAuley 2001). The decline, fragmentation, and isolation of early successional forest habitats may be limiting ruffed grouse recruitment and therefore population densities (Dessecker and McAuley 2001).

1.3 Protection and Regulatory Status

Hunting regulations protect ruffed grouse in New Hampshire.

1.4 Population and Habitat Distribution

The ruffed grouse is a year-round resident in New England. They are more common inland than along the seacoast (DeGraaf and Yamasaki 2001), generally at elevations below 3,000 ft. Development poses a significant threat to grouse habitat in the lower third of the state, but pockets of grouse habitat should persist there for the foreseeable future. The Western Highlands and northern two-thirds of the state continue to provide extensive grouse habitat. Continual harvesting of mature forests of the industrial timberlands of northern New Hampshire produce quality grouse habitat (Robinson 1994).

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

Habitat conditions suitable for grouse are difficult to map using existing remotely sensed data (see Shrublands habitat profile, section 1.6).

1.7 Sources of Information

Two small game surveys are implemented annually. Small game sighting data are solicited from small game hunters and successful deer bow hunters, and these observations are used as an index of New Hampshire's small game species distribution and abundance. Ruffed grouse drumming routes have been run each spring since 1999. Two routes were established in each Wildlife Management Unit. These surveys are efficient at generating useful population data. Over time, survey results will provide invaluable trend data for management decision-making.

1.8 Extent and Quality of Data

Ruffed grouse have been studied and monitored since colonial times. With the implementation of these surveys in 1999, quality data exist on the relative abundance of these species.

1.9 Distribution Research

A better means of mapping grouse habitat is needed (see Shrublands habitat profile). An effort should be made to increase participation in the Small Game Survey to get better information on the abundance and distribution of grouse throughout the state.

Element 2: Species/Habitat Condition

2.1 Scale

Counties will be used as the conservation-planning unit for this habitat because that is the scale at which most information exists and because most technical and financial assistance (from the USDA NRCS, UNH Cooperative Extension, and others) is provided to private landowners by county.

2.2 Relative Health of the Population

Ruffed grouse populations naturally experience irregularly cyclical booms and crashes (Robinson 1994). Cyclical patterns aside, it is difficult to ascertain trends in the state's grouse population since drumming surveys just started in 1999. However, declines in early successional forest habitats and the isolation of these habitats in some landscapes may be limiting ruffed grouse recruitment and therefore population densities in some regions of the state (Dessecker and McAuley, 2001).

Forests in the northeastern Unites States were historically subject to several sources of disturbance (DeGraaf and Yamasaki 2003). Fire, wind, beaver (*Castor canadensis*), flooding, and Native American activity continually produced early successional forests (DeGraaf and Yamasaki 2003). Largely in response to forest maturation, young forest habitats have now become critically uncommon in much of the eastern United States and especially the Northeast (Brooks and Birch 1988, Trani et al., 2001).

Abandonment of agricultural lands reached a peak in New England in the late 1800s to mid-1900s and a wave of early successional habitats followed (Dessecker and McAuley 2001). Today, such habitats are less common than they were in pre-settlement times in several regions of the northeastern United States (Dessecker and McAuley 2001). On the other hand, the proportion of early successional habitat in northern industrial forests is currently several times that which occurred in pre-settlement times (Dessecker and McAuley 2001).

2.3 Population Management Status

Ruffed grouse are managed by hunting regulations. Season length and daily bag are determined on a biyearly basis.

2.4 Relative Quality of Habitat Patches

Because no young forest habitat map was created, it is difficult to assess habitat quality at the patch scale (see Shrubland Habitat Profile).

2.5 Habitat Patch Protection Status

Since no habitat map was generated, the habitat patch protection status of grouse habitat in New Hampshire is unknown. However, given the ephemeral nature of young forest habitats, tree harvesting and other vegetation manipulation techniques will need to be employed to generate suitable habitat for ruffed grouse. This can occur on both public and private land.

2.6 Habitat Management Status

Refer to element 2.6 in the shrubland profile for information on habitat management programs that assist with managing shrubland and other early-successional habitats.

2.7 Sources of Information

Sources of information for element 2 include journal articles, websites, GIS data, and white papers.

2.8 Extent and Quality of Information

It is difficult to assess the amount and condition of young forest habitats without an adequate habitat map to prioritize areas to field check.

Element 3: Species and Habitat Threat Assessment

3.1.1 Development (Fragmentation, Habitat Loss and Conversion)

(A) Exposure Pathway
Direct loss of shrubland habitat occurs through the conversion of these lands for residential, industrial, and commercial purposes. Development patterns lead to fragmentation of remaining undeveloped habitats, creating smaller patches that may not sustain wildlife populations and promoting generalist predators that prey on shrubland-dependent wildlife (Barbour and Litvaitis 1993, Litvaitis 2005).

(B) Evidence
New Hampshire's population grew by 17.2% from 1990 to 2004--the fastest growing state in the Northeast for the past four decades. New Hampshire has lost more than 17,000 acres of open space to development each year in the past five years (SPNHF, unpublished report).
Young forest habitats are important to a large suite of animals, including ruffed grouse (DeGraaf et al. 2005). Wildlife that utilizes young forest habitat conditions benefited from the wave of early successional habitats that followed the peak of farm abandonment in the late 1800s. As forests matured the amount of early successional habitats declined, leading to declines in associated wildlife species. In parts of New Hampshire, especially the southern tier, the amount of young forest habitat of functional quality for wildlife may now be falling below historic levels as current landscape conditions are strikingly different than in pre-settlement times (Brooks 2003, Litvaitis 2003, DeGraaf et al. 2005). Remaining patches of forest are broken up or fragmented into isolated patches. Species with small home ranges (such as ruffed grouse) may be able to occupy the remaining habitat patches. However, even these animals may be hampered by the consequences of human land uses that surround small patches of habitat. Increases in generalist predators may reduce or even eliminate small populations of prey species (Barbour and Litvaitis 1993, Oehler and Litvaitis 1996). Over time, these small patches may contain fewer species than similarly sized patches that are surrounded by extensive forests (Litvaitis 2005).

3.1.2 Altered Natural Disturbance (Natural Succession)

(A) Exposure Pathway
Shrubland-dependent vertebrate wildlife species require dense understory cover; their occurrence is influenced more by the height and density of vegetation than by specific plant communities (Litvaitis 2003). Ruffed grouse colonize a site after a woody understory is well developed (approximately 10 years post disturbance) and disappear from the site approximately 20 years post disturbance as the stand matures (DeGraaf et al. 2005). Hence populations of ruffed grouse and other young forest species shift in space and time in response to natural disturbances and human land uses (Litvaitis 2005). As more open land is converted to development there is less overall space for young forest-dependent species to shift into when natural forest succession or lack of active management makes their current habitat patch unsuitable.

(B) Evidence
The New England landscape has gone through dramatic changes over the last 350 years. In the mid 1800s, 75% of the arable land in central and southern New England was in pasture and farm crops. One hundred years later, New England was once again forested – a result of farm abandonment after richer farm fields opened up in the Midwest (DeGraaf et al. 2005). Today, about 80% of New Hampshire is forested again. However, the second growth forests lack the structural diversity including the range of seral stages present in pre-settlement forests (DeGraaf et al. 2005). The forests have matured, while natural disturbance processes, such as fire, have been disrupted, reducing the amount of early successional conditions (Litvaitis 2003, DeGraaf et al. 2005). The conversion of young forests to residential and commercial development combined with forest maturation (i.e., lack of disturbance) is reducing early successional habitat to levels at or below historical levels (Brooks 2003).

3.2 Sources of Information

Sources of information on threats to ruffed grouse and young forests included peer-reviewed scientific papers, GIS-analysis in reports by New Hampshire organizations, and gray literature.

3.3 Extent and Quality of Data

The decline in young forest habitats and their associated wildlife species is well documented.

3.4 Threat Assessment Research

No further research on threats seems warranted.

Element 4: Conservation Actions

4.1.1 Habitat Conservation, Habitat Protection

(A) Direct Threats: Development
(B) Justification
The pattern and magnitude of loss of open space in New Hampshire, especially the southern part of the state, is a major threat to sustaining wildlife habitats including early successional forests. Permanently protecting large blocks of forest suitable for forest management and the creation of young forest stands, especially in the south, will provide an opportunity to manage for natural early successional forests.

Fee simple acquisition of priority forest areas by NHFG or other partners will enable these agencies to manage for the range of wildlife species that depend on them, including ruffed grouse. Conservation easements can be used to ensure long-term management of these habitat types by private landowners. Given the pace of development and loss of open space in New Hampshire, this conservation action should receive priority, especially in the southern part of the state. Once lands are permanently protected the decision cannot be reversed, however, management decisions to benefit priority wildlife species can be adapted as needed.

(C) Conservation Performance Objective
The conservation objective is to permanently protect, through fee simple acquisition or conservation easements, forested habitats that provide opportunity to manage for young forest habitat conditions.

(D) Performance Monitoring
The measurable component is the acres of forestland that are permanently protected and managed.

(E) Ecological Response Objective
The ecological objective is to ensure that populations of ruffed grouse and other priority wildlife successfully reproduce in these permanently protected forestlands.

(F) Response Monitoring
Populations of ruffed grouse should be monitored to determine their reproductive success and to determine if additional management is needed to provide suitable habitat.

(G) Implementation
Habitat maps developed for the WAP will be analyzed to determine which remaining blocks of forested habitats provide the best opportunity for forest management including the establishment of young forest conditions (see Shrublands habitat profile).

(H) Feasibility
The ephemeral nature of early successional forests makes it difficult to permanently protect them. The best approach may be to identify large blocks of

forest that provide opportunity for forest management. The New Hampshire Land and Community Heritage Investment Program is a critical resource for maintaining and protecting large forest blocks, if new funds become available. Although permanent land conservation is typically more expensive than other conservation measures, this action may be required to sustain young forest-dependent wildlife.

4.1.2 Vegetation Management, Restoration, and Management

(A) Direct Threat: Altered Natural Disturbance (Natural Succession)

(B) Justification
Since young forest habitats are relatively short-lived (20 to 25 years in most cases), periodic management is needed to maintain this habitat type. Managing forest vegetation for a specific height and density should encourage many early successional species, depending on spatial scale and landscape context. Creating small patches of young forest habitats in a developing landscape may not yield desired results because of competing pressures of predation, disturbance, and the effect of fragmentation on wildlife movement. Managed habitats should be positioned near existing patches of shrubland, wetland, or a beaver flowage to maintain landscape-scale connectivity. Initially, the size of timber harvests would be larger than natural disturbances to offset the shortfall in early-successional habitat that currently exists (for example 4-10 ha) (Litvaitis 2005). As forests mature, management efforts (especially timber harvests) could then be patterned after canopy gaps (Runkle 1991) or modified to specific silviculture practices of a region (Seymour et al. 2002) if other forms of early-successional habitats (e.g. native shrublands and beaver impoundments) are adequately represented.

(C) Conservation Performance Objective
The conservation objective is to provide adequate young forest habitat conditions to sustain populations of ruffed grouse and other young forest-dependent wildlife.

(D) Performance Monitoring
The measurable component is the number and acreage of areas managed as young forest habitat.

(E) Ecological Response Objective
The ecological objective is to increase the amount of functional young forest habitat that supports ruffed grouse and other habitat associates.

(F) Response Monitoring
Drumming surveys in managed areas could be used as an index of abundance, and over time, indicate success of grouse management.

(G) Implementation
Large forested blocks suitable for forest management will first need to be identified. If in public ownership, then resource managers can manage the habitat. If on private lands, then an education and outreach program could be directed at landowners to maintain diverse habitats on their lands, including early successional habitats. UNH Cooperative Extension and the New Hampshire Coverts Program have an extensive network of landowners interested in wildlife and could be valuable partners in developing the means to educate landowners and facilitate forest management on private lands.

(H) Feasibility
NHFG can work with its state and federal partners to develop management plans on public lands that promote a variety of forested stages including blocks of young forests, and developing an education campaign on the importance of maintaining a suite of forested conditions including young forest habitats.

4.2 Conservation Action Research

An important step in maintaining young forest habitat conditions is the identification of large forest blocks conducive for forest management.

Element 5: References

5.1 Literature

Bergen, K.M., D.G. Brown, M.C. Dobson, and E. Gustafson. 2002. Integrating Radar Remote Sensing of Forested Habitat Structure: A Pilot Project for Biodiversity Informatics. Pages 149-154 in Proceedings, National Science Foundation National Conference on Digital Government Research, Los

Angeles, California.

Bergen, K.M., and M.C. Dobson. 1999. Integration of remotely sensed radar imagery in modeling and mapping of forest biomass and net primary production. Ecological Modelling 122: 257-274.

Bergen, K.M., M.C. Dobson, and L.E. Pierce. 1997. Effects of within-season dielectric variations on terrain classification using SIR-C/X-SAR. Proceedings of the International Geoscience Remote Sensing Symposium, Singapore, China.

Brooks, R.T., and T.W. Birch. 1988. Changes in New England forests and forest owners: implications for wildlife habitat resources and management. Transactions of the North American Wildlife and Natural Resources Conference 53:78-87.

Complex Systems Research Center. 2002. Landcover Assessment - 2001. University of New Hampshire, Durham. http://www.granit.sr.unh.edu/data/datacat/pages/nhlc01.pdf. Accessed 8 February 2002.

DeGraaf, R.M., M. Yamasaki, W.B. Leak, and J.W. Lanier. 1992. New England wildlife: management of forested habitats. Gen. Tech. Rep. NE-144, Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experimental Station.

DeGraaf, R.M., and M. Yamasaki. 2001. New England Wildlife: habitat, natural history, and distribution. University Press of New England, Hanover, New Hampshire, USA.

Dessecker, D.R., and D.G. McAuley. 2001. Importance of early successional habitat to ruffed grouse and American woodcock. Wildlife Society Bulletin 29(2):

Gullion, G. 1984. Managing northern forests for wildlife. The Ruffed Grouse Society, Coraopolis, Pennsylvania, USA.

Hart, B., and D. Tripp-Taylor. 2002. Saving special places: Community funding for land conservation. Society for the Protection of New Hampshire Forests and Center of Land Conservation Assistance.

Miles, P.D. Dec-23-2004. Forest inventory mapmaker web-application version 1.7. U.S. Department of Agriculture, Forest Service, North Central Research Station, St. Paul, MN. [Available only on internet: www.ncrs2.fs.fed.us/4801/fiadb/index.htm]

Runkle, J.R. 1991. Gap dynamics of old-growth eastern forests: management implications. Natural Areas Journal 11:19-25.

Seymour, R.S., A.S. White, and P.G. deMaynadier. 2002. Natural disturbance regimes in northeastern North America—evaluating silvicultural systems using natural scale and frequencies. Forest Ecology and Management 155:357–367.

Silver, H. 1957. A History of New Hampshire game and furbearers. New Hampshire Fish and Game Department, Survey Rep. 6, Concord, New Hampshire, USA.

Sundquist, D. 2002. Piscassic River Wildlife Habitat Modeling Study. The Society for the Protection of New Hampshire's Forests. Concord, New Hampshire, USA.

Straw, J.A., D.G. Krementz, M.W. Olinde and G.F. Sepik. 1994. American woodcock. Pages 97-114 in Migratory shore and upland game bird management in north America, T.C. Tacha and C.E. Braun editors. Int. Assoc. of Fish and Wildl. Agencies. Washington D.C.

Robinson, E.G. 1994. Ruffed Grouse. Pages 89-90 in Atlas of Breeding Birds of New Hampshire (Editor Carol R Foss). New Hampshire Audubon, Concord, New Hampshire, USA.

Trani, M.K., R.T. Brooks, T.L. Schmidt, V.A. Rudis, and C.M. Gabbard. 2001. Patterns and trends of early successional forests in the eastern United States. Wildlife Society Bulletin 29:413-424.

United States Forest Service. 2005. Program structure for forest inventory and monitoring: FIA fact sheet series. United States Department of Agriculture. 2pp. http://fia.fs.fed.us/library/fact-sheets/overview/Pgm_Structure_FS.pdf.

Williamson, S. Forester's guide to wildlife habitat improvement, 2nd edition. University of New Hampshire Cooperative Extension p.41

SPECIES PROFILE

Rusty Blackbird

Euphagus carolinus

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G4
State Rank: S2
Author: Carol R. Foss, New Hampshire Audubon

Element 1: Distribution and Habitat

1.1 Habitat description

Breeding habitat for the rusty blackbird in New Hampshire consists of spruce-fir and mixed spruce-fir-hardwood forest adjacent to streams, ponds, bogs, fens, and beaver ponds at elevations between approximately 1,000 and 4,000 feet in the White Mountains Ecoregion.

1.2 Justification

This species has declined dramatically during the past few decades (NatureServe, Greenberg and Droege 1999, Niven et al. 2004). Breeding Bird Survey data from 1966 to 2001 indicate a statistically significant decline of 10.7% (Greenberg 2003), and Christmas Bird Count data suggest a 5.1% annual decrease between 1965 and 66 and 2002 and 2003. Descriptions of this species' abundance in bird distribution books, annotated checklists, and local checklists published during the twentieth century suggest a large scale, long-term decline that began between 1921 and 1950 (Greenberg and Droege 1999). Use of pesticides on the breeding and wintering grounds, destruction of wintering habitat, acidification of waterbodies on the breeding grounds, and efforts to control blackbirds on winter roosts may have contributed to the decline of this species.

1.3 Protection and Regulatory Status

This species is protected under the federal Migratory Bird Treaty Act

1.4 Population and Habitat Distribution

Population sizes are unknown at state, regional, and range-wide scales. Within New Hampshire, habitat is distributed at 1,000 to 4,000 ft elevation in and north of the White Mountains. The New Hampshire Breeding Bird Atlas documented confirmed breeding of this species in 9 locations, probable breeding in 6 locations, and possible breeding in 8 locations between 1981 and 1986. The Maine Breeding Bird Atlas Project (1978 to 1983) documented the presence of the species in 59 atlas blocks but confirmed breeding in only 14 blocks (Adamus 1987). A roadside survey of potential habitat in Maine during the 2001 and 2002 breeding seasons that included broadcast vocalizations documented the species at only 18 of 188 sites surveyed (Hodgman and Hermann 2003).

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

1.7 Sources of Information

Published literature, New Hampshire Bird Records Database, unpublished report of field investigation in White Mountains.

1.8 Extent and Quality of Data

The New Hampshire Breeding Bird Atlas provides the most comprehensive data on Rusty Blackbird distribution in New Hampshire, based on fieldwork

conducted between 1981 and 1986. Since then, the New Hampshire Bird Records database has documented serendipitous observations.

1.9 Distribution Research

- Survey all documented recent and historical occupied locations to determine current presence and population sizes
- Develop and validate model to describe potential habitat in New Hampshire
- Survey potential habitat identified by model using Maine protocol
- Monitor nesting success at occupied sites
- Determine wintering location(s) for New Hampshire breeding population

Element 2: Species/Habitat Condition

2.1 Scale

Based on recent distribution of rusty blackbirds in New Hampshire, it is appropriate to address the population and habitat of this species at the subsection scale, with sub-populations in the Connecticut Lakes, Mahoosuc-Rangeley Lakes, and White Mountains subsections. Although rusty blackbirds occur and occasionally breed in the northern portion of the New Hampshire Uplands Subsection, their occurrence there is scattered and sporadic, and this subsection is not addressed below.

2.2 Relative Health of Populations

Relative health of rusty blackbird populations is unknown, although available evidence suggests that the Connecticut Lakes sub-population may be the largest of the 3.

2.3 Population Management Status

The rusty blackbird is not currently managed.

2.4 Relative Quality of Habitat Patches

- *Connecticut Lakes Subsection*: Unknown. Extensive and intensive harvesting of spruce-fir forests in some areas of this subsection may have degraded breeding habitat. Acidification of water bodies in breeding habitat may be less severe in this than in the White Mountains Subsection.
- *Mahoosuc-Rangeley Lakes Subsection*: Unknown. Extensive and intensive harvesting of spruce-fir forests in some areas of this subsection may have degraded breeding habitat. Acidification of water bodies in breeding habitat may be less severe in this than in the White Mountains Subsection.
- *White Mountains Subsection*: Unknown. National Forest Management policies protect high elevation and riparian vegetation. Acidification of foraging wetlands may be more severe in this subsection.

2.5 Habitat Patch Protection Status

- *Connecticut Lakes Subsection*: Much of the breeding habitat in this subsection is within the easement area of the Connecticut Lakes Headwaters.
- *Mahoosuc-Rangeley Lakes Subsection*: Some breeding habitat in this subsection is within the Lake Umbagog National Wildlife Refuge, the Nash Stream Forest, the Bunnell Preserve, and the Kilkenny section of the White Mountain National Forest. However, much of the habitat in this subsection is on industrial forestlands that have been intensively harvested in recent years.
- *White Mountains Subsection*: Most of the breeding habitat in this subsection is within the White Mountain National Forest.

2.6 Habitat Management Status

No habitat is being managed specifically for this species.

2.7 Sources of Information

Personal knowledge and consultation with experts.

2.8 Extent and Quality of Data

No data exist regarding either water level or forest management for currently occupied rusty blackbird habitat in New Hampshire.

2.9 Condition Assessment Research

- Determine protection/ownership status of occupied habitat

- Determine water level and forest management policies and practices for occupied habitat
- Determine water quality, riparian vegetation characteristics, and aquatic insect diversity for occupied habitat

Element 3: Species and Habitat Threat Assessment

3.1.1. Acid Deposition

(A) Exposure Pathway
Acid deposition depletes the natural buffering capacity of water body, pH of water body decreases to a level that is toxic to sensitive aquatic species, populations of sensitive species are extirpated from water body, and numbers of emerging insects are low at critical times in breeding cycle.

(B) Direct Evidence
Species richness of phytoplankton, protozoans, zooplankton, periphyton, and macroinvertebrates declines with decreasing pH (Hoffman et al. 1995). Mayfly, stonefly, and caddisfly larvae are particularly sensitive to reduced pH, and biomass has declined in some acidified lakes and streams (Okland and Okland 1986). New England receives high levels of acid deposition (National Acid Precipitation Assessment Program 1991). No data are available regarding macroinvertebrate abundance and species composition at New Hampshire wetlands currently or historically occupied by rusty blackbirds.

3.1.2. Agriculture

(A) Exposure Pathway
Control measures, including the use of lethal agents are used to reduce numbers of blackbirds depredating grain crops and creating large night roosts in the southern and south-central United States during the non-breeding period. Although red-winged blackbirds are the primary target species, rusty blackbirds feed primarily on crop and weed seeds during the non-breeding season, and lethal control agents are designed to target icterids in general. Another potential pathway is through ingestion of toxic maggots in wetland areas. Birds that have ingested the poison DRC-1339 typically seek water and die in or near wetlands. Their carcasses can provide an excellent substrate for *Clostridium botulinum*, and maggots feeding on the carcasses can ingest the botulism toxin, resulting in an outbreak of avian botulism among birds feeding on the maggots.

(B) Direct Evidence
Rusty Blackbirds winter in bottomlands, swamps, and riparian areas and forage in open fields (Avery 1995). Their winter diet includes crops and weed seeds (Martin et al. 1951) as well as various invertebrates (Beal 1900, McCaskie 1971). Wintering locations for New Hampshire's rusty blackbird breeding population are not known, so direct evidence of poisoning in these wintering areas is lacking.

3.2 Sources of Information

Published literature.

3.3 Extent and Quality of Data

No data are available regarding the application of these threats specifically to New Hampshire's rusty blackbird breeding population.

3.4 Threat Assessment Research

- Compare water quality and aquatic insect diversity for currently occupied habitat, historical habitat that is no longer occupied, and unoccupied potential habitat as identified by physical characteristics
- Compare soil chemistry in currently successful breeding areas, currently unsuccessful breeding areas, and abandoned historical breeding areas
- Identify wintering areas for New Hampshire's breeding population and determine history of blackbird control measures, current blackbird control policies and practices, and history of wetland loss at these sites

Element 4: Conservation Actions

4.1.1. Regulate lethal blackbird control in wintering areas. See Strategies: Regional Coordination, Advise IAFWA Regional Coordination Team.

4.1.2. Advise IRAT for acid deposition.

4.2 Conservation Action Research

Before conservation action research can be designed, threat research must be completed.

Element 5: References

5.1 Literature

Adamus, P.R. 1987. Atlas of Breeding Birds in Maine. Maine Department of Inland Fisheries and Wildlife, Augusta.

Avery, M.L. 1995. Rusty Blackbird. No. 200 in A. Poole and F. Gill, eds. The Birds of North America. The Academy of Natural Sciences of Philadelphia.

Greenberg, R. 2003. Rusty Blackbird. The troubled blackbird of the bog. nationalzoo.si.edu/ConservationAndScience/Migratory Birds/Featured Birds.

Greenberg, R., and S. Droege. 1999. The decline of the Rusty Blackbird (*Euphagus carolensis*) and the use of ornithological literature to document long-term population trends. Conservation Biology **13:** 553-559.

Hodgman, T.P., and H.Hermann. 2003. Rusty Blackbird. Pp. 65-72 in H. Hermann, T.P. Hodgman, and P. deMaynadier, eds. A Survey of Rare, Threatened, and Endangered Fauna in Maine: St. John Uplands and Boundary Plateau (2001-2002). Maine Department of Inland Fisheries and Wildlife, Bangor, Maine.

Hoffman, D.J., B.A. Rattner, G.A. Burton, Jr., and J. Cairns, Jr. 1995. Handbook of Ecotoxicology. Lewis Publishers, Boca Raton, FL.

National Acid Precipitation Assessment Program (NAPAP). 1991. 1990 Integrated Assessment Report, Washington, D.C.

Niven, D.K., J.R. Sauer, G.S. Butcher, and W.A. Link. 2004. Christmas Bird Count provides insights into population change in land birds that breed in the boreal forest. American Birds 58: 10-20.

Okland, J., and K.A. Okland. 1986. The effects of acid deposition ion benthic animals in lakes and streams. Experentia 42: 471.

Richards, T. 1995. Rusty Blackbird. Pp. 344-345 in Foss, C.R., ed. The Atlas of Breeding Birds in New Hampshire. Arcadia, an imprint of The Chalford Publishing Corporation, Dover, NH and The New Hampshire Audubon, Concord.

Samuel, M.D., D.R. Goldberg, T.E. Rocke, and K.M. Johnson. 2002. The risk of avian botulism outbreaks from avicide DRC-1339 in North Dakota wetlands. Special Symposium "Management of North American Blackbirds," Bismarck, ND, September 27, 2002. USDA Animal and Plant Health Inspection Service, Wildlife Services, National Wildlife Research Center, Fort Collins, CO.

5.2 Data sources

New Hampshire Bird Records database

SPECIES PROFILE

Salt Marsh Sharp Tailed Sparrow

Ammodramus caudacutus

Federal Listing: Not listed
State Listing: Special concern
Global Rank: G4
State Rank: S3B
Authors: Megan J. McElroy and Kimberly J. Babbitt, University of New Hampshire

Element 1: Distribution and Habitat

1.1 Habitat Description

In New Hampshire, saltmarsh sharp-tailed sparrows (hereafter, saltmarsh sparrow) inhabit salt marshes, which are grass-dominated tidal wetlands existing in the transition zone between ocean and upland (Niering and Warren 1980) (see Salt Marshes habitat profile). They breed in marshes where smooth cordgrass, saltmeadow grass, and blackgrass are bordered by cattail, reed, and marsh elder (Greenlaw and Rising 1994). Sparrows forage on the ground in dense, wet grasses (e.g., cordgrass, blackgrass), areas of wrack, and edges of ditches, pools, and salt pannes (Greenlaw and Rising 1994). Their diet consists mainly of adult and larval insects, spiders, and amphipods. Grass seeds and herbaceous plants become an important part of their diet during fall migration (Greenlaw and Rising 1994).

1.2 Justification

Saltmarsh sparrows were designated a species of high conservation priority by Partners in Flight (Breeding Tier I). In New Hampshire, the saltmarsh sparrow is a species of special concern. Saltmarsh sparrows have a restricted breeding range with 90% occurring in the Northeast (DiQuinzio et al. 2001). Therefore, protecting saltmarsh sparrow populations and their breeding habitat in the Northeast is critical to global survival of this species. Few data exist on population trends and threats, especially in New Hampshire. No long-term studies of this species have been conducted in New Hampshire. Habitat loss and degradation are probably the most pressing threats to salt marsh sparrows in New Hampshire.

Saltmarsh sparrow breeding success is related to the size of habitat patches (Shriver et al. 2004). Large patches of good-quality salt marsh habitat must be available across the landscape for sparrow populations to persist and grow. Invasive reeds and grasses, such as cattails and common reed, have replaced typical salt marsh vegetation in marshes where undersized culverts and other structures restrict tidal flooding (Sinicrope et al. 1990, Burdick et al. 1997, Brawley et al. 1998). Areas of invasive plants in and around salt marshes decrease available habitat for saltmarsh sparrows because they are not suitable habitat.

The current lack of knowledge regarding saltmarsh sparrow populations in New Hampshire and threats to these populations parallels that for other closely related salt marsh birds, such as Nelson's sharp-tailed sparrow and seaside sparrow. Additional research and monitoring may allow this salt marsh guild to serve as an indicator of marsh health, the effects of marsh degradation, and the success of habitat restoration and other management practices.

1.3 Protection and Regulatory Status

- The Migratory Bird Treaty Act of 1918 legally protects saltmarsh sparrows from the take, transport, and use of the species, including eggs, nests, and feathers.
- NHDES regulates human impacts on salt marshes. Activities that may involve filling, dredging, or destroying wetlands are subject to strict guidelines and require approved permits before work can commence (RSA 482-A).

1.4 Population and Habitat Distribution

Saltmarsh sparrows breed on the Atlantic Coast of North America from southern Maine to North Carolina (Sibley 1996). Saltmarsh sparrows inhabit salt marshes in southeastern New Hampshire (Gavutis 1994, NHBR, McElroy and Babbitt, unpublished data). Data collected in 2004 indicate 3 distinct breeding clusters: Great Bay, Rye, and a small portion of the Hampton salt marshes (McElroy and Babbitt, unpublished data). The distribution and patchiness of saltmarsh sparrow populations have changed over the last century because of large-scale changes in their habitat.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

1.7 Sources of Information

A literature review was conducted to obtain information on saltmarsh sparrow habitat, populations, distribution, and status. NHA database of bird records provided historical information on the distribution of saltmarsh sparrows in New Hampshire. Detailed information on current population distribution and status came from data collected in 2004 by researchers from UNH.

1.8 Extent and Quality of Data

Historical bird records from NHA consist of sightings reported by birders. Although this information is vital for understanding historical distribution, it does not offer an accurate view of population size or confirmed breeding locations throughout the state. The most extensive dataset to date comes from UNH researchers. It includes confirmed breeding locations and population estimates throughout the state, but covers only one year. Long-term trends in population locations and sizes in New Hampshire are still unknown.

1.9 Distribution Research

A long-term survey of salt marsh habitat specifically for saltmarsh sparrows (i.e., point counts conducted during breeding season at established points) is needed to determine distribution of the species in New Hampshire. Long-term surveys are necessary because the quality of salt marsh habitat changes over time, potentially affecting saltmarsh sparrow populations from one breeding season to the next.

Element 2: Species/Habitat Condition

2.1 Scale

The New Hampshire conservation units for saltmarsh sparrow are Great Bay and Portsmouth and Coast (including Rye, Hampton, and Seabrook).

2.2 Relative Health of Populations

In New Hampshire, the abundance of saltmarsh sparrows during the breeding season is estimated at approximately 275-300 individuals (McElroy and Babbitt, unpublished data). Because a long-term survey of saltmarsh sparrows has not yet been implemented and Breeding Bird Survey routes do not sufficiently cover salt marshes, data on population trends are not available. Data collected during the 2004 breeding season showed sparrows at the following locations, categorized by breeding activity (Confirmed Breeding = nests found and/or fledglings observed; Possible Breeding = adults present throughout season, singing activity, no evidence of nests and/or fledglings; Potential Breeding = a few birds present feeding at some point in the season, no evidence of any current breeding activity) (table 1). Estimated Relative Abundance (ERA) categories are also included.

2.3 Population Management Status

Currently no population management efforts focus on saltmarsh sparrows in New Hampshire (see Salt Marshes habitat profile).

2.4 Relative Quality of Habitat Patches

Saltmarsh sparrows tend to breed in large (greater than 20 hectares), unrestricted, *Spartina*-dominated marshes with pannes, pools, and creeks or ditches for foraging (Greenlaw and Rising 1994, McElroy and Babbitt, unpublished data). However, sparrows may occupy marshes that do not meet those criteria and may be absent from marshes that do meet the crite-

ria. Consequently, any salt marsh in New Hampshire could provide key ecological attributes. For example, small marshes might not be suitable nesting habitat but may serve as important stopover sites. More research is needed to understand the factors that determine habitat quality for salt marsh sparrows.

2.5 Habitat Patch Protection Status

See Salt Marshes habitat profile (element 2.5)

2.6 Habitat Management Status

See Salt Marshes habitat profile (element 2.6)

2.7 Sources of Information

A literature review was performed to obtain information on research and habitat management. Research by UNH scientists provided information on the population and management status. Information on habitat protection, restoration, and management came from the New Hampshire Coastal Program's website.

2.8 Extent and Quality of Data

Currently, the most extensive dataset comes from researchers at UNH and includes confirmed breeding locations and population estimates throughout the state. However, this dataset covers only one field season. Therefore, a long-term study is needed for an adequate assessment of population health and habitat suitability.

2.9 Condition Assessment Research

Long-term monitoring of saltmarsh sparrow populations is essential for knowledge of population dynamics, trends, and ecology. Monitoring will provide valuable data to increase understanding of the threats to saltmarsh sparrow and the effects of habitat management efforts.

Surveys are needed to determine abundance of saltmarsh sparrows at sites used by the species. This will provide a more accurate assessment of marshes that rank high in priority for protection or conservation. Because this species is non-territorial, point-count surveys and similar methods cannot accurately estimate population abundance. A long-term mark-recapture banding effort would provide a more accurate estimate of sparrow abundance at key sites.

A long-term dataset of presence/absence and abundance estimates at marshes throughout New Hampshire could serves as the basis for a GIS map of locations with high densities of breeding birds. This information is critical for conservation and research efforts for saltmarsh sparrows in New Hampshire and for understanding habitat suitability for this species.

Element 3: Species and Habitat Threat Assessment

3.1.1 Development (Habitat Loss and Conversion)

See Salt Marshes habitat profile

3.1.2 Development (Fragmentation)

See Salt Marshes habitat profile

3.1.2 Altered Hydrology (Tidal Restriction), Transportation Infrastructure

See Salt Marshes habitat profile

3.2.2Introduced Species (Introduced Plants), Development (Habitat Loss and Conversion)

(A) Exposure Pathway

Disturbance to a site, such as the construction of a road restricting tidal flow, can exacerbate the spread of invasive plants (Niering and Warren 1980, Benoit and Askins 1999). In New Hampshire's salt marshes, the most threatening invasive species is common reed (*Phragmites australis*) (NHCP). Purple loosestrife (*Lythrum salicaria*) and narrow-leaf cattail (*Typha angustifolia*) also can disrupt the salt marsh plant community (NHCP). Increased runoff of fresh water and storm water from developed land surrounding the marsh causes lower soil salinities in the marsh, changes in soil saturation levels, sedimentation, and increased erosion. These conditions promote the spread of invasive species (NHCP).

(B) Evidence

Dense, monotypic stands of common reed provide unsuitable or less preferable habitat and food for many wildlife species (Roman et al. 1984). According to Benoit and Askins (1999), saltmarsh sparrows, a species normally found in *Spartina* grasses, are unlikely to use a marsh dominated by tall, thick stands

of common reed. The density of the reed stands may reduce foraging success or make prey inaccessible (Benoit and Askins 1999). Benoit and Askins (1999) found that saltmarsh sparrows were much less abundant in brackish mixture, cattail, and common reed survey plots than in short-grass meadow plots.

3.2.3 Altered Hydrology (Mosquito Ditching), Altered Natural Disturbance

(A) Exposure Pathway:
By the 1930s, about 90% of salt marshes from Maine to Virginia had been ditched for mosquito control (Reinert et al. 1981, Clarke et al. 1984, Post and Greenlaw 1994). The ecological impacts of parallel or grid ditching include reduced flood duration, lowered water table, changes in species composition throughout the marsh, and reductions in invertebrate populations. Today, ditching to eliminate breeding sites of the salt marsh mosquito (*Aedes sollicitans*) is viewed as totally unnecessary and ineffective (Reinert et al. 1981). However, old ditches still affect salt marsh hydrology and health.

(B) Evidence
Mosquito ditching reduces the abundance of cordgrass, an essential habitat feature for breeding saltmarsh sparrows, by draining standing water on the marsh surface (Brawley et al. 1998). Therefore, ditched marshes are potentially less suitable for saltmarsh sparrows because they are drier and may not provide a sufficient food supply of invertebrates. In a study of avian use of ditched and unditched marshes in Rhode Island, the density of saltmarsh sparrow females was higher in unditched marshes (53.4 females/100 hectares) than in ditched marshes (34.5 females/100 hectares) (Reinert et al. 1981).

3.2.4 Mercury, Non-Point Source Pollution

(A) Exposure Pathway
Deposition and biomagnification of mercury in aquatic ecosystems is a major environmental issue (Shriver et al. 2002, Kamman et al. 2004). Mercury is emitted into the atmosphere from the combustion of fossil fuels, medical waste, and municipal waste and then deposited on the landscape (Kamman et al. 2004). Ultimately, mercury accumulates in watersheds and bioaccumulates to upper trophic levels in wetland and other aquatic systems (Kamman et al. 2004). Salt marshes receive pollution and stormwater runoff from lakes, rivers, storm drains, roads, and construction areas (NHCP). Saltmarsh sparrows are insectivorous during the breeding season, feeding primarily on immature and adult insects, supplemented by other arthropods and small mollusks (Greenlaw and Rising 1994). It is possible that saltmarsh sparrows are harmed by mercury deposition and could be indicators of methylmercury availability in New England salt marshes (Shriver et al. 2002).

(B) Evidence
The Biodiversity Research Institute in Maine has conducted numerous studies on methylmercury exposure in birds (BRI: www.briloon.org). Elevated methylmercury levels in birds have the potential to disrupt behavior, physiology, and reproductive success (Lane and Evers 2005). Recently, saltmarsh sparrows have become an increasing conservation concern. Researchers at the Biodiversity Research Institute are conducting studies to assess mercury exposure and risk to saltmarsh sparrows and other passerines breeding in New England salt marshes (see Shriver et al. 2002, Lane and Evers 2005). Lane and Evers (2005) found elevated levels of mercury in saltmarsh sparrow blood sampled at several sites from Maine and Massachusetts. In 1998-2000, 5 birds at Scarborough Marsh in Scarborough, Maine, had foot and/or beak deformities (Lane and Evers 2005).

3.2.5 Sources of Information

Information on threats to saltmarsh sparrows was obtained from a literature review, New Hampshire Coastal Program, NHNHB, and Biodiversity Research Institute in Gorham, Maine.

3.3 Extent and Quality of Data

Threats to saltmarsh sparrows have only recently gained significant attention from researchers and managers. It is well documented that historical marsh degradation from human activities is correlated with decreases in sparrow populations. However, researchers studying the effects of mercury and wetland restoration are attempting to evaluate the significance of these new threats to saltmarsh sparrows and other salt marsh nesting birds. Therefore, although the po-

tential for these threats to occur and affect sparrow populations is documented, continued research of these threats and their impacts on sparrow populations is warranted.

3.4 Threat Assessment Research

Threats to saltmarsh sparrow populations are currently being investigated and documented throughout the northeast in Maine, Massachusetts, Connecticut, and Rhode Island (see references for published studies). Researchers at UNH have started to examine threats to the state's sparrow populations, but more research is needed. For example, the impact of invasive plant species and the impact of increased human disturbance of habitats surrounding marshes (e.g., increased road density and noise) are two important areas for future research.

More research is needed to determine the effects of methylmercury on saltmarsh sparrow populations in New Hampshire. The effect of methylmercury has become a widespread regional ecological and human health concern. The Biodiversity Research Institute has started to investigate the effects of mercury on salt marsh birds in New England, but research is needed in New Hampshire. Salt marsh birds are species of high conservation priority regionally due to habitat loss and degradation. However, mercury may pose an increasing threat to these populations. Once mercury effects have been assessed through scientific research, conservation actions can be implemented to combat the issue.

Element 4: Conservation Actions

4.1.1 Protecting remaining salt marsh habitat and surrounding upland buffer habitat, Habitat Protection (See Saltmarsh Habitat Profile)

(A) Conservation Performance Objective
For saltmarsh sparrows, the salt marsh and upland buffer protection performance objective is to maintain a *Spartina*-dominated, tidal system with suitable nesting and foraging habitat. The objective for each individual site is to maintain salt marsh structure, function, and value for saltmarsh sparrow habitat. At sites currently occupied, or that could potentially be occupied, by saltmarsh sparrows, the objective would be to maintain the current habitat structure and function. The ultimate goal for the performance objective is to preserve salt marsh habitat with structure and function that does or potentially could maintain a breeding population of saltmarsh sparrows.

(B) Performance Monitoring:
Performance monitoring should be conducted at as many salt marshes (larger than 15 hectares for saltmarsh sparrows) as possible, or at sites of high priority or concern, on a regular basis. For saltmarsh sparrows, monitoring and research should focus on: habitat use (migration/breeding), abundance, density, breeding and nesting activity, nest success, foraging success, and site population trends.

(C) Ecological Response Objective
The desired ecological response to salt marsh protection is persistence of saltmarsh sparrow populations (current or new) with stable or increasing densities at all potential sites. This response should be immediate at natural, undisturbed sites that are protected from further human disturbance and development.

(D) Response Monitoring
The response indicator for successful marsh protection is stabilizing or increasing population trends at occupied sites. Therefore, the most essential and basic monitoring tool for this response is conducting bird surveys. Bird surveys, such as standardized point counts, conducted during the breeding season on an annual basis, can determine presence or absence at a particular site. Nest monitoring is also beneficial and more reliable than surveys at confirming a site as a breeding and nesting location. These data should initially be collected every breeding season until long-term population information for all potential sites in New Hampshire is obtained and trends are deemed stable or increasing. At this point, monitoring frequency could be reduced—for example, sampling at each site during 1 breeding season every 3 years.

4.1.2 Restoring degraded salt marshes back to Spartina-dominated systems, Restoration and Management (See Salt Marsh Habitat Profile)

(A) Conservation Performance Objective
Specifically for saltmarsh sparrows, the salt marsh restoration performance objective is to create a *Spartina*-dominated, tidally-influenced system with suit-

able nesting and foraging habitat. The objective for an individual site is to establish marsh structure and function comparable to that of natural, undisturbed marsh systems occupied by saltmarsh sparrows. With limited quantifiable data on time period for restoration success, Warren et al. (2002) suggests that full restoration of ecological functions, including sparrow breeding, can occur within 2 decades. Therefore, the ultimate goal for the performance objective is to create habitat with salt marsh structure and function that potentially could sustain a breeding population of saltmarsh sparrows, within 20 years of restoration.

(B) Performance Monitoring
Annual performance monitoring should be conducted at all restoration sites, including pre-restoration monitoring, if feasible. If pre-restoration monitoring is not possible due to time constraints or severity of marsh degradation, then reference site monitoring is acceptable. All monitoring and research activities should be conducted at reference sites and restoration sites to to allow assessment of restoration success. Monitoring should be performed until at least 15-20 years after restoration to determine long-term outcomes. For saltmarsh sparrows, monitoring and research priorities for assessing restoration success include: habitat use (migration/breeding), abundance, density, breeding and nesting activity, nest success, foraging success, and site population trends.

(C) Ecological Response Objective:
The desired ecological response to marsh restoration is colonization of restored sites by saltmarsh sparrows and stable or increasing populations over time. This response should be observed within approximately 15-20 years after restoration (Warren et al. 2002). Ultimately and ideally, saltmarsh sparrow abundance and population trends should be comparable to that of similar reference sites. Successful marsh restoration, in terms of saltmarsh sparrows, will be measured by the colonization and continued presence of successfully breeding sparrows (i.e., source population, or stable or increasing population size).

(D) Response Monitoring:
The response indicator for successful marsh restoration is the colonization and continued presence of successfully breeding saltmarsh sparrows. Therefore, like habitat protection, the most essential and basic monitoring tool for this response is bird surveys. Bird surveys such as standardized point counts conducted during the breeding season on an annual basis can determine presence or absence of the species. Nest monitoring is also beneficial in determining nest success at a restored site. These data should initially be collected every breeding season until long-term population information for restored sites in New Hampshire is obtained and trends are deemed stable or increasing. At this point, monitoring frequency could be reduced—for example, sampling during 1 breeding season every 3 years.

Element 5: References

5.1 Literature:

Benoit, L. K., and R. A. Askins. 1999. Impact of the spread of Phragmites on the distribution of birds in Connecticut tidal marshes. Wetlands 19:194-208.

Benoit, L. K., and R. A. Askins. 2002. Relationship between habitat area and the distribution of tidal marsh birds. Wilson Bulletin 114:314-323.

Brawley, A. H., R. S. Warren, and R. A. Askins. 1998. Bird use of restoration and reference marshes within the Barn Island wildlife management area, Stonington, Connecticut, USA. Environmental Management 22:625-633.

Broome, S. W., E. D. Seneca, and W. W. Woodhouse, Jr. 1988. Tidal salt marsh restoration. Aquatic Botany 32:1-22.

Burdick, D. M., M. Dionne, R. M. Boumans, and F. T. Short. 1997. Ecological responses to tidal restorations of two northern New England salt marshes. Wetlands Ecology and Management 4:129-144.

Clarke, J. A., B. A. Harrington, T. Hruby, and F. E. Wasserman. 1984. The effect of ditching for mosquito control on salt marsh use by birds in Rowley, Massachusetts. Journal of Field Ornithology 55: 160-180.

DiQuinzio, D. A., P. W. C. Paton, and W. R. Eddleman. 2001. Site fidelity, philopatry, and survival of promiscuous saltmarsh sharp-tailed sparrows in Rhode Island. Auk 118:888-899.

DiQuinzio, D. A., P. W. C. Paton, and W. R. Eddleman. 2002. Nesting ecology of saltmarsh sharp-tailed sparrows in a tidally restricted salt marsh. Wetlands 22:179-185.

Gavutis, G. W., Jr. 1994. Sharp-tailed Sparrow (*Am-*

modramus caudacutus). Pages 324-325 *in* C. Foss, editor. Atlas of breeding birds in New Hampshire. New Hampshire Audubon, Concord, New Hampshire.

Greenlaw, J. S., and J. D. Rising. 1994. Sharp-tailed Sparrow (Ammodramus caudacutus). Number 112 *in* A. Poole and F. Gill, editors. The birds of North America. The Academy of Natural Sciences, Philadelphia, Pennsylvania, USA.

Hunt, P. 2004(Draft). A regional perspective on New Hampshire's birds of conservation priority: objectives, threats, research needs, and conservation strategies. New Hampshire Audubon, Concord, New Hampshire.

Johnson, R. G., and S. A. Temple. 1990. Nest predation and brood parasitism of tallgrass prairie birds. Journal of Wildlife Management 54:106-111.

Kamman, N. C., P. M. Lorey, C. T. Driscoll, R. Estabrook, A. Major, B. Pientka, and E. Glassford. 2004. Assessment of mercury in waters, sediments, and biota of New Hampshire and Vermont lakes, USA, sampled using a geographically random design. Environmental Toxicology and Chemistry 23: 1172-1186.

Lane, O., and D. Evers. 2005. Developing a geographic exposure profile of methylmercury availability in salt marshes of New England. Report BRI 2005-04 submitted to the Maine Department of Inland Fisheries and Wildlife, Maine Department of Environmental Protection, and Rachel Carson National Wildlife Refuge. Biodiversity Research Institute, Gorham, Maine.

Mitsch, W. J., and J. G. Gosselink. 2000. Wetlands. Third edition. John Wiley & Sons, Inc., New York, New York, USA.

NHCP (New Hampshire Coastal Program). New Hampshire Department of Environmental Services, Concord, New Hampshire. NHCP home page: http://www.des.state.nh.us/Coastal/ Accessed 2004 November.

NHNHB (New Hampshire Natural Heritage Bureau). 2004. Natural communities of New Hampshire. http://www.nhdfl.org/formgt nhiweb/Documents/NaturalCommunitiesWeb.pdfAccessed 2004 November.

Niehaus, A. C., S. B. Heard, S. D. Hendrix, and S. L. Hillis. 2003. Measuring edge effects on nest predation in forest fragments: do finch and quail eggs tell different stories? American Midland Naturalist 149:335-343.

Niering, W. A., and R. S. Warren. 1980. Vegetation patterns and processes in New England salt marshes. BioScience 30:301-306.

Post, W., and J. S. Greenlaw. 1994. Seaside sparrow (Ammodramus maritimus). Number 127 *in* A. Poole and F. Gill, editors. The birds of North America. The Academy of Natural Sciences, Philadelphia, Pennsylvania, USA.

Reinert, S. E., F. C. Golet, and W. R. DeRagon. 1981. Avian use of ditched and unditched salt marshes in southeastern New England: a preliminary report. Presented at the 27th Annual Meeting, Northeastern Mosquito Control Association, Nov. 2-4, 1981, Newport, Rhode Island.

Roman, C. T., W. A. Niering, and R. S. Warren. 1984. Salt marsh vegetation change in response to tidal restriction. Environmental Management 8: 141-150.

Shriver, W. G., D. Evers, and T. Hodgman. 2002. Mercury exposure profile for sharp-tailed sparrows breeding in coastal Maine salt marshes. Report BRI 2002-11 submitted to the Maine Department of Environmental Protection. BioDiversity Research Institute, Gorham, Maine.

Shriver, W. G., T. P. Hodgman, J. P. Gibbs, and P. D. Vickery. 2004. Landscape context influences salt marsh bird diversity and area requirements in New England. Biological Conservation 119:545-553.

Sibley, D. 1996. Field identification of the sharp-tailed sparrow complex. Birding 28:197-208.

Sinicrope, T. L., P. G. Hine, R. S. Warren, and W. A. Niering. 1990. Restoration of an impounded salt marsh in New England. Estuaries 13:25-30.

Warren, R. S., P. E. Fell, R. Rozsa, A. H. Brawley, A. C. Orsted, E. T. Olson, V. Swamy, and W. A. Niering. 2002. Salt marsh restoration in Connecticut: 20 years of science and management. Restoration Ecology 10:497-513.

5.2 Data Sources:

NHBR. New Hampshire Bird Records, New Hampshire Audubon, Concord, New Hampshire.

PIF (Partners in Flight). Species assessment database. Bird conservation regions: breeding scores for BCR 30 and BCR 14. PIF homepage: http://www.rmbo.org/pif/pifdb.html

Element 6: List of Figures

Table 1. New Hampshire salt marshes with saltmarsh sharp-tailed sparrows during the 2004 breeding season (McElroy and Babbitt, unpublished data).

MARSH	TOWN	BREEDING	ERA
Bay Road	Newmarket	Confirmed	16 – 30
Pierce Point	Greenland	Confirmed	< 15
Drakeside Road	Hampton	Confirmed	31 – 50
Hampton Beach	Hampton	Confirmed	> 100
Squamscott River	Newfields	Confirmed	16 – 30
Fairhill Marsh	Rye	Confirmed	31 – 50
Rye Beach	Rye	Confirmed	16 – 30
Chapman's Landing	Stratham	Confirmed	16 – 30
Sagamore Creek	Portsmouth	Possible	< 15
Awcomin Marsh	Rye	Possible	16 – 30
Hampton River	Hampton	Potential	< 15
Little River	North Hampton	Potential	< 15

SPECIES PROFILE

Seaside Sparrow

Ammodramus maritimus

Federal Listing: Not listed
State Listing: Not listed legally, but identified as of special concern
Global Rank: G4
State Rank: S1B
Authors: Megan J. McElroy and Kimberly J. Babbitt, University of New Hampshire

Element 1: Distribution and Habitat

1.1 Habitat Description

Seaside sparrows inhabit salt marshes, or grass-dominated tidal wetlands existing in the transition zone between ocean and upland (Niering and Warren 1980) (see Salt Marshes habitat profile). In New England, seaside sparrows breed in both high and low marsh areas where smooth cordgrass, saltmeadow grass, and blackgrass dominate (Post and Greenlaw 1994). Sparrows forage mostly in open stands of smooth cordgrass, areas of wrack, and the edges of ditches, pools, and salt pannes (Post and Greenlaw 1994). Their diet consists primarily of adult and larval insects, spiders, and amphipods (Post and Greenlaw 1994).

1.2 Justification

Seaside sparrows are designated a species of high conservation priority by Partners in Flight (Breeding Tier I) (PIF) and a species of special concern in New Hampshire. Long-term studies of this species have not been conducted in New Hampshire, and few data exist on population trends, estimates, and threats in the state. Habitat loss and degradation are probably the most pressing threats to seaside sparrows in New Hampshire.

Seaside sparrows are salt marsh obligates and area-sensitive. High-quality salt marsh habitat available in large patches across a landscape is required for population persistence and growth. Tidal restrictions in salt marshes have resulted in invasive reeds and grasses, such as cattails and common reed, replacing salt marsh vegetation (Sinicrope et al. 1990, Burdick et al. 1997, Brawley et al. 1998). Areas of invasive plants in and around salt marshes decrease the suitable habitat for seaside sparrows.

The current lack of knowledge of seaside sparrow abundance and threats in New Hampshire is similar to that for closely related salt marsh birds, such as the saltmarsh sharp-tailed sparrow and Nelson's sharp-tailed sparrow. Human impacts on salt marshes are thought to affect these species in similar ways. Additional research and monitoring may allow this salt marsh guild to serve as an indicator of marsh health, the effects of marsh degradation, and the success of management practices such as restoration.

1.3 Protection and Regulatory Status

- The Migratory Bird Treaty Act of 1918 legally protects seaside sparrows from the take, transport, and use of the species, including eggs, nests, and feathers.
- NHDES regulates activities that affect salt marsh habitat. Activities that may involve filling, dredging, or destroying wetlands are subject to strict guidelines and require approved permits before work can commence (RSA 482-A).

1.4 Population and Habitat Distribution

The geographic range of the seaside sparrow includes the Atlantic and Gulf coasts of North America (Post 1974). In northern New England, seaside sparrow populations are uncommon, relatively small, and susceptible to local extinction (Marshall and Reinert 1990). New Hampshire is the historical northern edge of the breeding range for seaside sparrows along

the Atlantic coast. In New Hampshire, seaside sparrows have only been located in 1 marsh within the large Hampton salt marsh complex during the breeding season (Gavutis 1994, NHBR, McElroy and Babbitt, unpublished data). This marsh, a historical site for breeding, is located off Route 1A in Hampton between Routes 101 and 101E (Gavutis 1994, NHBR, McElroy and Babbitt, unpublished data).

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

1.7 Sources of Information

A literature review was conducted to obtain habitat, distribution, and population status information for seaside sparrows. The NHA database of Bird Records gave historical information on the distribution of seaside sparrows in New Hampshire. A population survey in 2004 by researchers at UNH provided information on current abundance and distribution.

1.8 Extent and Quality of Data

Historical bird records from NHA are sightings reported by birders. Although this information is vital to understanding historical distribution, it does not accurately describe population size or confirmed breeding locations throughout the state. The most comprehensive dataset comes from UNH researchers, and it indicates no breeding populations of seaside sparrows in New Hampshire. Although that dataset is spatially extensive, it covers only one year. Significant gaps still exist in knowledge of this species in the state, and long-term trends in population locations and sizes in New Hampshire are still unknown.

1.9 Distribution Research

Because of their habitat requirements, breeding seaside sparrows are likely to be found only in Hampton. A long-term survey (i.e., point counts during breeding season) throughout the Hampton marsh is recommended.

Element 2: Species/Habitat Condition

2.1 Scale

The New Hampshire conservation unit for seaside sparrow is the Coast (including Rye, Hampton, and Seabrook).

2.2 Relative Health of Populations

Fewer than 5 seaside sparrows are thought to live in New Hampshire during the breeding season (McElroy and Babbitt, unpublished data). Because a long-term survey of seaside sparrows has not been conducted and Breeding Bird Survey routes do not sufficiently cover salt marshes, population trends are unknown. In 2004, a complete survey of all potential breeding sites in New Hampshire's salt marshes in New Hampshire revealed no evidence of breeding activity. One individual was observed during a visit to the site of known historical occurrence for this species (see table 1) (McElroy and Babbitt, unpublished data).

In New Hampshire, the seaside sparrow is at the periphery of its geographic range. Therefore, it is scarce and not widely distributed in the state. New populations are unlikely to colonize sites in New Hampshire. The best potential for a breeding population is at the known historical breeding site: the Route 1A/101 marsh in Hampton. In 1985, a breeding population of 6-8 pairs of seaside sparrows occurred at this site (Gavutis 1994), but that level of abundance has not been recorded in subsequent years (NHBR). In the breeding seasons of 1986 through 2001, few seaside sparrows were reported, and from 2002 to 2004 only 1 individual was reported each breeding season (NHBR). All reported sightings during the breeding season occurred at the historical breeding site at the Hampton marsh.

2.3 Population Management Status

There are no ongoing population management efforts for seaside sparrows in New Hampshire. The only site where seaside sparrows currently occur in New Hampshire is the Route 1A/Route 101 marsh in Hampton. Therefore, this site would be high priority for any conservation actions.

2.4 Relative Quality of Habitat Patches

Throughout their range, seaside sparrows breed in large, unrestricted, *Spartina*-dominated marshes with pannes, pools, and creeks for foraging (Post and Greenlaw 1994). The historical site for seaside sparrows off Route 1A in Hampton is dominated by smooth cordgrass and salt hay, and it has many pannes, pools, and creeks (see Salt Marshes habitat profile).

2.5 Habitat Patch Protection Status

See Salt Marshes habitat profile (element 2.5).

2.6 Habitat Management Status

See Salt Marshes habitat profile (element 2.5).

2.7 Sources of Information

A literature review was performed to obtain information on research and habitat management. Research conducted by UNH scientists was used to determine the current status of the population and management efforts. Information on habitat protection and management came from the New Hampshire Coastal Program's Web site and published articles on restoration efforts.

2.8 Extent and Quality of Data

The most extensive dataset comes from a survey conducted by scientists at UNH. However, it covers only one field season. A long-term study is needed to assess population trends and habitat suitability. Significant gaps exist in knowledge of seaside sparrow populations in the state and the effectiveness of habitat restoration.

2.9 Condition Assessment Research

A complete survey is needed for seaside sparrows in the marshes of Hampton, New Hampshire. Long-term, standardized point counts during the breeding season could be used to identify areas of sparrow use and potential breeding sites. Maps based on long-term monitoring of sparrow presence/absence, abundance, and breeding activity could be produced to discern key spots for research, conservation, and habitat protection. This information is vital for conservation and research efforts for seaside sparrows and assessment of habitat suitability in New Hampshire. The lack of research and monitoring of salt marsh-dependent birds in New Hampshire leaves open the possibility that marshes outside of Hampton marsh provide suitable habitat for aspects of seaside sparrow life history (e.g., migratory stopover sites).

Element 3: Species and Habitat Threat Assessment

3.1.1 Development (Habitat Loss and Conversion)

(A) Exposure Pathway
See Salt Marshes habitat profile and Saltmarsh Sharp-tailed Sparrow profile

(B) Evidence
Habitat loss is a primary factor in the decline of wetland birds, especially species such as the seaside sparrow that depend on salt marshes for nesting (Post and Greenlaw 1994). Seaside sparrows tend to occur in large, contiguous marsh systems, making them vulnerable to habitat loss through land development.

3.2.2 Development (Fragmentation, Habitat Coversion Loss and Conversion)

See Salt Marshes habitat profile and Saltmarsh Sharp-tailed Sparrow profile

3.2.3 Altered Hydrology (Tidal Restriction), Transportation Infrastructure

See Saltmarsh Sharp-tailed Sparrow profile

3.2.4 Altered Hydrology (Mosquito Ditching), Altered Natural Disturbance

See Saltmarsh Sharp-tailed Sparrow profile

3.2.5 Introduced Species (Introduced Plants), Development (Habitat Loss and Conversion)

See Saltmarsh Sharp-tailed Sparrow profile

3.2.6 Mercury, Non-Point Source Pollution

See Saltmarsh Sharp-tailed Sparrow profile

3.3 Sources of Information

Information on threats to seaside sparrows was obtained from a literature review, New Hampshire Coastal Program, NHNHB, and Biodiversity Research Institute in Gorham, Maine.

3.4 Extent and Quality of Data

Threats to seaside sparrows have recently gained significant attention from scientists and managers. It is well documented that marsh degradation from human activities correlates with declines in sparrow populations. Researchers studying mercury are attempting to evaluate the significance of this new threat to seaside sparrows and other salt marsh nesting birds.

3.45Threat Assessment Research

Scientists are investigating threats to seaside sparrow populations throughout the northeast in Massachusetts, Connecticut, and Rhode Island (see references for published studies). Two important areas for future research are impacts of invasive plants and increased human disturbance near marsh habitat (e.g., road density and noise).

More research is needed to determine the effects of methylmercury on seaside sparrow populations in the region. Methylmercury has become a widespread ecological and human health concern. The Biodiversity Research Institute is investigating the effects of mercury on salt marsh birds in New England. Once mercury's impacts are determined through scientific research, conservation actions can combat the issue.

Studies of sparrow abundance are needed to provide a foundation for threat assessment. Little is known about New Hampshire's seaside sparrows, such as whether a breeding population exists.

Element 4: Conservation Actions

4.1.1 Protecting remaining salt marsh habitat and surrounding upland buffer habitat, Habitat Protection

See Salt Marshes habitat profile and Saltmarsh Sharp-tailed Sparrow profile

(C) Conservation Performance Objective

The conservation performance objective is to maintain or improve salt marsh structure and function in areas that could serve as breeding sites for seaside sparrows, such as the Hampton marsh that historically was documented as a breeding site.

(D) Performance Monitoring

Performance monitoring should be conducted regularly at large salt marshes within the conservation unit, especially the Hampton marsh along Route 1A. Monitoring and research should include habitat use (migration/breeding), abundance, density, breeding, nesting activity, and site population trends.

(E) Ecological Response Objective

The desired ecological response to salt marsh protection is stabilized or increasing populations of seaside sparrows at one or more sites. The response should begin immediately at natural, undisturbed sites protected from further human disturbance. Salt marsh protection would be deemed successful if 2 to 4 pairs breed annually in Hampton.

4.1.2 Restoring degraded salt marshes back to Spartina-dominated systems, Restoration and Management

See Salt Marshes habitat profile and Saltmarsh Sharp-tailed Sparrow profile

(D) Performance Monitoring

The Hampton marsh complex is the most likely site for any future colonization by seaside sparrows. Portions of the marsh on the Blackwater River and Hampton River were ditched extensively. Any habitat restoration initiatives to raise water level on the marsh could benefit seaside sparrows by increasing smooth cordgrass abundance. Assessment of restoration success with respect to seaside sparrows should include habitat use (migration/breeding), abundance, density, breeding and nesting activity, nest success, foraging success, and site population trends.

(F) Response Monitoring

The response indicator for successful marsh restoration is the colonization and persistence of breeding seaside sparrows. Bird surveys, such as standardized point counts, conducted during the breeding season on an annual basis can be used to determine presence or absence at a restored site. Monitoring should be

conducted every breeding season over the long term until the data indicate stable or increasing populations. Subsequently, monitoring frequency could be reduced to sampling perhaps 1 breeding season every 3 years.

Element 5: References

5.1 Literature:

Benoit, L. K., and R. A. Askins. 1999. Impact of the spread of Phragmites on the distribution of birds in Connecticut tidal marshes. Wetlands 19:194-208.

Benoit, L. K., and R. A. Askins. 2002. Relationship between habitat area and the distribution of tidal marsh birds. Wilson Bulletin 114:314-323.

Brawley, A. H., R. S. Warren, and R. A. Askins. 1998. Bird use of restoration and reference marshes within the Barn Island wildlife management area, Stonington, Connecticut, USA. Environmental Management 22:625-633.

Broome, S. W., E. D. Seneca, and W. W. Woodhouse, Jr. 1988. Tidal salt marsh restoration. Aquatic Botany 32:1-22.

Burdick, D. M., M. Dionne, R. M. Boumans, and F. T. Short. 1997. Ecological responses to tidal restorations of two northern New England salt marshes. Wetlands Ecology and Management 4:129-144.

Clarke, J. A., B. A. Harrington, T. Hruby, and F. E. Wasserman. 1984. The effect of ditching for mosquito control on salt marsh use by birds in Rowley, Massachusetts. Journal of Field Ornithology 55: 160-180.

Gavutis, G. W., Jr. 1994. Seaside Sparrow (Ammodramus maritimus). Pages 326-327 *in* C. Foss, editor. Atlas of breeding birds in New Hampshire. New Hampshire Audubon, Concord, New Hampshire, USA.

Hunt, P. 2004(Draft). A regional perspective on New Hampshire's birds of conservation priority: objectives, threats, research needs, and conservation strategies. New Hampshire Audubon, Concord, New Hampshire.

Johnson, R. G., and S. A. Temple. 1990. Nest predation and brood parasitism of tallgrass prairie birds. Journal of Wildlife Management 54:106-111.

Kamman, N. C., P. M. Lorey, C. T. Driscoll, R. Estabrook, A. Major, B. Pientka, and E. Glassford. 2004. Assessment of mercury in waters, sediments, and biota of New Hampshire and Vermont lakes, USA, sampled using a geographically random design. Environmental Toxicology and Chemistry 23: 1172-1186.

Lane, O., and D. Evers. 2005. Developing a geographic exposure profile of methylmercury availability in salt marshes of New England. Report BRI 2005-04 submitted to the Maine Department of Inland Fisheries and Wildlife, Maine Department of Environmental Protection, and Rachel Carson National Wildlife Refuge. Biodiversity Research Institute, Gorham, Maine.

Mitsch, W. J., and J. G. Gosselink. 2000. Wetlands. Third edition. John Wiley & Sons, Inc., New York, New York.

NHCP (New Hampshire Coastal Program). New Hampshire Department of Environmental Services, Concord, New Hampshire. NHCP home page: http://www.des.state.nh.us/Coastal/ Accessed 2004 November.

NHNHB (New Hampshire Natural Heritage Bureau). 2004. Natural communities of New Hampshire. http://www.nhdfl.org/formgt/nhiweb/Documents/NaturalCommunitiesWeb.pdfAccessed 2004 November.

Niehaus, A. C., S. B. Heard, S. D. Hendrix, and S. L. Hillis. 2003. Measuring edge effects on nest predation in forest fragments: do finch and quail eggs tell different stories? American Midland Naturalist 149:335-343.

Niering, W. A., and R. S. Warren. 1980. Vegetation patterns and processes in New England salt marshes. BioScience 30:301-306.

Post, W., and J. S. Greenlaw. 1994. Seaside sparrow (Ammodramus maritimus). Number 127 *in* A. Poole and F. Gill, editors. The birds of North America. The Academy of Natural Sciences, Philadelphia, Pennsylvania, USA.

Reinert, S. E., F. C. Golet, and W. R. DeRagon. 1981. Avian use of ditched and unditched salt marshes in southeastern New England: a preliminary report. Presented at the 27th Annual Meeting, Northeastern Mosquito Control Association, Nov. 2-4, 1981, Newport, Rhode Island.

Roman, C. T., W. A. Niering, and R. S. Warren. 1984. Salt marsh vegetation change in response to tidal restriction. Environmental Management 8: 141-150.

Shriver, W. G., D. Evers, and T. Hodgman. 2002.

Mercury exposure profile for sharp-tailed sparrows breeding in coastal Maine salt marshes. Report BRI 2002-11 submitted to the Maine Department of Environmental Protection. BioDiversity Research Institute, Gorham, Maine.

Sinicrope, T. L., P. G. Hine, R. S. Warren, and W. A. Niering. 1990. Restoration of an impounded salt marsh in New England. Estuaries 13:25-30.

Warren, R. S., P. E. Fell, R. Rozsa, A. H. Brawley, A. C. Orsted, E. T. Olson, V. Swamy, and W. A. Niering. 2002. Salt marsh restoration in Connecticut: 20 years of science and management. Restoration Ecology 10:497-513.

5.2 Data Sources:

NHBR. New Hampshire Bird Records, New Hampshire Audubon, Concord, New Hampshire.

PIF (Partners in Flight). Species assessment database. Bird conservation regions: breeding scores for BCR 30 and BCR 14. PIF homepage: http://www.rmbo.org/pif/pifdb.html Accessed 2005 April.

SPECIES PROFILE

Sedge Wren

Cistothorus platensis

Federal Listing: Not listed
State Listing: Endangered
Global Rank: G5
State Rank: S1
Author: Pamela D. Hunt, New Hampshire Audubon

Element 1: Distribution and Habitat

1.1 Habitat Description

In the core of its breeding range, the sedge wren uses wetlands dominated by sedges or grasses. Such areas include wet hayfields, sphagnum moss bogs, and the margins of ponds (Herkert et al. 2001), and in these habitats, they prefer shrub cover. The species does not use wetlands with sparse vegetative cover or those dominated by cattails (Typha sp.). Historically, coastal populations in the Northeast also occurred in salt marshes.

Recent verified reports from New Hampshire come from several habitat types. Three or 4 (depending on definition) are from wet shrubby areas at the margins of marshes or wet meadows, 2 are from weedy grass fields, and 1 or 2 are from tussock marshes.

Historic sites with a clear pattern of occupancy may provide clues as to the species' habitat preferences in New Hampshire. Such sites include Cherry Pond (Jefferson), Danbury Bog (Danbury), and Merrymeeting River (Alton/New Durham). Habitat at the first 2 locations is characterized by shallow, emergent, grassy wetland with high shrub density. There may also be bog-like vegetation at all 3 sites, here defined as floating or partially floating mats of sphagnum that support a mix of heaths and herbaceous species typical of bogs and fens. Similar habitat is present along Turee Brook in Concord and Bow, where the species was common in the early 1900s (White 1924, 1937).

Sedge wrens tend to breed earlier in the west than in the east (Herkert et al. 2001), and most documented breeding happens in the Northeast between July and September. This phenological difference makes many records from New Hampshire problematic, since early-season sightings may represent transients rather than potential breeders.

1.2 Justification

The sedge wren has never been common in New Hampshire, which is generally considered the edge of its range in North America. In the late 1800s and early 1900s, it was recorded in Rye (Dearborn 1903) and Bow Bog and in other areas around Concord (White 1924, 1937), where it was relatively common. Additional localities in the early 1940s included sites in Andover, Hanover, Fitzwilliam, Manchester, and Sutton (Records of New England Birds). From the late 1940s onward, sedge wren reports in New Hampshire have dwindled, with the largest decrease occurring from the late 1960s to the early 1970s (figure 1). Since 1980, there has been an average of only 1 report every 3 years.

1.3 Protection and Regulatory Status

- Migratory Bird Treaty Act (1918)
- New Hampshire Endangered Species Conservation Act (RSA 212)
- Sedge wren habitat is protected by wetland statutes administered by the New Hampshire Department of Environmental Services.

1.4 Population and Habitat Distribution

A map of sedge wren locations in the state (figure 2) shows several clusters appearing in different times. Clusters are defined as areas with at least 5 historical records in an area roughly 24 km in diameter (with

the exception of the Squam cluster). These clusters are listed in table 1. Smaller clusters include Colebrook (4 records), southern Merrimack County (Concord/Dunbarton, 4 records), Androscoggin River (Errol/Dummer, 3-4 records), Fitzwilliam (3 records), and Merrymeeting River (Alton/New Durham, 3 records, 1949-50).

Sedge wrens have historically been uncommon in the region - here including New England, New York, the Mid-Atlantic States, and eastern Canada. Within this region, populations appear to be concentrated to the south (Chesapeake and Delaware Bays) and west (Great Lakes/St. Lawrence Valley) (Gibbs and Melvin 1992). In the latter region, data from the New York State Breeding Bird Atlas do not appear to indicate any change in range from the early 1980s to the present (New York State Department of Environmental Conservation 2004), although some data indicate that the population has declined from historic levels (Andrle and Carroll 1988). Similar declines have been noted in Massachusetts (Veit and Petersen 1993).

In contrast, populations appear to be increasing at the core of the species' range, including in parts of the Midwest and eastern Great Plains (Sauer et al. 2004). Data from Christmas Bird Counts suggest that winter populations (which presumably reflect breeding populations) in the southern United States increased between 1980 and the early 1990s, at which point they leveled off or declined slightly (National Audubon Society 2002). Irrespective of local population status, it appears that the sedge wren has always been at the periphery of its range in New England.

1.5 Town Distribution Map

See figure 2.

1.6 Habitat Map

N/A

1.7 Sources of Information

Basic natural history information in this profile was largely gathered from the literature cited in element 5. Data on sedge wren distribution in New Hampshire were compiled from New Hampshire Bird Records (NHBR), a database maintained by New Hampshire Audubon.

1.8 Extent and Quality of Data

Given the species' recent scarcity in the state, the available data are probably insufficient to fully warrant conservation should action be desired. In addition, the potential for confusion with the similar marsh wren (Cistothorus palustris) makes even evaluation of historic records problematic.

1.9 Distribution Research

Although sedge wrens are too scarce in New Hampshire to warrant any species-specific inventory or monitoring projects, there may be value in searches of recently active sites to determine if the species is still present. Any broad wetland bird monitoring project should include this species, and should ensure that observers can identify it.

Element 2: Species/Habitat Condition

2.1 Scale

Given the inconsistent temporal and spatial nature of sedge wren records in New Hampshire, it is probably inappropriate to address the species' conservation at any scale smaller than the entire state. Even locations with a history of records (table 1) have rarely hosted the species for more that 2 years in a row, so it is essentially impossible to determine which factors – if any – were responsible for the species' disappearance. The species is somewhat nomadic, so its absence should not be construed as evidence for poor habitat quality.

2.2 Relative Health of Populations

Data provide no clear evidence for the presence of a persistent sedge wren population in New Hampshire. The species has not been present for more than 1 year at any location for the last 30 years, and although populations are known to shift locations, this paucity of records suggests that most, if not all, sedge wrens in the state originate beyond our borders. There are 9 sites known to support the species in the state. One of the once more reliable locations in the state is Danbury Bog (6 records 1950-1964 and one in 1990). One other site of interest is the Pondicherry Refuge in Jefferson and Whitefield, which hosted wrens be-

tween 1958 and 1964.

2.3 Population Management Status

Sedge wren populations are not currently managed in New Hampshire.

2.4 Relative Quality of Habitat Patches

The ephemeral nature of site occupancy for this species makes evaluation of habitat quality difficult, if not impossible. Since large areas of potential habitat are unoccupied, even the presence of sedge wrens may not be a good indicator of suitable habitat. More data are needed on actual breeding status at occupied sites.

2.5 Habitat Patch Protection Status

Many older records of this species lack information on specific locality, so the analysis that follows is based primarily on sites known to support the species since 1979. Of 9 such locations for the species, 6 (67%) are protected in whole or in part by easement or fee-simple (e.g. Danbury bog and Pondicherry Refuge).

2.6 Habitat Management Status

No habitat management has occurred for sedge wrens in New Hampshire.

2.7 Sources of Information

Data on site occupancy were compiled from NHBR. Limited data on habitat quality and management were obtained from the literature.

2.8 Extent and Quality of Data

Data on sedge wrens and their habitat in New Hampshire is spatially and temporally inconsistent.

2.9 Condition Assessment Research

Data on sedge wren distribution are not sufficient to determine potential habitat or the condition of habitat at historic locations.

Element 5: References

5.1 Literature

Andrle, R.F., and J.R. Carroll. 1988. The atlas of breeding birds in New York state. Cornell University Press, Ithaca, New York, USA.

Dearborn, N. 1903. The birds of Durham and Vicinity. Contrib. Zool. Lab. 6. New Hampshire College of Agriculture and Mechanical Arts, Durham, New Hampshire, USA.

Gibbs, J.P., and S.M. Melvin. 1992. Sedge wren, Cistothorus platensis. Pages 191-209 in Migratory nongame birds of management concern in the Northeast, K.J. Schnieder and D.M. Pence, editors. U.S. Department of the Interior, Fish and Wildlife Service, Newton Corner, Massachusetts, USA.

Herkert, J.R., D.E. Kroodsma, and J.P. Gibbs. 2001. Sedge wren (Cistothorus platensis). In The Birds of North America, No. 582, A. Poole and F. Gill, editors. The Birds of North America, Inc., Philadelphia, Pennsylvania, USA.

Records of New England Birds. Refers to data from a succession of publications: Bulletin of New England Bird Life (published bimonthly 1936-1944 by the New England Museum of Natural History, Boston), Records of New England Birds (published monthly from 1945 to 1955 by the Massachusetts Audubon Society in their "Bulletin of the Massachusetts Audubon society"), and Records of New England Birds (published monthly as a separate publication from 1956 to 1960 and from 1964 to 1968).

Sauer, J.R., J.E. Hines, and J. Fallon. 2004. The North American breeding bird survey, results and analysis 1966-2003. Version 2004.1, U.S. Geological Survey Patuxent Wildlife Research Center, Laurel, Maryland, USA.

Veit, R.R., and W.R. Petersen. 1993. Birds of Massachusetts. Massachusetts Audubon Society, Lincoln, Massachusetts, USA.

White, F.B. 1924. A preliminary list of the birds of Concord, New Hampshire. Rumford Press, Concord, New Hampshire, USA.

White, F.B. 1937. Local notes on the birds at Concord and vicinity. Rumford Press, Concord, New Hampshire, USA.

5.2 Data Sources

National Audubon Society 2002. The Christmas Bird Count Historical Results [Online]. http://www.audubon.org/bird/cbc. Accessed 18 January 2005

New Hampshire Bird Records. New Hampshire Audubon, Concord, New Hampshire, USA.

New York State Department of Environmental Conservation. 2004. New York State breeding bird atlas website. www.dec.state.ny.us/apps/bba/results. Accessed 18 January 2005.

Element 6: List of Figures

Figure 1. Relative abundance of sedge wrens in New Hampshire, 1946-2003. Numbers represent the total numbers of reports in a given five year period, without correction for multiple records from the same location within the time period.

Table 1. Distribution of historical records of sedge wren in New Hampshire, 1937 to 2003. Only clusters (see text) with at least 5 records are included.

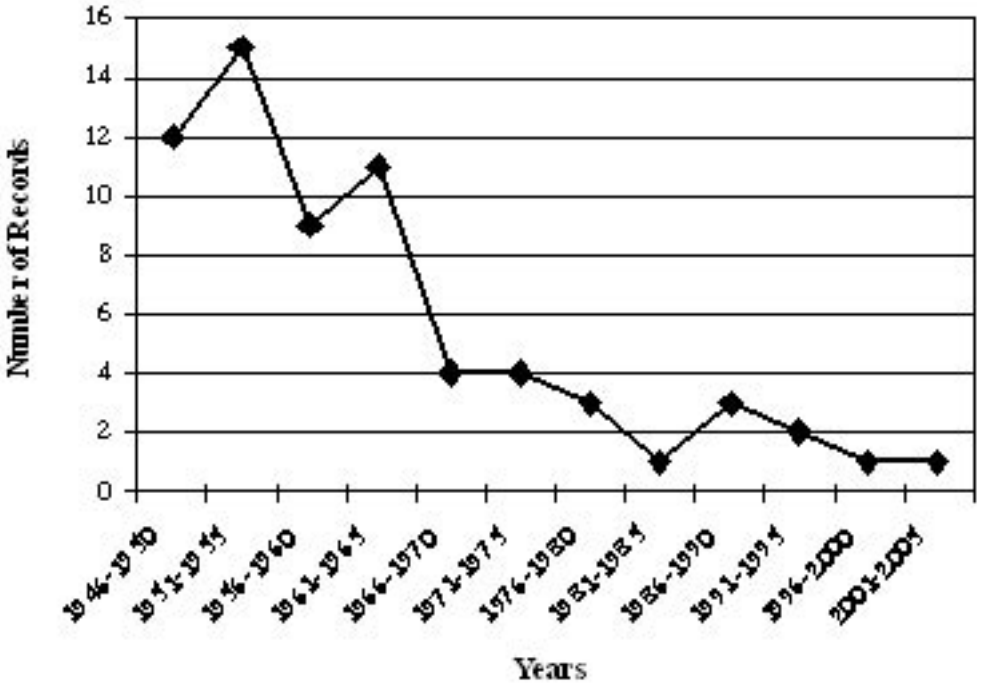


Figure 1. Relative abundance of sedge wrens in New Hampshire, 1946-2003. Numbers represent the total numbers of reports in a given five year period, without correction for multiple records from the same location within the time period.

Cluster	Towns included	# of records	Dates of sedge wren records	Records with breeding evidence*
nw Merrimack County	Danbury, Andover, Wilmot, Sutton	13	1938, 1949-52, 1954, 1960, 1964, 1989, 1990?	Andover: June 1938
				Danbury: Jul 1954
Squam Lake area	Sandwich, Meredith, New Hampton	10	1947-49, 1952, 1957, 1959, 1973, 1979, Atlas (early 1980s)	
Cherry Pond	Jefferson, Whitefield	7	1958, 1960-1964	Summer 1958
Southwest	Walpole, Marlow, Westmoreland, Keene	7	1949, 1955, 1958, 1960, 1963, 1968	Roxbury: Sept 1968
Seacoast	Durham, Newmarket Kensington, E Kingston	7	1954, 1963, 1967, 1969, 1985, 1994, 2001	Newmarket: Jun 1985
				Kensington: May-Jun 1994
				Durham: Jul-Aug 2001

Table 1. Distribution of historical records of sedge wren in New Hampshire, 1937 to 2003. Only clusters (see text) with at least 5 records are included.

* "breeding evidence" is defined as one of the following: 1) present on territory for at least 2 weeks, 2) multiple singing males, 3) evidence of a mated pair, 4) nest building, or 5) young.

SPECIES PROFILE

Semipalmated Sandpiper
Calidris pusilla

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: SNA , New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

Semipalmated sandpipers use beaches, mudflats, tundra, sandy areas along rivers and ponds, and dotted sand dunes during the summer for feeding and nesting (Godfrey 1986, Peterson 1980). Coastal mudflats and intertidal zones are used for feeding and staging areas in preparation for migration (DeGraaf and Yamasaki 2001, Boates and Smith 1989). Evidence shows high fidelity to migratory staging areas, and females tend to return to the same breeding areas, especially if they were successful in raising young the previous year (Gratto 1992). Sandpipers are territorial and monogamous during the breeding season.

1.2 Justification

Approximately 71% of the regional population migrates through New Hampshire, with 200 to 600 birds occurring along the coast during migration (Hunt 2005). The primary threat to these populations is degradation of coastal and inland wetlands, where the birds make crucial stopovers on their long migratory route between northeast North America and wintering areas in South America (Senner and Howe 1984; Lank 1989; Gratto et al. 1981, 1987, 1988, 1992). Development along the Atlantic coast has resulted in significant habitat loss and degradation and has exposed semipalmated sandpiper habitat to increased pressure from human recreation (United States Fish and Wildlife Survey 1985, National Survey on Recreation and the Environment 1994).

1.3 Protection and Regulatory Status

- Migratory Birds Convention (1916)
- Migratory Bird Treaty Act (1918)
- BCR 14 moderate concern
- BCR 30 moderate concern

1.4 Population and Habitat Distribution

Semipalmated sandpipers are possibly the most abundant shorebird (NatureServe 2005), with flocks of up to 300,000 birds observed in key wintering and migratory staging areas (Gratto 1992). International Shorebird Survey data taken during migration did not show significant declines in semipalmated sandpipers in the past 12 years (Howe et al. 1989). The total population is estimated to be 3.5 million (Morrison et al. 2001).

1.5 Town Distribution Map
Not completed for this species.

1.6 Habitat Map
See coastal sand dune systems.

1.7 Sources of Information

Information on semipalmated sandpiper habitat, population distribution and status was collected from literature, NatureServe data, and the internet.

1.8 Extent and Quality of Data

Semipalmated sandpipers have been well studied during migration, but little is known about their wintering biology, and breeding biology has only been studied in Alaska and northern Manitoba (Gratto 1992).

Data on the local distribution of the species are limited. Increased and consistent monitoring efforts, combined with intensive management of human recreation in feeding and migration areas, are needed.

1.9 Distribution Research

Conservation and preservation of migratory areas are vital to the population's survival. Although protecting key staging areas is crucial, much of the population depends on the many smaller staging areas distributed throughout the migration route, such as the New Hampshire coast. Management along the New Hampshire coast should include managing human recreational uses in coastal sand dunes and along mudflats as well as increasing public education and outreach. The possibility of restoring salt marshes to create feeding areas should also be investigated.

Element 5: References

5.1 Literature

Boates, J.S., and P.C. Smith. 1989. Crawling behavior of the amphipod *Corophium volutator* and foraging by Semipalmated Sandpipers *Calidris pusilla*. Canadian Journal of Zoology 67: 457–462.

DeGraaf R.M., and M. Yamasaki. 2001. New England Wildlife Habitats, Natural History, and Distribution. University Press of New England, Hanover, New Hampshire, USA.

Godfrey, W.E. 1986. The Birds of Canada. National Museum of Natural Science, Ottawa, Ontario, Canada.

Gratto, C.L. 1988. Natal philopatry and age of first breeding of the Semipalmated Sandpiper. Wilson Bulletin 100: 660–663.

Gratto, C.L., and F. Cooke. 1987. Geographic variation in the breeding biology of the Semipalmated Sandpiper. Ornis Scand. 18: 233–235.

Gratto, C.L., and R.I.G. Morrison. 1981. Partial postjuvenal moult of the Semipalmated Sandpiper (*Calidris pusilla*). Wader Study Group Bulletin 33:33–37.

Gratto-Trevor, C.L. 1992. Semipalmated Sandpiper. *In* The Birds of North America, No. 6, A. Poole, P. Stettenheim, and F. Gill, editors. Philadelphia: The Academy of Natural Sciences; Washington, DC: The American Ornithologists' Union.

Howe, M.A., P.A. Geissler, and B.A. Harrington. 1989. Population trends of North American Shorebirds based on the International Shorebird Survey. Biological Conservation 49:185.

Hunt, P. 2005. A Regional Perspective on New Hampshire's Birds of Conservation Priority: Objectives, Threats, Research Needs, and Conservation Strategies. Audubon Society of New Hampshire, Concord, New Hampshire, USA.

Lank, D.B. 1989. Why fly by night? Inferences from tidally-induced migratory departures of sandpipers. Journal of Field Ornithology 60: 154–161.

Morrison, R.I.G., R.E. Gill, Jr., B.A. Harrington, S. Skagen, G.W. Page, C.L. Gratto-Trevor, and S.M. Haig. 2001. Estimates of shorebird populations in North America. Occasional Paper Number 104, Canadian Wildlife Service, Environment Canada, Ottawa, Ontario, Canada.

National Survey on Recreation and the Environment (NSRE). 1994. The Interagency National Survey Consortium, Coordinated by the USDA Forest Service, Recreation, Wilderness, and Demographics Trends Research Group, Athens, GA and the Human Dimensions Research Laboratory, University of Tennessee, Knoxville, TN.

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life (web application). Version 4.2 NatureServe, Arlington, Virginia. Available at http://www.natureserve.org/explorer.

Peterson, R.T. 1980. Peterson Field Guides Eastern Birds. Houghton- Mifflin Company. New York, NY.

Senner, S.E., and M.A. Howe. 1984. Conservation of Nearctic shorebirds, Pages 379–421 *in* Behavior of marine animals, Vol. 5., J. Burger and B.L. Olla, editors. Plenum Press, New York.

Spaans, A.L. 1984. Waterbird studies in coastal

Surinam: a contribution to wetland conservation in northeastern South America. Ann. Rept. 1983, Res. Inst. Nature Manage. Netherlands.

U.S. Fish and Wildlife Service (USFWS). 1985. Endangered and Threatened Wildlife and Plants: Determination of endangered and threatened status for the piping plover: Final rule. Federal Register 50 (238): 50726-50734.

SPECIES PROFILE

Spruce Grouse

Falcipennis canadensis

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S3
Author: Jillian R. Kelly, New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

Spruce grouse prefer dense conifer forests and low-elevation bogs (Boag and Schroeder 1992, Smith 1994). Forest structure, rather than specific tree species, greatly influences spruce grouse (Greenwald 1984); tree species commonly associated with spruce grouse habitat in New England include black spruce, tamarack, and balsam fir (Bryant and Kuropat 1980, Allen 1985). Structural components important to spruce grouse include forest openings, bog edges, trees with live branches extending to the ground, and sparse ground cover with optimum forage such as *Vaccinium* (Robinson 1980). In the winter, spruce grouse feed entirely on short conifer needles (NatureServe 2005). New Hampshire natural communities associated with spruce grouse habitat include high-elevation spruce-fir, high elevation balsam fir, black spruce-red spruce, lowland spruce-fir, and peatlands.

1.2 Justification

Although spruce grouse habitat in the East is naturally patchy, anthropogenic destruction of spruce-fir habitat has further contributed to extreme isolation of spruce grouse populations (Keppie 1997). Anecdotal evidence (limited chick and female sightings) suggests that spruce grouse are declining in New Hampshire. High market demands for spruce and fir has led to extensive cutting of mature softwood habitat at lower elevations.

In New Hampshire, Weeks (quoted in Silver 1957) stated that spruce grouse were common in Coos County at the time of settlement, but by 1880, they were seldom seen. Habitat loss, market hunting, and susceptibility of populations to harvest were thought to be the primary causes (Silver 1957).

1.3 Protection and Regulatory Status

Spruce grouse are a species of conservation concern but are not listed in New Hampshire. Spruce grouse cannot be hunted in New Hampshire (RSA 209:4). Spruce grouse are listed in other states/provinces, including Vermont (endangered), New York (endangered), Nova Scotia (Uncommon), Minnesota (Uncommon), Wisconsin (Threatened), and Michigan (Uncommon) (Lumsden and Weeden 1963).

1.4 Population and Habitat Distribution

Spruce grouse are distributed throughout the northern United States and Canada. In the East, the southern range limit includes northern Minnesota, Wisconsin, Michigan's Lower Peninsula, New York, Vermont, northern New Hampshire, and eastern Maine (AOU 1983).

According to Silver (1957), spruce grouse were historically common as far south as the Berkshire Hills and Worcester County, Massachusetts. Today, spruce grouse in New Hampshire can be found in and north of the White Mountains. In most cases, there is very little overlap between spruce grouse and ruffed grouse habitat. Common densities of spruce grouse in suitable habitat are around 12-24 grouse/mi^2, as opposed to 80 or more ruffed grouse/mi^2 in suitable habitat (Johnsgard 1983, Greenwald 1984, Robinson 1980).

1.5 Town Distribution Map

Figure 1.

1.6 Habitat Map

See the high elevation spruce-fir map.

1.7 Sources of Information

Information on spruce grouse habitat was derived from the high elevation spruce-fir map. Information on population distribution and status was collected from recent research (Todd 2003), New Hampshire Fish and Game data, public observation records, Audubon bird records, Breeding Bird Survey (BBS) data (Hunt 2005), and Breeding Bird Atlas (BBA) locations (Smith 1994).

1.8 Extent and Quality of Data

Data on New Hampshire's spruce grouse populations are limited. There are few historic or recent data on distribution and abundance, particularly data collected in a systematic manner. Current information is based largely on general observations, Audubon bird records, observation records collected from the public, and surveys conducted for the Breeding Bird Atlas for New Hampshire (Smith 1994). BBS survey methods are poor for detecting spruce grouse.

1.9 Distribution Research

New Hampshire needs a systematic assessment of spruce grouse populations and habitat.

Element 2: Species Condition

2.1 Scale

Spruce grouse primarily occur in three areas: Connecticut Lakes, Mahoosuc-Rangeley region, and the White Mountains (Figure 1). Habitat polygons within subsections will be aggregated to form planning units.

2.2 Relative Health of Populations

Connecticut Lakes region: Historically, spruce grouse were likely abundant in the Connecticut Lakes region due to the extensive spruce-fir habitat. Overall, spruce-fir habitat has declined due to current and historic land use. Spruce grouse may persist sporadically throughout low-elevation spruce forests, but populations may be isolated and unstable (Keppie 1997). High elevation spruce-fir habitat is more common and likely maintains spruce grouse populations in the region.

Mahoosuc-Rangeley region: Historically, spruce grouse were likely abundant within the Mahoosuc-Rangeley region, especially along the Androscoggin River Valley in lowland spruce-fir forests and bogs. Spruce grouse persist in low elevation habitats, but populations may be isolated and unstable (Keppie 1997). They may be more abundant at higher elevations where forest cutting has not been as intense.

White Mountains region: Historically, spruce grouse were abundant in the White Mountains wherever spruce-fir habitat occurred (low and high elevations). Spruce grouse persist in isolated high elevation habitats, but preliminary data suggest that productivity may be low and populations may be unstable (Keppie 1997, Todd 2003). Furthermore, spruce grouse in high elevation habitat may be subjected to longer and colder temperatures, resulting in late breeding and decreased annual production (Todd 2003).

2.3 Population Management Status

In the Connecticut Lakes and Mahoosuc-Rangeley regions, NHFG has placed signs showing the difference between spruce grouse and ruffed grouse at locations where hunters/hikers may encounter both species. Observation data come from interviews with NHFG personnel. High elevation bird surveys are periodically conducted in the White Mountain National Forest (last survey 1993-1997). Past research projects on spruce grouse have also concentrated on habitat found in the White Mountain subsection (Todd 2003).

2.4 Relative Quality of Habitat Patches

Connecticut Lakes region: Conserved land within the Connecticut Lakes region has excellent potential to support spruce grouse. Increasing and improving the amount of spruce-fir within this subsection will improve foraging opportunities for spruce grouse.

Active habitat management will also allow for pre-commercial thinning and release of softwood regeneration to promote the growth of branches extending out near ground level for displaying males. Cover for spruce grouse will be improved by providing closed canopy spruce-fir to provide overhead cover as protection from predators. Small openings, interspersed (patch cuts) will also promote productivity by providing dense cover and feeding opportunities for young.

Mahoosuc-Rangeley region: Conserved land within the Mahoosuc-Rangeley subsection may also support spruce grouse, but unlike the Connecticut Lakes subsection, most of the conserved habitat is at higher elevations. This may require different research and management objectives. Unconserved land has the highest potential for providing spruce grouse habitat within this subsection. Under timber investment and industrial ownership, historical habitat has drastically declined and continues to be harvested at an accelerated pace.

White Mountain region: Populations currently persist in the White Mountain subsection, but are likely isolated due to fragmentation of habitat patches (Todd 2003).

2.5 Habitat Patch Protection Status

Connecticut Lakes region: Within the Connecticut Lakes subsection, the majority of both high elevation spruce-fir and low elevation spruce-fir habitat is protected under conservation easement or fee ownership. The Connecticut Lakes Timber Company currently owns 146,400 acres of working forest that is under easement. NHFG owns in fee 25,000 acres within the subsection. High elevation habitat that remains unprotected includes most of Crystal Mountain and Blue Ridge, as well as Sanguinary and Rice Mountain Ridges. Low elevation habitat that remains unprotected can be primarily found in the Clarksville and Colebrook vicinity. Unincorporated towns have some level of protection through zoned districts.

Mahoosuc-Rangeley region: The majority of the high elevation spruce-fir habitat in the Mahoosuc-Rangeley subsection is currently protected through easement or title fee. Unprotected high elevation habitat includes Dixville/Mt. Kelsey mountain ridge. Low elevation spruce-fir habitat in the Mahoosuc-Rangeley subsection remains virtually unprotected. Unincorporated towns have some level of protection through zoned districts.

White Mountain region: High elevation spruce-fir habitat in the White Mountains subsection is entirely protected by the White Mountain National Forest (WMNF). Under the Proposed Land and Resource Plan for the WMNF, wind towers can be considered as well as ski area expansions in designated areas. Virtually all of the low elevation spruce-fir is under federal ownership as part of the WMNF. Unincorporated towns located within the subsection also have some level of protection through zoned districts.

2.6 Habitat Management Status

Connecticut Lakes region: Under the Connecticut Lakes Headwaters DRAFT stewardship plan, a primary goal is to increase the overall occurrence of spruce-fir in all size classes. Under the stewardship plan for the Connecticut Lakes Natural Area (CLNA, NHFG ownership), a primary goal for the property is to establish and maintain wildlife habitats that provide for game and non-game wildlife species native to the Connecticut Lakes Ecoregion. Specific consideration will be given to the landscape context and habitat availability existing outside the boundaries of the CLNA, with emphasis on those species considered rare or of conservation concern. Boreal forest species are a specific target for this goal. Unincorporated towns located within the subsection have specific zoning for critical wildlife habitat (PD3 zones), high elevation habitat above 2700 feet in elevation (PD6 zones), wetlands (PD7 zones), and unusual areas (PD8 zones).

Mahoosuc-Rangeley region: Conserved land within the Mahoosuc-Rangeley subsection includes the Vicki Bunnell preserve, Nash Stream State Forest, Kilkenny section of the WMNF, and the Randolph Town Forest, all of which have specific goals for promoting boreal forest and wildlife species within their boundaries. Unincorporated towns located within the subsection have specific zoning for critical wildlife habitat (PD3 zones), high elevation habitat above 2,700 ft in elevation (PD6 zones), wetlands (PD7 zones), and unusual areas (PD8 zones). The major-

ity of low-lying spruce-fir habitat found within this subsection remains in large landownership and therefore has extreme pressure placed on it for producing softwood timber.

White Mountain region: Virtually all of the White Mountains subsection is made up of the WMNF. Under the Proposed Land and Resource Plan for the WMNF (2004), there is an overall objective of increasing softwood (from 12 to 24%) throughout the forest. Furthermore, the age class objectives for softwood is to have 59-63 % of all softwood as mature habitat, and 30% as old habitat. Mature forest structure can be a problem in regions where spruce grouse have declined. Spruce grouse directly benefit from forest management designed to keep pockets of habitat in earlier successional stages (NatureServe 2005). Unincorporated towns located within the subsection have specific zoning for critical wildlife habitat (PD3 zones), high elevation habitat above 2700 feet in elevation (PD6 zones), wetlands (PD7 zones), and unusual areas (PD8 zones).

2.7 Sources of Information

Information on habitat protection and management was obtained from literature review, expert review, consultation (W. Staats, and J. Kanter, NHFG, personal communication), the Draft of the Connecticut Lakes Headwaters Forest Stewardship Plan, the Draft Plan for Connecticut Lakes Natural Area, Zoning Ordinances for Coos County Unincorporated Places and the WMNF Proposed Land and Resource Management Plan.

2.8 Extent and Quality of Data

Systematic assessments include New Hampshire BBA and BBS. Overall, there is little to no information on the distribution, size, and connectivity of local spruce grouse populations in New Hampshire.

2.9 Condition Assessment Research

Research could include a systematic assessment of distribution, habitat assessment, survivorship of chicks and juveniles, juvenile dispersal, and population connectivity.

Element 3: Species Threat Assessment

3.1.1 Unsustainable Harvest (Forestry Operations and Management)

(A) Exposure Pathway
The exposure pathway is the method and timing of timber harvesting that converts spruce-fir stands to different forest types (specifically deciduous), thus resulting in a direct loss of spruce grouse habitat. Consequently, individual spruce grouse populations become isolated or locally extinct.

(B) Evidence
Spruce grouse population isolation is well documented in the WMNF (Todd 2003). Population isolation outside the forest, although not documented, is suspected to be more extensive and severe at some locations (W. Staats, NHFG, personal communication). Preliminary habitat mapping shows a high rate of spruce-fir conversion as well.

3.1.2 Unregulated Take (Incidental Take)

(A) Exposure Pathway
Upland bird hunters mistaking spruce grouse for ruffed grouse

(B) Evidence
Incidental takes that are collected and reported to conservation officers. Currently <1 incidentally shot spruce grouse are reported each year (J. Kelly, NHFG, personal communication).

3.2. Sources of Information

Information on threats was taken from Silver (1957), Todd (2003), Keppie (1997), and expert review and consultation (W. Staats, NHFG, personal communication).

3.3. Extent and Quality of Data

Scant data exist on the threats to isolated populations, especially outside the WMNF. The current extent of incidental take is localized to the Connecticut Lakes subsection, with suspected occurrence within the Mahoosuc-Rangeley subsection (J. Kelly, NHFG,

personal communication).

3.4. Threat Assessment Research

Potential threat assessment research would include collecting information methods for retaining/creating spruce grouse habitat, methods for maintaining large landownership, and studies on juvenile dispersal, population expansion, and habitat recolonization rates. Better data collection and reporting methods are also needed to document incidental takes of spruce grouse.

Element 4: Conservation Actions

4.1.1 Increase the amount of suitable spruce-fir habitat for spruce grouse through habitat management and protection, Restoration and Management

(A) Direct Threat: Unsustainable Harvest (Forestry Operations and Management)

(B) Justification
Increasing the effective population size of spruce grouse in Acadian spruce-fir habitat is directly linked to managing for and promoting spruce-fir at lower elevations. The spatial scale of the action meets the spatial scale of the threat because it is a distribution wide approach to spruce grouse habitat loss.

(C) Conservation Performance Objective
The desired outcome is to increase the amount of Acadian spruce-fir habitat to provide connectivity between spruce grouse populations throughout historic Acadian spruce-fir distribution. This long-term objective will likely take 30 years or more.

(D) Performance Monitoring
Restoration of suitable spruce-fir habitat can be monitored by documenting the amount of spruce-fir statewide and by monitoring spruce grouse populations within these habitats.

(E) Ecological Response Objective
Spruce grouse populations can be monitored to assess the extent and quality of spruce-fir habitat. As effective population size is reached and maintained, the conservation action can be reassessed. Where appropriate, emphasis can be shifted away from habitat protection and toward management for structure beneficial to spruce grouse (e.g., small forest openings interspersed within spruce-fir cover). Successful population restoration will be indicated by greater than 50% of identified potential habitat being occupied by spruce grouse. Most beneficial to spruce grouse would be a large area with a mosaic of even-aged stand of spruce-fir, including an array of different ages classes (Boag and Schroeder 1992).

(F) Response Monitoring
Areas for potential high elevation habitat monitoring would include the WMNF, Vicki Bunnell Preserve (The Nature Conservancy), Kilkenny section of the WMNF, Nash Stream State Forest (Long Mountain), and a variety of privately owned high mountain ridges. Low elevation locations would include East Inlet (CLNA and TNC), and Bog Branch of Cedar Stream (CLNA, South Bay Bog), Perry Ponds (Pittsburg), CLHW property, Molligewock (Cambridge), Second College Grant (Bennett Brook), Lake Umbagog NWR, Success, and Pondicherry NWR. Baseline data should be developed for each location and monitored on a 2-5 year interval.

(G) Implementation
Increasing effective population size is a long-term process that should be monitored based on the amount and location of spruce-fir restored across the landscape. NHFG, WMNF, the New Hampshire Department of Resources and Economic Development, and the U.S. Fish and Wildlife Service can perform the identified actions at the appropriate and identified locations. Technical assistance can be provided to private landowners to maximize Acadian spruce-fir.

(H) Feasibility: 1.72

4.1.2 Promote education and knowledge of spruce grouse distribution and habitat, especially in popular ruffed grouse hunting locations, Education and Outreach and Regulation and Policy

(A) Direct Threat
Human recreation- incidental take
(B) Justification
Increasing awareness will benefit spruce grouse by in-

fluencing the way that people perceive spruce grouse and their habitat. As a result, people may be more likely to report sightings and pay more attention to the habitat they are in while hunting, and be less apt to incidentally take a spruce grouse. The spatial scale of the action is appropriate for the scale of the threat because the effort will be implemented throughout historic spruce grouse distribution.

(C) Conservation Performance Objective:
Conservation performance objectives will include identifying and placing signs at more locations, encouraging conservation officers to become more interactive with hunters to explain the differences between spruce grouse and ruffed grouse.

(D) Performance Monitoring
The method for monitoring the performance of the education and outreach effort would be a decrease in the number of incidentally taken spruce grouse. Yearly interviews with District 1 Conservation Officers are currently being used to collect this information. If it is deemed that incidental takes are having impacts on local populations, more intensive area posting/signage can be used.

(E) Ecological Response Objective
The desired ecological response of the conservation action is to decrease or eliminate incidental shootings of spruce grouse. A measurable indicator of the desired ecological response is a decrease in the number of birds taken, and a better understanding from the hunting public regarding spruce grouse and their habitat.

(F) Response Monitoring
Response monitoring can be done through field interviews with hunters and interviews with local conservation officers.

(G) Implementation
Signs have already been designed and used at some locations. Prior to 1 October 2005 the signs should be reviewed, finalized, and printed on a durable surface that can withstand outdoor conditions. Interviews with the Conservation Officers are currently done on an informal basis. Providing a summary of some of the information that would be beneficial to the objective may be presented in an interoffice memo prior to the hunting season. Field interviews at locations where signs are posted may be warranted on a specific location basis depending on the amount of activity or potential for incidental shooting of spruce grouse.

(H) Feasibility: 3.06
This task would be highly feasible. NHFG is currently responsible for most of the tasks, which are ongoing and could be slightly expanded to provide more of an impact. Funding requirements would only be for the cost of sign printing and staff time to place them at specified locations. Local chapters of the Audubon and conservation groups could be used to maintain signage and perform informal interviews.

Element 5: References

5.1 Literature Cited

Allen, T.A. 1985. Seasonal changes in habitat use by Maine spruce grouse. Canadian Journal of Zoology 63: 2738-2742.

American Ornithologists' Union (AOU), Committee on Classification and Nomenclature. 1983. Check-list of North American Birds. Sixth Edition. American Ornithologists' Union, Allen Press, Inc., Lawrence, Kansas.

Boag , D.A., and M.A. Schroeder. 1992. Spruce Grouse. Pages 4-27 *in* The birds of North America, No 5. A. Poole, P. Stettenheim, and F. Gill, editors. The American Ornithologists Union, Washington D.C., USA.

Bryant, J., and P. Kuropat. 1980. Selection of winter forage by sub arctic browsing vertebrates. Annual Review of Ecology and Systematics 11: 261-285.

Greenwald, M. 1984. Some notes on spruce grouse (*Dendragapus cannadensis*). Bird observer of Eastern Massachusetts 12:249-266.

Johnsgard, P.A. 1983. The grouse of the world. University of Nebraska, Lincoln, Nebraska, USA.

Kanter, J. New Hampshire Fish and Game. Nongame and Endangered Species Coordinator. 2004.

Kelly, J. New Hampshire Fish and Game. Region 1 Wildlife Biological Technician. 2004.

Keppie, D.M. 1997. Fragmentation of spruce grouse habitat: a synthesis of the present and direction for the future. Wildlife Biology 3:284.

Lumsden, H.G., and R.B. Weeden. 1963. Notes on the harvest of spruce grouse. Journal of Wildlife

Management 27: 587-591.

Robinson, W.L. 1980. Fool Hen The Spruce Grouse on the Yellow Dog Plains. The University of Wisconsin Press. Madison, Wisconsin, USA.

Silver, H. 1957. A History of New Hampshire Game and Furbearers. Evans Printing Company, Concord, New Hampshire, USA.

Smith, S. 1994. Spruce grouse *Dendragapus canadensis*. Pp. 64 In: Atlas of Breeding Birds in New Hampshire, C.R. Foss, editor. Arcadia. Dover, New Hampshire, USA.

Staats, W. New Hampshire Fish and Game. Region 1 Wildlife Biologist. 2004.

Todd, A.E. 2003. Population Distribution and Vegetative Structure of Brood Rearing Habitat of Spruce Grouse (*Falcipennis canadensis*) in the White Mountain National Forest of New Hampshire. M.S. Thesis, University of New Hampshire, Durham.

5.2 Data Sources

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life (web application). Version 4.2 NatureSErsve, Arlington, Virginia. Available http://www.natureserve.org/explorer.

SPECIES PROFILE

Three-Toed Woodpecker

Picoides dorsalis

Federal Listing: Not listed
State Listing: Threatened
Global Rank: G5
State Rank: S1
Author: Laura S. Deming, New Hampshire Audubon

Element 1: Distribution and Habitat

1.1 Habitat Description

The three-toed woodpecker inhabits boreal and montane coniferous forests of Canada and the northern United States, from Alaska to California in the west, and northern Wisconsin east to northern New York and northern New England. This species is a year round resident throughout its range, where it occurs in sites with abundant dead and dying trees caused by disease, fire, flooding, insects, wind, and pollution. In the east, they occur at elevations from 360 to 1,250 m (1,180 to 4,100 ft) (Winkler et al. 1995).

Although three-toed woodpeckers are closely associated with spruce forests, the composition of occupied habitats varies across its range. In eastern North America, this species has been found in moist coniferous habitats, such as bogs and spruce-fir swamps. Three-toed woodpeckers in Michigan and Vermont commonly occur in black spruce, tamarack, and balsam fir swamps (Van't Hof and Van't Hof 1983, Oatman 1985). In New York, breeding pairs often choose nest sites in spruce-larch forests with stands of dead trees surrounding open bogs, or black spruce bogs among the Adirondack High Peaks (Leonard 2001, Peterson 1988). In New Hampshire, three-toed woodpeckers inhabit spruce-fir forests, bogs, and logged areas with standing dead conifers in the North Country and above 3,000 ft (910 m) in the White Mountains (Foss 1994). In northern Maine, they have been found in mixed hardwood old growth forests (Gunn and Hagan in Leonard 2001). In Canada, they may be found in mixed conifer and riparian willow habitats, and they have been observed occasionally in isolated hardwood-dominated stands in St. Lawrence lowlands (Leonard 2001). Nests may be dug in dead or dying coniferous or deciduous trees, or in hard or soft snags or stumps with diameters of at least 12 in (31 cm) (Foss 1994). Nest trees are often near water.

1.2 Justification

The three-toed woodpecker is locally common in the western part of its range and rare in eastern North America. Its quiet, reclusive nature and relatively inaccessible habitat contribute to this species being under-recorded by most surveys. Historic observations indicate that this species is less common than the black-backed woodpecker, which shares its habitat throughout North America.

Three-toed woodpeckers feed primarily on bark beetles, which are most abundant on dead and dying trees with shedding bark, and therefore require standing dead trees for foraging. Suitable habitats with abundant dead and dying trees are created through natural disturbances such as fire, wind, disease, insect outbreaks, flooding, and human activities such as logging. However, extensive logging of coniferous forests has reduced the amount of standing dead and dying timber over the past 150 years. In addition, beaver activity, insect outbreaks, salvage logging of affected stands, and suppression of forest fires, have reduced and degraded former three-toed woodpecker habitats.

Three-toed woodpeckers have been studied very little in North America, so there are too few data to determine significant changes in population distribution or abundance. However, long-term studies in northern Europe have correlated Eurasian woodpeck-

er decline there with activities common here (beavers, salvage logging, fire suppression, habitat fragmentation, etc.). North American Breeding Bird Survey (BBS) data indicate significant annual declines of 15.0% for the United States and 13.4% across North America. However, these results are based on a very small sample size (just 12 survey routes for the United States, and 18 for all of North America), and very low abundances of three-toed woodpeckers on each route (J. Sauer personal communication in Leonard 2001).

Despite relatively low abundance and lack of data, several observers have noted declines in this species over the past century. Forbush (1927 in Oatman 1985) noted that their numbers in Vermont had likely been reduced by extensive logging of spruce forests in the eighteenth and nineteenth centuries, and both Saunders (1929) and Bull (1974) indicated three-toed woodpeckers had become scarcer in New York. In Maine, declines in this species were attributed to timber harvesting (Hagan et al. 1997). The few observations in New Hampshire since 1884 indicate that three-toed woodpeckers occupy a small number of historic sites (Foss 1994).

1.3 Protection and Regulatory Status

The three-toed woodpecker is protected in the United States under the Migratory Bird Treaty Act of 1918 and in Canada under the Migratory Birds convention Act of 1994. It is considered a Sensitive Species by the United States Bureau of Land Management and Region 4 of the United States Forest Service (USFS), and is a Watch Species by the United States Fish and Wildlife Service (USFWS). It is listed as a Species of Special Concern in Idaho, a Sensitive Species in Utah, a Species of Concern in Washington, A Sensitive Species in Oregon, and a Rare and Uncommon Native Species in Vermont.

In New Hampshire, three-toed woodpeckers are listed as Threatened. This designation makes it unlawful to kill, possess, process, sell or offer for sale, deliver, carry, transport or ship such species within the state or export them from the state. Three-toed woodpeckers have also been identified as species of conservation concern by the New Hampshire Living Legacy Project, New Hampshire Important Bird Areas Program, the New Hampshire Forest Resources Plan Ecological Assessment, the White Mountain National Forest (WMNF), and by the New Hampshire Natural Heritage Bureau.

1.4 Population and Habitat Distribution

In New Hampshire, three-toed woodpeckers have been documented in the North Country and in the White Mountains, with Mt. Passaconaway (Waterville Valley) being the southern-most location documented in the state (Foss 1994). The earliest documentation of three-toed woodpeckers in New Hampshire was in August 1884, of a female and young bird shot below Hermit Lake in Tuckerman's Ravine. The second documented record was in July 1886, of a bird observed in the Great Gulf Wilderness (Chadbourne 1887 in Foss 1994). A few reports of three-toed woodpecker sightings followed until the 1950s, when sightings became more frequent. Since 1884, sightings have been documented in at least 12 towns, from Waterville Valley to Pittsburg (table 1). All but 2 of these reports were of observations during the breeding season. Two reports were of birds seen in October, one at an unknown location in Bethlehem (where the reporter indicated he had seen them there previously) in 1981, and one on the Isreal Ridge Trail on Mt. Adams in 1996. Both of these locations are areas where three-toed woodpeckers have been seen during the breeding season.

1.5 Town Distribution Map

See figure 1.

1.6 Habitat Model

Zapisocki et al. (2000) developed a Habitat Suitability Index Model for three-toed woodpeckers in west-central Alberta that includes the following within-stand features:

- Average diameter at breast height (dbh) of canopy trees
- Average top height of 100 coniferous trees/ha that have the largest dbh
- Total density of standing dead trees or stubs greater than or equal to 16 cm (6.3 in) dbh per hectare
- Percent composition of pine, spruce, fir, and larch species in the tree canopy
- Percent of ground covered by a vertical projection of tree crown areas on to the ground

- Includes trees greater than or equal to 8 cm (3.2 in) dbh

These features describe the year-round requirements for foraging, nesting, and cover. Based on studies of three-toed woodpeckers in the northwest, values associated with these features are as follows:

- Trees greater than 8 cm (3.15 in) are suitable for foraging or nesting, and trees greater than or equal to 20 cm (7.9 in) are optimal
- Tree heights greater than 4 m (13 ft) are suitable, and trees greater than or equal to 8 m (26 ft) are optimal
- Stands with numerous snags have more food and potential nests, and stands with greater than or equal to 1.2 snags/ha are optimal
- Conifer-dominated stands (more than 50% conifer) are preferred, and stands with more than 20% conifers are unsuitable
- Tree canopy closure must be more than 6% for a stand to be suitable for three-toed woodpeckers, and stands with closure greater than 50% are optimal

These habitat features may be applicable to New Hampshire and the rest of the Northeast, but use in this region should be done in conjunction with model testing and verification procedures (Zapisocki et al. 2000).

Information on average dbh, tree height, and snag density is generally unavailable on a wide scale in New Hampshire. Measures of percent of coniferous species coverage and percent canopy cover may be derived from aerial photos or from existing land cover analyses of aerial photos. Potential three-toed woodpecker habitat might be identified on a landscape scale by mapping currently and potentially disturbed habitats within conifer-dominated forests from the White Mountains north. Data needed for this landscape model might include:

- Land cover data to identify conifer-dominated stands
- Aerial photos of conifer dominated stands to determine % canopy closure and possibly % conifer cover. Aerial photos might also show disturbed habitats, especially standing dead trees
- Hydrology and National Wetland Inventory (NWI) maps to show wetlands and waterbodies, where this species is often found
- Current and potential beaver flowages, to show where flooding could cause tree mortality
- Topography and digital elevation models to show high wind areas where tree mortality may be caused by wind throw

1.7 Sources of Information

Information on historic and recent three-toed woodpecker distribution and habitat was found in breeding bird atlases from New York, Vermont, and New Hampshire, and from the three-toed woodpecker account of the Bird of North America series. Data on three-toed woodpecker observations were derived from the New Hampshire Audubon's New Hampshire Bird Records (NHBR) database. Other information was found in literature on three-toed woodpecker studies.

1.8 Extent and Quality of Data

There are very few data on three-toed woodpeckers in New Hampshire and in the Northeast in general. Their habitat is often remote and difficult to survey, and this species' relatively quiet behavior makes them challenging to detect.

1.9 Distribution Research

Surveys of historic sites and high-potential habitats would establish a baseline of information on current distribution and relative abundance of this species. Since this species occurs at all elevations, surveys could be coordinated with wetland bird surveys and high elevation bird surveys.

Element 2: Species/Habitat Condition

2.1 Scale

Three-toed woodpeckers have been documented the White Mountains, Lake Umbagog, and Pittsburg.

2.2 Relative Health of Populations

There are too few data to determine the relative quality of these sites, or the relative health of populations

of this species. The most recent observations have occurred at East Inlet (Pittsburg) in 1998, Whaleback Ponds near Lake Umbagog (Errol) in 2004, and in the Presidential Range of the White Mountains in 2000. All of these areas are currently protected as either state or federal lands.

2.3 Population Management Status

Three-toed woodpeckers are not currently managed in New Hampshire.

2.4 Relative Quality of Habitat Patches

As mentioned in section 2.2, there is too little information on three-toed woodpeckers and their habitats to assess relative quality of sites. The conservation status of all known sites increases the probability that coniferous forest habitats will be managed to maintain or enhance habitat for this species.

2.5 Habitat Patch Protection Status

All of the known recent sites are protected. Two state agencies—the Department of Resource and Economic Development (DRED) and New Hampshire Fish and Game (NHFG)—own most of the town of Pittsburg, and East Inlet is within a large territory owned by the NHFG. Whaleback Ponds are within the Lake Umbagog National Wildlife Refuge, and the White Mountains are entirely within the White Mountains National Forest. Most of these areas will be exempt from logging activities and will eventually provide mature and old growth spruce stands suitable for three-toed woodpecker habitat.

High elevation spruce-fir habitats are almost completely protected in New Hampshire through a suite of regulations and agreements, including a no-cut zone above 2,700 ft on state, federal, and private conservation lands (the Bunnell tract and The Nature Conservancy). They are additionally protected by zoning ordinances (PD6 zones) in unincorporated towns, the cooperative High Elevation memorandum of understanding (MOU)OU for large landowners developed by NHFG and DRED, a conservation easement held by DRED, and an MOU between the WMNF and NHFG related to wildlife habitat management (J. Kelly in press).

These measures effectively protect most high elevation spruce-fir habitat. However, there is montane black spruce-red spruce habitat (2,500 to 3,000 ft) below 2,700 ft that may not be protected, as well as northern hardwood-spruce-fir forests from 2,100 to 2,800 ft that may still undergo timber harvests.

2.6 Habitat Management Status

None of these sites is being managed specifically for three-toed woodpeckers.

2.7 Sources of Information

Known sites were derived from NHBR, and conservation and management status was obtained from NHFG, the Umbagog National Wildlife Refuge, and the WMNF.

2.8 Extent and Quality of Data

There are few data on distribution and abundance of three-toed woodpeckers and no information on the availability and condition of suitable habitat for them.

2.9 Condition Ranking

2.10 Condition Assessment Research

Because three-toed woodpeckers are at the southern edge of their range in New Hampshire and occur in such scattered locations throughout the northern half of the state, it is probable that many suitable habitats are unoccupied simply because this species has not colonized them, or that they have not been detected. An assessment of the condition of known and potential habitat should incorporate data on spruce-fir patch size, stand age, tree dbh and height, canopy closure, and information on availability of large (greater than 25 cm (9.8 in) dbh) dead trees and snags.

Element 3: Species and Habitat Threat Assessment

3.1 Threats

See form 1: Threat Identification; form 2: Threat Ranking; and form 3: Local Threat Weighting (attached). Form 4 (Feasibility Ranking) for three-toed

woodpecker will be the same as those for High Elevation Spruce Fir and Acadian Spruce Fir Forests. See the High Elevation Spruce Fir Forest and Acadian Spruce Fir Forest habitat profiles for a complete list of threats

3.1.1 Unsustainable Harvest (Forestry Operations and Management)

Timber harvesting is the most serious threat for high elevation and lowland spruce fir forests, and past and logging has reduced and degraded spruce-fir habitats throughout the state. Logging is a minimal threat to high elevation habitats today, but past harvesting activity will continue to affect the availability and condition of high elevation spruce-fir forests for many years.

Harvesting of lowland spruce-fir is still a threat, as stands are cut on relatively short rotations, eliminating the opportunity for forests to develop mature and over-mature stands on which three-toed woodpeckers depend. Increased fragmentation of forests, as well as more intensive management, has reduced the role of natural disturbances, such as fire, flooding, and insect outbreaks on forest structure and composition. Dead and dying timber is not marketable, and is often salvaged to clear a site for new growth. The loss of habitat for bark beetles and other insects results in a landscape that can not support three-toed woodpeckers or other species associated with mature and over-mature stands.

3.1.2 Mercury

Terrestrial and aquatic ecosystems are vulnerable to air-borne pollutants such as mercury and other heavy metals. High levels of mercury have been found in blood and tissues of many species of fish, mammals, birds and salamanders, all of which live in or are associated with wetlands, streams and other waterbodies. More recent research on forest songbirds in Vermont, however, indicates that insectivorous songbirds from high elevation spruce-fir forests to lower elevation deciduous woodlands are also accumulating high levels of mercury (Evers 2005). Deposition of mercury may be highest in certain high elevation sites, and mercury may accumulate in wetland habitats. Three-toed woodpeckers are often found in such areas and may therefore be vulnerable to mercury toxicity.

3.2 Sources of Information

Threats information for three-toed woodpeckers was derived from the literature and discussions with experts and colleagues during threat identification and ranking meetings. Habitat profiles and threat rankings for both high elevation and lowland spruce-fir habitats were used for the three-toed woodpecker threats analysis and were modified appropriately.

3.3 Extent and Quality of Data

Several studies on the effects of timber harvesting on three-toed woodpeckers have been conducted in Europe and the western United States and Canada. Although fewer studies have been done in the east, the results parallel those of research conducted elsewhere. There is very little information on the effects of development or human recreation on this species. Many observers suggest that three-toed woodpeckers are relatively unfazed by human presence, but there is virtually no information on the impacts of ski area development, hiking, timber harvesting, recreational vehicles, hunting, or other activities on this species.

3.4 Threat Assessment Research

Since there are few observations of three-toed woodpeckers in New Hampshire, priority research should focus on determining presence of this species at historic and recent breeding territories, followed by searches in likely potential habitats. This would provide baseline information on distribution and habitat selection, as well as breeding success and life history data.

Element 4: Conservation Actions

Three-toed woodpeckers are especially dependent on disturbed habitats within spruce-fir forests. Therefore, in order to provide sufficient habitat for this species, conifer-dominated stands in the White Mountains and northward should be managed to accommodate natural disturbances and patches of mature and over mature timber. Areas likely to be subject to high winds or beaver activity should be either left unmanaged or managed to leave large areas of standing dead trees. Sites affected by fire, insect outbreaks,

or other disturbances should be managed similarly. Finally, sites that were originally spruce-fir and have grown back as hardwood-dominated stands should be managed to encourage conifer species.

Element 5: References

5.1 Literature

Andrle, R.F., and J.R. Carroll. 1988. The Atlas of Breeding Birds in New York State. Cornell University Press, Ithaca, New York, USA.

Bull, J. 1974. Birds of New York State. Doubleday/ Natural History Press, Garden City, NY. Reprint. Cornell University Press, Ithaca, New York, USA. 1985.

Evers, D. 2005. Mercury Connections: The extent and effects of mercury pollution in northeastern North America. BioDiversity Research Institute. Gorham, Maine, USA.

Forbush, E.H. 1927. Birds of Massachusetts and other New England states. Vol. 2. Boston: Massachusetts Department of Agriculture.

Foss, C.R. 1994. Atlas of Breeding Birds of New Hampshire. New Hampshire Audubon, Concord, New Hampshire, USA.

Goggans, R., R.D. Dixon, and L.C. Seminara. 1988. Habitat use by Three-toed and Black-backed woodpeckers. Oregon Department of Fish Wildlife Nongame Report 87-3-02.

Gunn, J.S., and J.M. Hagan III. 2000. Woodpecker abundance and tree use in uneven-aged managed, and unmanaged, forests in northern Maine. Forest Ecology and Management 126:1-12.

Hagan, J.M. III, P.S. McKinley, A.L. Meehan, and S.L. Grove. 1997. Diversity and abundance of landbirds in a northeastern industrial forest. Journal of Wildlife Management 61:718-735.

Leonard, D.L. Jr., 2001. Three-toed woodpecker (*Picoides tridactylus*). *In* The Birds of North America, No. 588 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, Pennsylvania, USA.

Murphy, E.C., and W.A. Lehnhausen. 1998. Density and foraging ecology of woodpeckers following a stand-replacement fire. Journal of Wildlife Management 62:1359-1372.

Oatman, G.F. 1985. Three-toed Woodpecker, *Picoides tridactylus*. Pp. 162-163 in The Atlas of Breeding Birds of Vermont, S.B. Laughlin and D.P. Kibbe, editors. University Press of New England, Hanover, New Hampshire, USA.

Peterson, J.M.C. 1988. Three-toed Woodpecker, *Picoides tridactylus*. Pages 236-239 in The Atlas of Breeding Birds in New York State, R.F. Andrle and J.R. Carroll, editors. Cornell University Press, Ithaca, New York, USA.

Rimmer, C.C., K.P. McFarland, D.C. Evers, E.K. Miller, Y. Aubry, D. Busby, and R.J. Taylor. Mercury levels in Bicknell's thrush and other insectivorous passerine birds in montane forests of the northeastern United States and Canada. Pages 16-17 in Mercury Connections: The extent and effects of mercury pollution in northeastern North America, D. Evers, editor. BioDiversity Research Institute. Gorham, Maine, USA.

Ruge, K. 1997. Three-toed woodpecker. Pp. 458-459 in The EBCC atlas of European breeding birds: their distribution and abundance (E.J.M. Hagemeijer and M.J. Blair, eds.). T. and A.D. Poyser, London.

Saunders, A.A. 1929. The summer birds of the northern Adirondack mountains. Roosevelt Wild Life Bulletin 5:327-499.

Van't Hof, T.J., and H.M. Van't Hof. 1983. Summer records of Northern Three-toed Woodpecker (*Picoides tridactylus*) and Gray-cheeked Thrush (*Catharus minima*) in northern Michigan. Jack-Pine Warbler 61:82.

Winkler, H., D.A. Christie, and D. Nurney. 1995. Woodpeckers. An identification guide to the woodpeckers of the world. Houghton Mifflin Co., Boston, Massachusetts, USA.

Zapisocki, R., B. Beck, J. Beck, M. Todd, R. Boanr, and R. Quinlan. 2000. Three-toed woodpecker Year-round Habitat: Habitat Suitability Index Model, Version 6. Weldwood Forest Management Area, Hinton, Alberta.

5.2 Data Sources

NHBR. New Hampshire Bird Records, New Hampshire Audubon, Concord, NH.

Element 6: List of Figures

Table 1 (data from Foss 1994 and New Hampshire Bird Records (NHBR)).

Location (Town)	Date (s)
Tuckerman's Ravine (Sargent's Purchase)	1884, 1960s & 70s
Great Gulf Wilderness, Caps Ridge Trail, Jefferson Notch, Mt. Adams (Thompson & Meserve's Purchase)	1886, 1960s & 70s, 2000
Mt. Passaconaway (Waterville Valley)	1893
Umbagog Lake (Errol)	1890-1940, 2004
Mt. Starr King (Jefferson)	1890-1940
Carter Range (Bean's Purchase/Shelburne)	1890-1940
Greeley Ponds, Nancy Pond (Livermore)	1927, 1960-1981
East Inlet. Indian Stream (Pittsburg)	1952, 1954, 1980-1998
Mt. Webster (Hart's Location)	1960s & 70s
Kancamagus Pass (Livermore/Lincoln)	1960s & 70s
Mt. Clinton (Bean's Grant)	1960s & 70s
Avalon Trail (Bethlehem)	1981
Atlas block bog (Success)	1986
Isreal Ridge Trail, Mt. Adams (Low & Burbank's Grant)	1996

SPECIES PROFILE

Upland Sandpiper

Bartramia longicauda

Federal Listing: Not listed
State Listing: Endangered
Global Rank: G5
State Rank: S1
Author: Pamela D. Hunt and Diane De Luca, New Hampshire Audubon

Element 1: Distribution and Habitat

1.1 Habitat Description

Upland sandpipers occupy a wide range of grassland habitats. In the East, these include airfields, blueberry barrens (Maine), and mixed agricultural areas. The species needs a mix of short (less than 20 cm) and tall (up to 60 cm) grasses for foraging and nesting, respectively. Taller structures—such as fence posts, runway lights or signs, and taller forbs such as mullein—are needed for singing perches. Upland sandpipers avoid grasslands with high densities of legumes or with a dense litter layer (Carter 1992, Houston and Bowen 2001).

Upland sandpipers require large areas of grassland for breeding. Ideally, such fields should be over 60 ha (150 acres), and even fields as large as 120 ha (300 ac) may not necessarily support the species (Carter 1992, Vickery et al. 1994). Territories average 8 to 12 ha (20 to 30 ac), and the species is often loosely colonial where it reaches higher densities (Carter 1992). Sites used by sandpipers in New Hampshire include large airfields (Pease, Manchester, Nashua) and large agricultural mosaics (Dover, Rochester, Haverhill).

1.2 Justification

The upland sandpiper has always been rare in New Hampshire. It probably did not occur in the state until the 1800s, after forest clearing allowed it to expand eastward from the Midwest (Foss 1994). It was primarily limited to major river valleys and coastal plain, where it occasionally reached high densities. Population declines in New Hampshire began as early as 1900 (Foss 1994), although detailed data are lacking. As recently as the early 1980s, upland sandpipers still bred in at least 5 locations (Foss 1994, figure 1), although there were fewer sightings of migrating birds (NHBR, figure 2.). Breeding has only been confirmed at the Pease Airfield in Portsmouth and Newington (with at least one confirmed breeding event just off the airfield at the Great Bay National Wildlife Refuge), although sightings from Dover, Manchester, and southern Coos County in the last decade (figure 1) imply that birds are still visiting appropriate habitat elsewhere in the state.

The upland sandpiper is of conservation concern throughout the Northeast. Many historic habitats in New England were on large dairy farms, and these have been gradually disappearing (A. Jones, personal communication). Over the range as a whole, Breeding Bird Survey data indicate an insignificant increase of 0.8% per year from 1966, but a 1.2% annual decline since 1980. In the Northeast, the corresponding values are both declines: 0.4% since 1966 and 1.7% since 1980 (Sauer et al. 2004). The steeper declines since 1980 coincide with the period of greatest decrease in the New Hampshire breeding population.

1.3 Protection and Regulatory Status

This species is protected at the federal level by the Migratory Bird Treaty Act, which prevents the killing of most non-game birds and collection of their nests or eggs. The New Hampshire Endangered Species Conservation Act (RSA 212) protects upland sandpipers in New Hampshire.

1.4 Population and Habitat Distribution

From the 1960s onward, most of New Hampshire's upland sandpipers have occurred in 3 areas of the state: 1) the upper Connecticut River Valley (Haverhill through Northumberland), 2) the Merrimack Valley from Plymouth southward, and 3) the seacoast (figure 1). Specific locations where sandpipers have been recorded since 1980 are presented in table 1.

Only a small proportion of the continental upland sandpiper population occurs in New England, which supports roughly 250 breeding pairs. The majority of these (150 pairs) breed in eastern Maine, with another 50 to 60 pairs at Westover Air Force Base in western Massachusetts (Jones et al. 2001). New Hampshire's share of the regional population is thus extremely small.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

N/A

1.7 Sources of Information

Basic natural history information in this profile was largely gathered from the literature cited in element 5. Data on upland sandpiper distribution in New Hampshire were compiled from NHBR and reports on breeding surveys at the Pease Airfield.

1.8 Extent and Quality of Data

The combination of an active amateur birder population and systematic grassland bird surveys over the last decade makes it unlikely that breeding sandpipers would have been overlooked in southern New Hampshire. However, the historic breeding areas in the upper Connecticut River valley have not been well surveyed, and recent records from Lancaster and Whitefield suggest that a small population may persist somewhere in the north.

1.9 Distribution Research

A comprehensive survey of suitable habitat in the upper Connecticut River valley and lower Merrimack River valley is needed. Observers should search for the species in Haverhill, in the extensive grasslands in the Lancaster area, and at the Manchester Airport. Surveys should broadcast sandpiper vocalizations during the breeding season. Such research should reach out to farmers and local residents in areas where suitable habitat remains to inform people of the species' rarity and distinguishing characteristics, and encourage data reporting.

Element 2: Species Condition

2.1 Scale

Given the severely restricted current distribution (1 site), the best approach to conservation of this species in the state should focus on 4 units:

- Pease Airfield and vicinity
- Agricultural lands in southern Strafford County (especially Durham, Dover, Rochester)
- Lower Merrimack River Valley (especially Manchester Airport)
- Upper Connecticut River Valley (Haverhill to Lancaster)

2.2 Relative Health of Populations

The only population in New Hampshire occurs at the Pease Airfield in Portsmouth and Newington. This population has been monitored regularly since 1989 and has averaged 8 to 12 pairs during the period (figure 3). This population has produced a minimum of 10 to 15 chicks in most breeding seasons, although surveys have not always been comprehensive. Since 1990, single birds or pairs have appeared in nearby areas of Newington (table 1), suggesting that dispersing individuals occasionally settle in suitable habitat away from the airfield. Populations that once consistently occupied sites in Haverhill and Manchester were last recorded in 1984 and 1985, respectively, although the species was reported at the Manchester Airport in 1999. Since 1985, only 5 sites other than Pease have supported upland sandpipers for more than a year, and even in those cases there was little evidence of breeding activity.

2.3 Population Management Status

No management specific to this species—other than periodic monitoring—is currently occurring in New Hampshire. See Section 2.6 for details on habitat management at the only occupied site.

2.4 Relative Quality of Habitat Patches

The 4 units identified in section 2.1 vary in type of land use, development pressures, and habitat management. At the Pease Airfield, sandpipers are being managed (see section 2.6). Sandpipers are not being managed in adjacent areas of Newington, where occupancy is irregular. Strafford County agricultural lands are at greater threat from development, and because they are closer to the species' core range, they probably represent better potential habitat. The Manchester Airport has an extensive area of suitable habitat, but security and safety concerns have so far made it impossible even to determine the extent of sandpiper use at this site, much less implement management beneficial to the species. Finally, the northern agricultural areas are at somewhat lower risk from habitat conversion than those near the seacoast. In all areas, any assessment of habitat quality will need to consider both the composition (i.e., mix of grass heights) and size of available fields as discussed in section 1.1.

2.5 Habitat Patch Protection Status

With the exception of the Weapons Storage Area at the Great Bay National Wildlife Refuge, none of the breeding areas identified above are protected. A memorandum of understanding is in place at the Pease Airfield (see section 2.6).

2.6 Habitat Management Status

Starting in the 1990s, several entities cooperated to manage upland sandpiper habitat at the Pease Airfield. The resulting mowing regime meets airport safety regulations and protects sandpipers during vulnerable early stages of nesting (incubation and pre-flight chick). Mowing of safety areas begins by 1 May to discourage nesting attempts, and no other areas of the airfield are mowed until after 31 July (De Luca 2002). Airport personnel are regularly informed of active nesting areas (when monitoring is being done) so that disturbance is minimized. Although a fence surrounding the habitat discourages large mammals from approaching the runway, sightings of fox and coyote have increased (De Luca 2002). Given that these species pose a predation risk to sandpipers, there may be need to reconsider predator control at this site.

The Great Bay National Wildlife Refuge is managing its grassland areas, including the weapons storage area where sandpipers have recently bred. Management includes mowing and burning to maintain grassland, and such activities are not done until after the breeding season.

At the Strafford County Farm in Dover, there is an agricultural lease agreement covering the years 2003 to 2008. This agreement includes the following provisions beneficial to grassland birds:

- Delayed mowing in wetter areas
- Raise mowing bar to 6 inches or more in areas with grassland bird concentrations
- Attach flushing bars to the front of mowers
- Avoid night mowing
- 16 acres have been set aside as a reserve, and will not be mowed until after 1 August
- If upland sandpipers are found on the farm, an un-mowed buffer should be established around the occupied area

2.7 Sources of Information

Summaries of population health were based on data from NHBR and reports of upland sandpiper monitoring produced by NHA. Details of management practices at the Pease Tradeport and Strafford County Farm were taken from management agreements for those 2 locations.

2.8 Extent and Quality of Data

With the exception of Pease Airfield, data are largely lacking for all areas of the state. Even there, current monitoring intensity may not be sufficient to detect productivity or to determine what factors may be responsible for recent population declines.

2.9 Condition Assessment Research

Increased sightings of potential predators at the Pease Airfield suggest that predator monitoring may need to be implemented. Since Pease is the only known population of upland sandpipers in the state, it is especially important to understand the quality of this site for breeding sandpipers. In addition, no studies of the actual grassland habitat at Pease have been conducted since the original Pease Air Force Base was decommissioned in 1990. An assessment of current habitat condition at this site could be valuable in guiding future management activity.

Element 5: References

5.1 Literature

Andrle, R.F., and J.R. Carroll. 1988. The Atlas of Breeding Birds in New York State. Cornell University Press, Ithaca, New York, USA.

Carter, J V. 1992. Upland Sandpiper, *Bartramia longicauda*. Pp. 235-252 *in* Migratory nongame birds of management concern in the Northeast, K.J. Schnieder and D.M. Pence, editors. U.S. Department of te Interior, U.S. Fish and Wildlife Service, Newton Corner, Massachusetts, USA.

De Luca, D. 2002. 2002 upland sandpiper status at Pease International Tradeport. Report to the New Hampshire Fish and Game Department. New Hampshire Audubon, Concord, New Hampshire, USA.

De Luca, D. 2004. Upland sandpiper monitoring protocol for New Hampshire. Report to the New Hampshire Fish and Game Department. New Hampshire Audubon, Concord, New Hampshire, USA.

Foss, C.R. 1994. Atlas of Breeding Birds of New Hampshire. New Hampshire Audubon. Concord, New Hampshire, USA.

Jones, A.L., and P.D. Vickery. 1997. Distribution and population status of grassland birds in Massachusetts. Pp. 187-199 *in* Grasslands of northeastern North America: Ecology and conservation of native and agricultural landscapes, P.D. Vickery and P.W. Dunwiddie, editors. Massachusetts Audubon Society, Linc.oln, Massachusetts, USA.

Jones, A.L., G. Shriver, and P.D. Vickery. 2001. Regional inventory of grassland birds in New England and New York, 1997-2000. Report to National Fish and Wildlife Foundation. Massachusetts Audubon Society, Lincoln, Massachusetts, USA.

Houston, C.S., and D.E. Bowen, Jr. 2001. Upland Sandpiper (*Bartramia longicauda*). *In* The Birds of North America, No. 580, A. Poole and F. Gill, editors. The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, DC.

Laughlin, S.B., and D.P. Kibbe. 1985. The Atlas of Breeding Birds of Vermont. University Press of New England, Hanover, New Hampshire, USA.

Sauer, J.R., J.E. Hines, and J. Fallon. 2004. The North American Breeding Bird Survey, Results and Analysis 1966-2003. Version 2004.1, USGS Patuxent Wildlife Research Center, Laurel, Maryland, USA.

Veit, R.R., and W.R. Petersen. 1993. Birds of Massachusetts. Massachusetts Audubon Society, Lincoln, Massachusetts, USA.

Vickery, P.D., M.L. Hunter, Jr., and S.M. Melvin. 1994. Effects of habitat area on the distribution of grassland birds in Maine. Conservation Biology 8: 1087-1097.

Zeranski, J.D., and T.R. Baptist. 1990. Connecticut Birds. University Press of New England, Hanover, New Hampshire, USA.

5.2 Data Sources

NHBR. New Hampshire Bird Records, New Hampshire Audubon, Concord, NH.

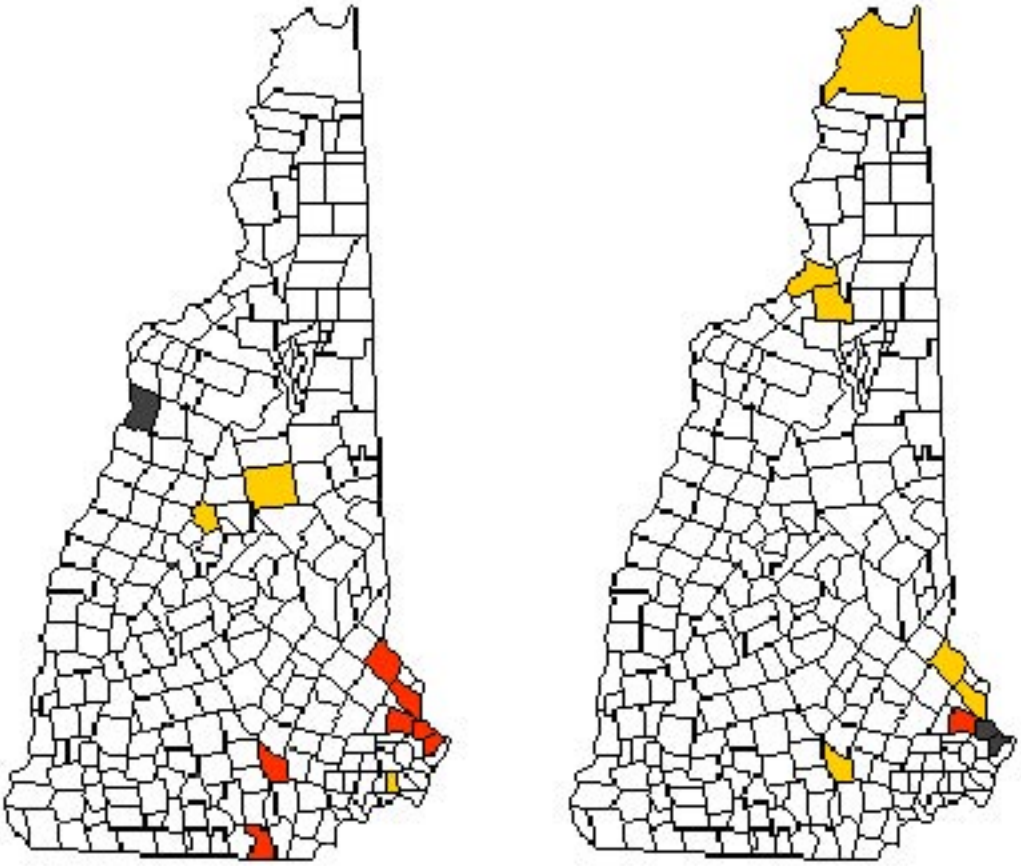
Element 6: List of Figures

Figure 1. Distribution of breeding season (late May-July) records of upland sandpiper in New Hampshire 1965-2004. Towns are coded according to the number of years in each period when sandpipers were reported: yellow = 1, red = 2-5, black = > 5 (data from NHBR and De Luca 2002). Records of birds in late May but not later in the season are excluded as being possible migrants unless they were reported from a site with a consistent pattern of use by the species.

Figure 2. Number of reports of migrant upland sandpipers in spring (April-May) from 1965-2004. For each five-year period, all year/location records have been combined. Migrant reports from the Pease

Airfield are not included in this analysis.

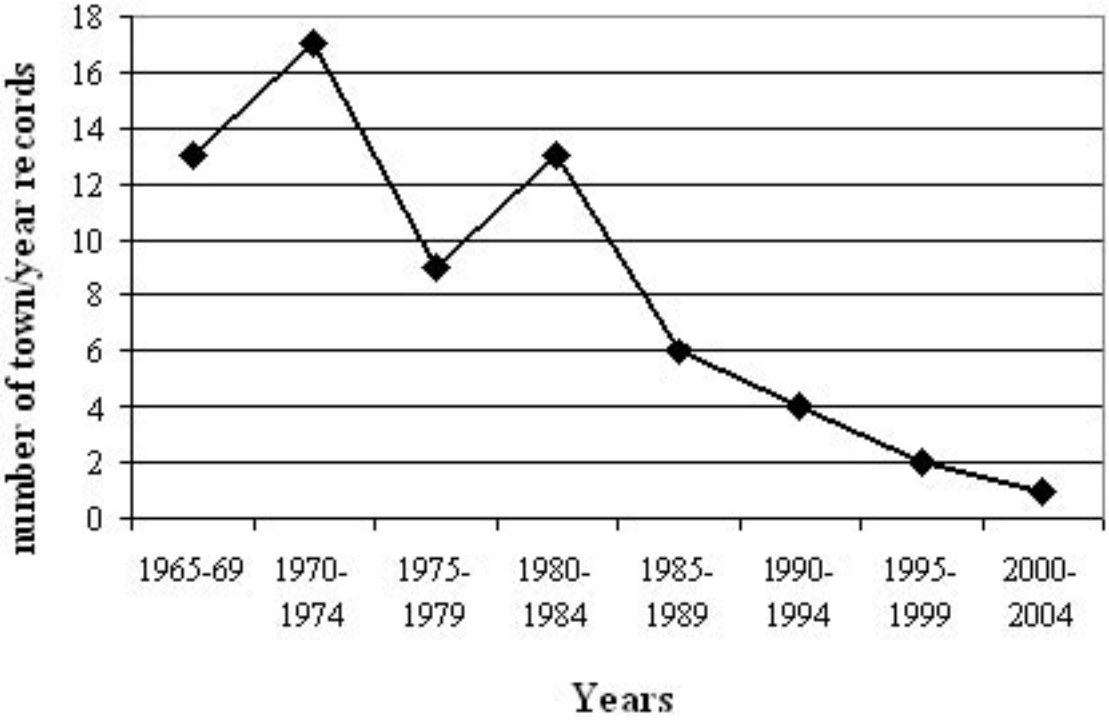
Figure 3. Numbers of upland sandpipers at the Pease Airfield, 1989 to 2004. Values represent the mid-point of the range given for numbers of pairs in a given year. Systematic surveys were not conducted in 2000 and 2001.



a. 1965-1984

b. 1985-2004

Figure 1



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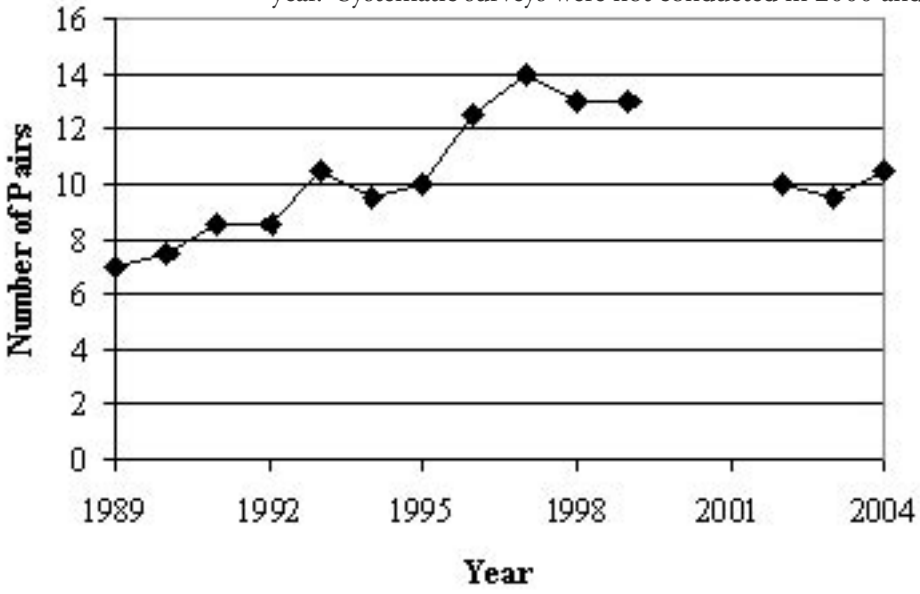


SPECIES PROFILE

Vesper Sparrow

Pooecetes gramineus

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S2S3B
Author: Alina, J. Pyzikiewicz, New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

The breeding habitat of the vesper sparrow consists of dry, open grassy areas with patches of bare ground and elevated perching areas. Such habitat includes old fields, crop and hayfields, cemeteries, and airports (Janeway 1994, Jones and Cornely 2002). Nests are built adjacent to woodlands and are concealed in small depressions on the ground and covered by vegetation or wood debris (Janeway 1994, Jones and Cornely 2002). The vesper sparrow forages on the ground, feeding on insects, grasshoppers, and caterpillars during the breeding season, and on grains and seeds all year long (Janeway 1994, Jones and Cornely 2002). Wintering habitats include grasslands, weedy fields, and other natural or cleared openings with sparse shrubby vegetation (Jones and Cornely 2002).

1.2 Justification

Development, reforestation, the decline of farmland, and agricultural practices such as mowing, have all led to the decline of the vesper sparrow throughout its range (Vickery et al. 1999, Jones and Cornely 2002). Breeding Bird Survey data (1966 to 2004) for New Hampshire show that the vesper sparrow is limited to 160 individuals and is declining at an annual rate of 13%. Grassland bird surveys between 1997 and 2000 by the Massachusetts Audubon Society counted only 11 (Jones et al. 2001, USGS Patuxent Wildlife Research Center 2005).

1.3 Protection and Regulatory Status

The vesper sparrow is protected under the Migratory Bird Treaty Act and through various grassland bird conservation programs (North American Bird Conservation Initiative, Partners in Flight Northeast Grassland Bird Working Group).

1.4 Population and Habitat Distribution

The range of the vesper sparrow extends from southern Canada to central Mexico (Ridgely et al. 2003). Breeding range includes southern Canada and the central United States, and wintering range includes the southern United States and central Mexico (Ridgely et al. 2003). In New Hampshire, the vesper sparrow can be found breeding in isolated pockets of open grasslands (airports, hayfields, power line right of ways) south of the White Mountains region (NHNHB 2005).

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

N/A

1.7 Sources of Information

Sources of information include the NHNHB Database, New Hampshire Breeding Bird Atlas, Janeway (1994), and Jones and Cornly (2002).

1.8 Extent and Quality of Data

Vesper sparrow habitat and population distribution is well studied throughout its range, but population

data in New Hampshire are limited.

1.9 Distribution Research

- Identify key grassland habitat areas
- Continue monitoring grassland habitats to better assess vesper sparrow abundance trends
- Conduct productivity and survival studies to provide information needed for determining causes of population declines
- Determine effects of agricultural management on populations that occur in such habitats

Element 5: References

5.1 Literature

Janeway, E.C. 1994. Vesper sparrow. Pages 318-319 *in* Breeding bird atlas of New Hampshire, C.R. Foss, editor. Arcadia, Dover, New Hampshire, USA.

Jones, S.L, and J.E. Cornley. 2002. Vesper sparrow (Pooecetes gramineus). *In* The Birds of North America, No 624, A. Poole and F. Gill, editors. The Birds of North America, Philadelphia, Pennsylvania, USA.

Jones, A.L., W.G. Shriver, and P.D. Vickery. 2001. Regional inventory of grassland birds in New England and New York, 1997-2000. Massachusetts Audubon Society, Lincoln, Massachusetts, USA.

Vickery, P.D., P.L. Tubaro, J.M. Cardoso da Silva, B.G. Peterjohn, J.R. Herkert, and R.B. Cavalcanti. 1999. Conservation of grassland birds in the western hemisphere. Studies in Avian Biology 19: 2-26.

5.2 Data Sources

New Hampshire Natural Heritage Bureau. 2005. Database of rare species and exemplary natural community occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

Ridgely, R.S., T.F. Allnutt, T. Brooks, D.K. McNicol, D.W. Mehlman, B.E. Young, and J.R. Zook. 2003. Digital Distribution Maps of the Birds of the Western Hemisphere, version 1.0. NatureServe, Arlington, Virginia, USA.

United States Geological Service Patuxent Wildlife Research Center. 2005. North American Breeding Bird Survey Internet data set. <http://www.pwrc.usgs.gov/bbs/>. Accessed 2 March 2005.

Sauer, J.R., J.E. Hines, and J. Fallon. 2004. *The North American Breeding Bird Survey, Results and Analysis 1966 - 2003. Version 2004.1. USGS Patuxent Wildlife Research Center, Laurel, Maryland, USA.*

SPECIES PROFILE

Whip-Poor-Will

Caprimulgus vociferous

Federal Listing: Not listed
State Listing: Special concern
Global Rank: G5
State Rank: S3B
Author: Pamela D. Hunt, New Hampshire Audubon

Element 1: Distribution and Habitat

1.1 Habitat Description

Whip-poor-wills inhabit areas of dry soils and open understory, especially in pine and oak woodlands (Clink 2002). They prefer to forage in open areas, such as fields, clearings, regenerating clear cuts, recent burns, and power line rights of way (Wilson 2003). Dry soil, which contributes to the sparse understory that whip-poor-wills prefer, may also allow for better drainage of the leaf litter where the birds lay their eggs. However, definitive data are lacking.

In New Hampshire, whip-poor-will records during the Breeding Bird Atlas were all from areas below 1,200 ft in elevation (Foss 1994), a pattern consistent with the species' distribution in New York (Andrle and Carroll 1988) and Vermont (Laughlin and Kibbe 1985). During a study in the Piscataquog River Watershed in 2003, whip-poor-will records were concentrated in the northeastern quarter of the watershed. A preliminary analysis of habitat at points where whip-poor-wills were detected suggests that birds were more likely to occur in areas identified by aerial photography as "dry pine forest," "gravel pit," or "disturbed" (photo interpretation by D. Sundquist, SPNHF).

1.2 Justification

Anecdotal accounts over much of the Northeast suggest a consistent decline in whip-poor-will populations, including in Vermont (Laughlin and Kibbe 1985, Murin and Pfeiffer 2003), New Hampshire (Foss 1994), Massachusetts (Veit and Petersen 1993, Petersen and Meservey 2003), Connecticut (Zeranski and Baptist 1990), and southern New Jersey (Sibley 1993). In New York, the current Breeding Bird Atlas indicates a dramatically reduced range compared to the years from 1980 to 1985 (New York Department of Environmental Conservation 2004). These declines are corroborated by data from the Breeding Bird Survey (BBS), which indicate significant declines in both the Northeast (USFWS region 5) and the eastern third of the continent (Sauer et al. 2004).

Because the BBS does not survey nocturnal species particularly well, these trends should be viewed with some caution, although other data also suggest long-term declines. Whip-poor-will is on the priority species lists in the CWCS for every state in Bird Conservation Region (BCR) 30 (New England/mid-Atlantic Coast), and it ranks moderate-to-high concern in other BCRs within its range. Although specific data are unavailable for New Hampshire, NHBR (see section 1.4) and anecdotal accounts make clear a range retraction from the northern and coastal areas.

1.3 Protection and Regulatory Status

This species is protected under the Migratory Bird Treaty Act, which prevents the killing of most non-game birds and collection of their nests or eggs.

1.4 Population and Habitat Distribution

In New Hampshire, whip-poor-wills have historically been most common south of the White Mountains (Foss 1994, and references therein). The northern edge of its distribution during the early 1980s corresponded fairly well with the 68 degree July isotherm. North of this line, there were more records in the

western highlands than in the White Mountains and areas to the north. Concentrations during the Breeding Bird Atlas occurred in central Carroll County in the Ossipee area, in a band from northwest Merrimack County to north-central Hillsborough County, and in central Strafford County (Foss 1994). In addition to the Atlas, the NHA conducted a statewide volunteer whip-poor-will survey program from 1980 to 1985. Data from this program indicate a range very similar to that indicated by the Atlas: concentrations in northern Carroll, Merrimack, eastern Hillsborough, Strafford, and central Rockingham Counties (figure 1a).

Recent data (NHBR) suggest that this range had not changed dramatically by the early 1990s (figure 1b) or early 2000s (figure 1c), although there is some indication of range retraction in the north and near the seacoast. It should be noted, however, that no standardized survey was in place during this period. Nonetheless, anecdotal data from throughout the state indicate a consistent decline, one that has apparently been going on since at least the early 1960s (Foss 1994).

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

N/A

1.7 Sources of Information

Basic natural history information in this profile was largely gathered from the literature cited in element 5. Data on whip-poor-will distribution in New Hampshire were compiled from NHBR, a database maintained by the NHA.

1.8 Extent and Quality of Data

Because whip-poor-wills are largely nocturnal, there are limited data on their demographics in New Hampshire. Most data are anecdotal, and even during the intensive Breeding Bird Atlas the species almost certainly went undetected in many areas. When surveys specific to this species were implemented in the Ossipee and Piscataqua River watersheds in 2003 and 2004, observers found the species quite common in some areas. This recent data should not be taken as evidence that the perceived decline is less extreme, only that overall populations are likely to be underestimated by anecdotal accounts. Given that the number of anecdotal accounts has been on the decline, it is safe to conclude that the species may be decreasing in the state and region (if the number of observers has not also declined).

1.9 Distribution Research

Northeast Partners in Flight has identified nightjar monitoring as a priority. Because whip-poor-wills and other nightjars are poorly surveyed by traditional methods like the BBS, there is need for standardized monitoring protocols to be implemented across the region, if not the entire range. Implementation of such surveys in New Hampshire—which would build upon monitoring initiated in 2003—is critical to determine the distribution and abundance patterns across the state. When conducted for several years, such a program will also provide valuable information on population trends. Data can then be used for habitat conservation or species-specific research.

Element 2: Species/Habitat Condition

2.1 Scale

Although there are areas where whip-poor-wills appear more concentrated in the state (Ossipee Pine Barrens, Merrimack and Hillsborough Counties), the lack of consistent statewide data makes it impossible to evaluate these putative concentrations. Because whip-poor-wills are not restricted to pine barrens habitats, it is similarly impractical to identify planning units based on habitat. As a result, all discussion of whip-poor-will conservation will treat the species' entire range as a single unit, with the recognition that certain habitats within this distribution will be divided into planning units. Whip-poor-will conservation can occur on a statewide scale as described in this profile, or within smaller units identified for specific habitats in which whip-poor-wills occur.

2.2 Relative Health of Populations

Based on the available data, statewide whip-poor-will populations are declining. Data from historic strongholds (Ossipee, Merrimack/Hillsborough) sug-

gest that the species remains common in these areas, although there are no comparable baseline data on abundance prior to 2003.

2.3 Population Management Status

Whip-poor-will populations are not currently managed in New Hampshire.

2.4 Relative Quality of Habitat Patches

In the absence of detailed data on habitat needs, it is not feasible to assess quality of whip-poor-will habitat at most scales. To the extent that habitat continues to be lost to development, succession, or fire suppression (see element 3), overall habitat quality is likely to continue to decline in most areas.

2.5 Habitat Patch Protection Status

Because whip-poor-wills remain widespread in the southern part of the state, and because specific locations are not determined (most records are of heard birds, often at some distance), an analysis of protection status is not possible. One could approximate this number by calculating the percent of the species' statewide range (south of 68 degree July isotherm plus western highlands) that is protected. However, this number would not reflect the patchy distribution of whip-poor-wills within the potential range.

2.6 Habitat Management Status

Habitat management specifically to benefit this species is not occurring anywhere in New Hampshire. However, ongoing attempts to restore or mimic fire in pine barrens would likely benefit whip-poor-wills, which have been documented concentrating in recently burned areas in southeastern Massachusetts (J. Kelly, United States Army – Fort Edward, personal communication). See the pine barrens habitat profile for more detail on habitat management issues.

2.7 Sources of Information

Information on whip-poor-will distribution in New Hampshire was obtained primarily from NHBR and was supplemented by historical accounts and recent surveys.

2.8 Extent and Quality of Data

See Section 1.8.

2.9 Condition Assessment Research

As discussed in section 1.9, coordinated whip-poor-will monitoring is needed before any attempt can be made to fully assess habitat condition. If areas of high concentration are discovered, detailed studies should be conducted to determine what makes the habitat attractive to whip-poor-wills.

Element 3: Species Threat Assessment

3.1.1 Development (Habitat Loss and Conversion)

Because the bulk of New Hampshire's whip-poor-will population occurs in the rapidly developing southern part of the state, the species is at high risk of losing habitat to development. At the same time, the pine barrens and other dry forests preferred by the species are usually located in river valleys and near lakes where development pressure is particularly intense.

3.1.2 Altered Natural Disturbance (Natural Succession)

(A) Exposure Pathway
Because of ongoing declines in agriculture (see grassland habitat profile), many open areas adjacent to forests are either growing up to shrubland or young forest or are being lost to development (section 3.1.1). Although early successional habitat may remain somewhat open for several years, it will eventually revert to forest if not managed.

(B) Evidence
Because whip-poor-wills require openings in which to forage, loss of fields or other early seral stages are believed to lower habitat quality (Cink 2002, Wilson 2003). If the amount of open habitat is reduced to the point where foraging efficiency is reduced, whip-poor-wills may no longer occupy the area even if nesting habitat remains suitable (Cink 2002).

3.1.3 Predation and Herbivory

(A) Exposure Pathway
Several authors (e.g., Laughlin and Kibbe 1985, Cink 2002, Petersen and Meservey 2003) have speculated that whip-poor-will declines are related to a decline in prey populations. In particular, it has been proposed that saturnid and sphingid moth populations over much of the Northeast were severely depressed following widespread spraying for the introduced gypsy moth (*Lymantria dispar*) from roughly 1950 to 1970. Any subsequent recovery of moth populations is believed to have been hampered by a parasitoid fly (*Compsilura concinnata*), which was introduced to combat gypsy moths (Schweitzer 2004). An alternate hypothesis is that moth declines are the result of atmospheric pollution (Andrele and Carroll 1988).

(B) Evidence
There are limited data on the nature and extent of moth declines in eastern North America where most gypsy moth control has occurred. Thus, any connection between large moth populations and whip-poor-will populations is largely speculative. Data on diet indicate that almost 60% of prey items are moths (Cink 2002), which at least corroborate the species' reliance on this group of insects.

3.1.4 Altered Natural Disturbance (Fire Suppression)

As per threat 3.1.1, this issue will be dealt with in the context of pine barrens habitat as a whole.

3.2 Sources of Information

Information used in this section was obtained primarily through a literature review.

3.3 Extent and Quality of Data

For threats related to habitat loss and maturation, there are generally extensive data on extent but relatively few data pertaining to effects on whip-poor-wills (see section 3.4). Data are even more lacking for hypotheses about declines in whip-poor-will prey populations.

3.4 Threat Assessment Research

Data are needed on habitat use patterns of whip-poor-wills throughout their range, although studies of this nature are currently underway in Massachusetts (J. Kelly, United States Army – Ft. Edward, personal communication). There are even fewer data linking declines in prey populations to whip-poor-will declines, and any study of this threat would need to monitor populations of prey insects and their parasitoids. Finally, there are few studies of whip-poor-wills on their winter grounds in Florida and Central America (Cink 2002), and one should not discount the possibility that habitat loss, pesticide use, or other factors operating during the non-breeding season are affecting whip-poor-will populations. The widespread range retraction over much of the Northeast could be an indication that non-local factors (i.e., during the non-breeding season) are affecting populations on a larger scale.

Element 4: Conservation Actions

In the absence of more data on how threats affect whip-poor-will populations in New Hampshire, it is not possible to identify species-specific conservation actions. Whip-poor-wills will likely benefit from any action, whether land protection or habitat restoration, that targets the pine barrens and other forested habitats in which they occur. In both habitats, it will be important to consider the species' need for openings and edges for foraging, and when possible plan to maintain core habitats in a mix of seral stages.

Element 5: References

5.1 Literature

Andrle, R.F., and J.R. Carroll. 1988. The Atlas of Breeding Birds of New York State. Cornell University Press, Ithaca, New York, USA.

Cink, C.L. 2002. Whip-poor-will (*Caprimulgus vociferus*). *In* The Birds of North America, No. 620 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, Pennsylvania, USA.

Foss, C.R. 1994. Atlas of Breeding Birds of New Hampshire. New Hampshire Audubon, Concord, New Hampshire, USA.

Hunt, P.D. 2004. Final Report on Whip-poor-will

Surveys in the Piscataquog River Watershed: Summer 2003. Report to Piscataquog Watershed Association and UNH Cooperative Extension. New Hampshire Audubon, Concord, New Hampshire, USA.

Laughlin, S.B., and D.P. Kibbe. 1985. The Atlas of Breeding Birds of Vermont. University Press of New England, Hanover, New Hampshire, USA.

Murin, T., and B. Bfeiffer. 2003. Birdwatching in Vermont. University Press of New England, Hanover, New Hampshire, USA.

New York Department of Environmental Conservation ((NYDEC)). 2005. NY Breeding Bird Atlas Website. www.dec.state.ny.us/apps/bba/results.

Petersen, W.R., and W.R. Meservey. 2003. Massachusetts Breeding Bird Atlas. Massachusetts Audubon Society, Lincoln, Massachusetts, USA.

Sauer, J.R., J.E. Hines, and J. Fallon. 2004. The North American Breeding Bird Survey, Results and Analysis 1966-2003. Version 2004.1, USGS Patuxent Wildlife Research Center, Laurel, Maryland, USA.

Schweitzer, D.F. 2004. Gypsy Moth (*Lymantria dispar)*: Impacts and Options for Biodiversity-Oriented Land Managers. NatureServe, Arlington, Virginia, USA.

Sibley, D. 1993. The Birds of Cape May. New Jersey Audubon Society, Franklin Lakes, New Jersey, USA.

Veit, R.R., and W.R. Petersen. 1993. Birds of Massachusetts. Massachusetts Audubon Society, Lincoln, Massachusetts, USA.

5.2 Data Sources

NHBR. New Hampshire Bird Records, New Hampshire Audubon, Concord, New Hampshire, USA.

SPECIES PROFILE

Willet

Catoptrophorus semipalmatus

Federal Listing: Not listed
State Listing: Special concern
Global Rank: G5
State Rank: S3B
Authors: Megan McElroy and Kimberly Babbitt, University of New Hampshire

Element 1: Distribution and Habitat

1.1 Habitat Description

Willets inhabit salt marshes, or grass-dominated tidal wetlands existing in the transition zone between ocean and upland (Niering and Warren 1980) (see Salt Marshes habitat profile). In New Hampshire, willets breed in large salt marshes dominated by *Spartina* grasses (Gavutis 1994, Lowther et al. 2001). Willets forage in sparsely vegetated *Spartina* grasses, along tidal creeks, at salt marsh edges, and at mussel beds and mudflats near salt marshes (Lowther et al. 2001). Their diet consists primarily of crustaceans, mollusks, polychaetes, and adult and larval insects (Lowther et al. 2001).

1.2 Justification

In New Hampshire, the willet is identified as a species of special concern. Little data exist on willet population trends, estimates, and threats in the state, and no long-term studies of the species have been conducted in New Hampshire. Loss and degradation of salt marshes are probably the most pressing threats to willet populations in New Hampshire. High-quality salt marsh habitat must be available in large patches across a landscape to support a population's survival and growth. Degradation and loss of salt marsh habitat caused by tidal restrictions have resulted in the replacement of typical salt marsh vegetation with invasive reeds and grasses, such as cattails and common reed (Sinicrope et al. 1990, Burdick et al. 1997, Brawley et al. 1998). Areas of invasive plants in and around salt marshes decrease available habitat for willets because they are not suitable habitat.

The lack of knowledge of population sizes and threats in New Hampshire is similar for other salt marsh nesting birds, such as salt marsh sharp-tailed sparrow and seaside sparrow. Research and monitoring of this salt marsh guild may indicate marsh health and provide insight into effects of marsh degradation and outcomes of restoration and other management practices.

1.3 Protection and Regulatory Status

- The Migratory Bird Treaty Act of 1918 legally protects willets from the take, transport, and use of the species (including eggs, nests, and feathers).
- Salt marsh habitat is regulated by NHDES. Activities that may involve filling, dredging, or destroying wetlands are strictly regulated and require approved permits before work can commence (RSA 482-A).

1.4 Population and Habitat Distribution

Eastern willets (i.e., the eastern subspecies) breed in coastal wetlands along the Atlantic and Gulf coasts (Lowther et al. 2001). In New Hampshire, willets breed in large salt marshes (Gavutis 1994, NHBR, McElroy and Babbitt, unpublished data). While willets may use any of these marshes as migratory habitat, breeding occurs in Hampton and Seabrook salt (NHBR, McElroy and Babbitt, unpublished data).

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

1.7 Sources of Information

A literature review was conducted to obtain willet habitat, population distribution, and status data. Historical information on the distribution of willets in New Hampshire comes from NHA's database of bird records. Information on current population distribution and status comes from data collected in 2004 by researchers from UNH.

1.8 Extent and Quality of Data

Historical bird records from NHA are sightings reported by birders. Although this information is vital to knowledge of historical distribution, it does not give an accurate account of population size or confirmed breeding locations throughout the state. The most comprehensive dataset comes from UNH researchers and includes confirmed breeding locations and population estimates throughout the state. Although this dataset is extensive, it covers only one year. Therefore, significant gaps exist in understanding of willet breeding populations throughout the state, and long-term trends in population locations and sizes in New Hampshire are unknown.

1.9 Distribution Research

To determine willet distribution in New Hampshire, a long-term survey of salt marsh habitat specifically for willets (i.e., point counts conducted during breeding season at established points) is needed in conjunction with regional efforts. It is essential that monitoring is long term because salt marsh habitat quality changes, potentially affecting willet populations from one breeding season to the next.

Element 2: Species/Habitat Condition

2.1 Scale

The New Hampshire conservation unit for the willet is Coast (including Rye, Hampton, and Seabrook)

2.2 Relative Health of Populations

In New Hampshire, the willet population during the breeding season is estimated at 100 individuals (McElroy and Babbitt, unpublished data). Because a sufficient long-term survey of willets has not been implemented and Breeding Bird Survey routes do not sufficiently cover salt marshes, data on population trends are not available. In 2004, a complete survey focused on the presence and abundance of willets at all potential breeding sites in New Hampshire's salt marshes (McElroy and Babbitt, unpublished data).

Data from the 2004 breeding season showed willet activity at the following sites, grouped by breeding category (Confirmed Breeding = nest(s) found; Possible Breeding = adults present throughout season, calling & territorial behavior, no evidence of nests and/or fledglings; Potential Breeding = a few birds present feeding at some point in the season, no evidence of any current breeding activity) (table 1). Estimated Relative Abundance (ERA) categories are also included.

2.3 Population Management Status

New Hampshire currently has no ongoing population management efforts for willets. The large marsh complex in Hampton contains all known breeding and possible breeding populations. Therefore, this location should be a priority for any conservation actions. In particular, the marsh off Route 1A between Routes 101 and 101E is an important breeding site for willets.

2.4 Relative Quality of Habitat Patches

In New England, willets breed in large, unrestricted, *Spartina*-dominated marshes with nearby foraging areas (Gavutis 1994, Lowther et al. 2001, McElroy and Babbitt, unpublished data). Most marshes along the coast in Hampton, Rye, and Seabrook potentially have the key ecological attributes (e.g., migratory or nesting habitat), but more research is needed to better understand the marshes' habitat quality for willets.

2.5 Habitat Patch Protection Status

See Salt Marshes habitat profile

2.6 Habitat Management Status

See Salt Marshes habitat profile

2.7 Sources of Information

A literature review provided information on research

and habitat management. Research by UNH scientists provided an assessment of population and management status. Information on habitat protection and management came from the New Hampshire Coastal Program's website and published articles on habitat restoration.

2.8 Extent and Quality of Data

The most extensive dataset comes from researchers at UNH. It includes confirmed breeding locations and population estimates throughout the state. However, this dataset covers only one field season. An adequate assessment of population health and habitat suitability would require a long-term study. Significant gaps exist in understanding of willet populations and the effects of habitat restoration in New Hampshire.

2.9 Condition Assessment Research

Long-term monitoring of willet populations is essential for knowledge of population dynamics, trends, and ecology. It would provide valuable data to increase understanding of threats to the species and the effects of habitat management efforts.

To determine population abundance at sites of known use (and therefore, a more accurate assessment of marshes of high protection/conservation priority), in-depth monitoring of the breeding population (in addition to point count surveys) is needed. This species is territorial, so point count surveys and similar methods can be used effectively to estimate population abundance and potential breeding sites.

Additionally, a long-term dataset of presence/absence and abundance estimates at marshes throughout New Hampshire would allow development of a GIS map showing locations with high densities of breeding willets. The maps would help target hotspots for research, conservation, and habitat protection.

Element 3: Species Threat Assessment

3.1.1 Development (Habitat Loss)

(A) Exposure Pathway
See Salt Marshes habitat profile and Saltmarsh Sharp-tailed Sparrow profile

(B) Evidence
Habitat loss is a significant factor in the decline of wetland birds that depend on salt marshes for nesting (Greenlaw and Rising 1994, Benoit and Askins 1999). Habitat loss could potentially affect willet population size; Shriver et al. (2004) found that occurrences of willets in the Gulf of Maine correlated with marsh size and proximity to other marshes. In Connecticut, willets were present only in marshes larger than 138 hectares (Benoit and Askins 2002). Therefore, continued habitat loss due to development pressures is likely to negatively affect willet populations in New Hampshire.

3.1.2 Development (Fragmentation)

(A) Exposure Pathway
See Salt Marshes habitat profile and Saltmarsh Sharp-tailed Sparrow profile

(B) Evidence
Willets are considered area-sensitive species, and populations could be negatively impacted by habitat fragmentation and decreasing patch size. In Connecticut, willet densities exhibited a positive relationship with marsh area (Benoit and Askins 2002).

3.1.3 Altered Hydrology (Tidal Restriction)

(A)Exposure Pathway
See Sharp-tailed Sparrow profile

(B) Evidence
Vegetative composition and structure are important components of willet ecology. Willets build nests along edges of salt marshes in smooth cordgrass, salt hay grass, or on wrack in the high marsh (Lowther et al. 2001, McElroy and Babbitt, unpublished data). However, brackish species and invasive plant species tend to replace salt marsh grasses in tidally restricted marshes (Niering and Warren 1980, Benoit and Askins 1999). Salt marshes with severe tidal restrictions lack quality nesting habitat for willets (Lowther et al. 2001).

3.1.4 Introduced Species (Introduced Plants)

(A) Exposure Pathway
See Sharp-tailed Sparrow Profile

(B) Evidence
Dense, monotypic stands of common reed provide unsuitable or less-preferable habitat and food for many wildlife species (Roman et al. 1984). Willets are normally found in *Spartina* spp. grass and are unlikely to use a marsh dominated by tall, thick stands of common reed or cattails. According to Benoit and Askins (1999), the presence of smooth cordgrass at a site was a significant predictor for the abundance of willets. Willets were absent from survey plots with mixed brackish vegetation, cattail, and common reed (Benoit and Askins 1999).

3.1.5 Altered Hydrology (Mosquito Ditching)

(A) Exposure Pathway
See Sharp-tailed Sparrow profile

(B) Evidence
Mosquito ditching reduces the abundance of cordgrass, an essential habitat feature for breeding willets, by draining standing water on the marsh surface (Benoit and Askins 1999, Lowther et al. 2001). Drier, ditched marshes may not provide quality nesting habitat or a sufficient abundance of invertebrates and therefore are less suitable for willets (Lowther et al. 2001). In addition, the lower water levels and the resulting invasion of bushes and brackish plants along ditch banks increases predators' access to the marsh (Post and Greenlaw 1994).

3.1.6 Mercury, Non-Point Source Pollution
See Sharp-tailed Sparrow profile

3.2 Sources of Information

Information on threats to willets was obtained from a literature review, New Hampshire Coastal Program, NHNHB, and Biodiversity Research Institute in Gorham, Maine.

3.3 Extent and Quality of Data

On a regional level, threats to willets have gained significant attention from researchers and managers, but in New Hampshire research is lacking. Effects of mosquito ditching, habitat loss, and invasive plants on the occurrence and abundance of willets have received some study in southern New England.

3.4 Threat Assessment Research

Threats to willet populations have not been documented in New Hampshire. Research priorities for threat assessment include population trends, effects of wetland restoration, and impacts of increased human disturbance near marsh habitat (e.g., increased road density and noise).

Research is needed to determine the effects of methylmercury on willet populations in New Hampshire. Methylmercury has become a major ecological and human health concern in the region. The Biodiversity Research Institute is investigating the effects of mercury on salt marsh birds in New England, which can provide a basis for conservation actions.

Element 4: Conservation Actions

4.1.1 Protecting remaining salt marsh habitat and surrounding upland buffer habitat, Habitat Protection
See Salt Marshes habitat profile and Saltmarsh Sharp-tailed Sparrow profile

4.1.2 Restoring degraded salt marshes back to Spartina dominated systems, Restoration and Management
See Salt Marshes habitat profile and Saltmarsh Sharp-tailed Sparrow profile

Element 5: References

5.1 Literature

Benoit, L. K., and R. A. Askins. 1999. Impact of the spread of Phragmites on the distribution of birds in Connecticut tidal marshes. Wetlands 19:194-208.

Benoit, L. K., and R. A. Askins. 2002. Relationship between habitat area and the distribution of tidal marsh birds. Wilson Bulletin 114:314-323.

Brawley, A. H., R. S. Warren, and R. A. Askins. 1998. Bird use of restoration and reference marshes within the Barn Island wildlife management area, Stonington, Connecticut, USA. Environmental Management 22:625-633.

Broome, S. W., E. D. Seneca, and W. W. Woodhouse, Jr. 1988. Tidal salt marsh restoration. Aquatic Botany 32:1-22.

Burdick, D. M., M. Dionne, R. M. Boumans, and F.

T. Short. 1997. Ecological responses to tidal restorations of two northern New England salt marshes. Wetlands Ecology and Management 4:129-144.

Clarke, J. A., B. A. Harrington, T. Hruby, and F. E. Wasserman. 1984. The effect of ditching for mosquito control on salt marsh use by birds in Rowley, Massachusetts. Journal of Field Ornithology 55: 160-180.

Gavutis, G. W., Jr. 1994. Willet (Catoptrophorus semipalmatus). Pages 82-83 *in* C. Foss, editor. Atlas of breeding birds in New Hampshire. New Hampshire Audubon, Concord, New Hampshire, USA.

Greenlaw, J. S., and J. D. Rising. 1994. Sharp-tailed Sparrow (*Ammodramus caudacutus*). Number 112 *in* A. Poole and F. Gill, editors. The birds of North America. The Academy of Natural Sciences, Philadelphia, Pennsylvania, USA.

Hunt, P. 2004(Draft). A regional perspective on New Hampshire's birds of conservation priority: objectives, threats, research needs, and conservation strategies. New Hampshire Audubon, Concord, New Hampshire.

Johnson, R. G., and S. A. Temple. 1990. Nest predation and brood parasitism of tallgrass prairie birds. Journal of Wildlife Management 54:106-111.

Kamman, N. C., P. M. Lorey, C. T. Driscoll, R. Estabrook, A. Major, B. Pientka, and E.

Glassford. 2004. Assessment of mercury in waters, sediments, and biota of New Hampshire and Vermont lakes, USA, sampled using a geographically random design. Environmental Toxicology and Chemistry 23:1172-1186.

Lane, O., and D. Evers. 2005. Developing a geographic exposure profile of methylmercury availability in salt marshes of New England. Report BRI 2005-04 submitted to the Maine Department of Inland Fisheries and Wildlife, Maine Department of Environmental Protection, and Rachel Carson National Wildlife Refuge. Biodiversity Research Institute, Gorham, Maine.

Lowther, P. E., H. D. Douglas, III, and C. L. Gratto-Trevor. 2001. Willet (*Catoptrophorus semipalmatus*). Number 579 in A. Poole and F. Gill, editors. The birds of North America. The Academy of Natural Sciences, Philadelphia, Pennsylvania, USA.

Mitsch, W. J., and J. G. Gosselink. 2000. Wetlands. Third edition. John Wiley & Sons, Inc., New York, New York.

NHCP (New Hampshire Coastal Program). New Hampshire Department of Environmental Services, Concord, New Hampshire. NHCP home page: http://www.des.state.nh.us/Coastal/ Accessed 2004 November.

NHNHB (New Hampshire Natural Heritage Bureau). 2004. Natural communities of New Hampshire. http://www.nhdfl.org/formgt/nhiweb/Documents/NaturalCommunitiesWeb.pdf Accessed 2004 November.

Niehaus, A. C., S. B. Heard, S. D. Hendrix, and S. L. Hillis. 2003. Measuring edge effects on nest predation in forest fragments: do finch and quail eggs tell different stories? American Midland Naturalist 149:335-343.

Niering, W. A., and R. S. Warren. 1980. Vegetation patterns and processes in New England salt marshes. BioScience 30:301-306.

Post, W., and J. S. Greenlaw. 1994. Seaside sparrow (Ammodramus maritimus). Number 127 *in* A. Poole and F. Gill, editors. The birds of North America. The Academy of Natural Sciences, Philadelphia, Pennsylvania, USA.

Reinert, S. E., F. C. Golet, and W. R. DeRagon. 1981. Avian use of ditched and unditched salt marshes in southeastern New England: a preliminary report. Presented at the 27th Annual Meeting, Northeastern Mosquito Control Association, Nov. 2-4, 1981, Newport, Rhode Island.

Roman, C. T., W. A. Niering, and R. S. Warren. 1984. Salt marsh vegetation change in response to tidal restriction. Environmental Management 8: 141-150.

Shriver, W. G., D. Evers, and T. Hodgman. 2002. Mercury exposure profile for sharp-tailed sparrows breeding in coastal Maine salt marshes. Report BRI 2002-11 submitted to the Maine Department of Environmental Protection. BioDiversity Research Institute, Gorham, Maine.

Sinicrope, T. L., P. G. Hine, R. S. Warren, and W. A. Niering. 1990. Restoration of an impounded salt marsh in New England. Estuaries 13:25-30.

Warren, R. S., P. E. Fell, R. Rozsa, A. H. Brawley, A. C. Orsted, E. T. Olson, V. Swamy, and W. A. Niering. 2002. Salt marsh restoration in Connecticut: 20 years of science and management. Restoration Ecology 10:497-513.

5.2 Data Sources

NHBR. New Hampshire Bird Records, New Hampshire Audubon, Concord, New Hampshire.

Table 1. New Hampshire salt marshes with willet populations during the 2004 breeding season (McElroy and Babbitt, unpublished data).

SPECIES PROFILE

American Woodcock

Scolopax minor

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S4
Author: Julie Robinson and Jim Oehler, New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

Woodcock (*Scolopax minor*) are an early successional species that use different habitats depending on activity, time of day, and season. Dense, shrub-dominated forests with moist soils are ideal habitats (Keppie and Whiting 1994). Moist soils ensure that earthworms, which comprise nearly 80% of woodcock diet, are near the soil surface and are available to foraging birds (Dessecker and McAuley 2001).

In spring, males need openings ("singing grounds") to perform courtship displays and attract females (Dwyer et al. 1988). Available nesting and rearing habitat determine the location of singing grounds rather than specific vegetation characteristics (Dessecker and McAuley 2001). Migrating and breeding woodcock favor areas of young aspen, birch, or alders and may also use overgrown fields, burned or recently logged areas, and wetlands (Lacaillade 1994). Nests and broods can be found in mixed-age forests, although young hardwood stands (especially aspen) are preferred (Mendall and Aldous 1943).

During summer, young hardwoods to older stands with a dense understory, particularly alder, provide daytime cover for feeding (Dessecker and McAuley 2001). In northern breeding areas, conifer stands are used rarely, except during droughts when they may be critical for survival (Straw et al. 1994). Diurnal habitats in fall and on migration are Young hardwood stands on moist soils with dense shrubs are important in the fall and during migration.

1.2 Justification

Woodcock numbers in New Hampshire tend to be stable and relatively strong compared to data from other portions of the eastern United States. Survey results for 2004 were relatively close to those reported in 2003. Southeast New Hampshire continues to show an increase in singing males, although this could be attributed to favorable survey conditions. Woodcock are most abundant in northern New Hampshire, where habitat is most suitable.

Habitat loss and degradation contribute to declining woodcock populations elsewhere in the East. Studies suggest that ground-nesting songbirds may currently be experiencing low reproductive rates (Straw et al. 1994). Decline and fragmentation of early successional forests may be limiting woodcock recruitment (Dessecker and McAuley 2001).

1.3 Protection and Regulatory Status

Woodcock hunting is regulated in New Hampshire under the waterfowl regulatory process. The American Woodcock is protected under the Migratory Treaty Act.

1.4 Population and Habitat Distribution

Breeding woodcock are relatively common throughout New Hampshire at elevations below 2,000 ft (610 m), although their numbers have declined since the 1960s in eastern New Hampshire (Lacaillade 1994). Singing ground survey data indicate that New Hampshire's highest woodcock concentrations occur in the west-central and southeast regions of the state and in northern Coos County (Lacaillade 1994). Historical

records for woodcock are vague. Since the woodcock is a small game bird, it was probably not hunted until larger game began to disappear (Silver 1957). Fishermen introduced earthworms to the Umbagog Region around 1825 for bait; woodcock were believed to have appeared there shortly afterwards and were common by the late 1800s (Silver 1957). Refer to element 1.4 in the ruffed grouse or shrubland profile for information on the abundance and distribution of habitat suitable for woodcock.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

No habitat map was generated for woodcock since habitat is difficult to map using existing remotely sensed data. Refer to element 1.6 in the ruffed grouse or shrubland profiles for more information.

1.7 Sources of Information

The primary source of information was the annual woodcock report compiled by the USFWS for those states that conduct annual singing ground surveys. Information was gleaned from this document through literature reviews, research projects conducted in the region, and available databases.

1.8 Extent and Quality of Data

The quality of population data for woodcock is very good, however, confirmed breeding records are difficult to obtain due to the species' inconspicuous nesting behavior (Lacaillade 1994). Singing ground surveys have been conducted since 1968 and summarized annually. Woodcock are managed on the basis of 2 regions or populations, Eastern and Central (Kelley 2004). There is a wing-collection survey of hunters that provides age-specific data used to assess reproductive success (Kelley 2004). The ratio of immature birds per adult female in the harvest provides an index to recruitment of young into the population (Kelley 2004). Many studies on brood ecology, early successional habitat, and influence of hunting have been completed in the Northeast.

1.9 Distribution Research

Current mapping data and technology are inadequate for mapping woodcock habitat. Technologies that can assess differences in vegetation structure (e.g., radar, lidar) should be investigated and applied to generate a map of American woodcock habitat. Studies are needed to determine where early successional habitat exists and where it can be created and maintained.

Element 2: Species/Habitat Condition

2.1 Scale

Counties will be used as the conservation-planning unit for this habitat because that is the scale at which most information exists and because most technical and financial assistance (from the USDA Natural Resources Conservation Service (NRCS), University of New Hampshire Cooperative Extension, and others) is provided to private landowners by county.

2.2 Relative Health of Population

The singing ground surveys indicate that New Hampshire's highest breeding concentrations occur in the west central and southeastern regions of the state and in northern Coos County (Lacaillade 1994). The Singing-ground survey in the Eastern Region in 2004 was not significantly different than the 2003 level (Kelley 2004). In the Eastern Region, the 2004 breeding population index was 1.84 singing-males per route. This was higher than the predicted value of 1.70 (Kelley 2004). Northern New England, including New Hampshire, has experienced an increase in the breeding population indices over the past 5 years of the singing ground survey. This could be due in part to favorable weather during the surveying season.

For the wing-collection survey, the recruitment index in the Eastern Region (1.5 immatures/adult female) was slightly higher than the 2003 index, but was 12% below the long term (1963-2002) average (Kelley 2004). In 2004, New Hampshire showed a statistically insignificant increase in the recruitment index. New Hampshire's Breeding Bird Atlas reveals that woodcock are still well distributed throughout the state, and suggests that they are most common in the central and southeast regions (Lacaillade 1994).

Elsewhere in the Eastern region, population abundance indices suggest a long-term decline (Kelly 2004). Loss and degradation of wetlands have destroyed breeding, migration, and wintering habitat (Lacaillade 1994). Pesticides have affected the earthworm populations in many areas, decimating the woodcock's primary food source (Lacaillade 1994).

2.3 Population Management Status

Reliable annual population estimates, harvest estimates, and information on recruitment and distribution are essential for comprehensive woodcock management.

2.4 Relative Quality of Habitat Patches

Refer to element 2.4 in the ruffed grouse and shrubland profile for information on relative quality of habitat patches for American woodcock.

2.5 Habitat Patch Protection Status

Since no habitat map was generated, the habitat patch protection status of young forest habitats in New Hampshire is unknown. However, given the ephemeral nature of young forest habitats, tree harvesting and other vegetation manipulation techniques will need to be employed to generate suitable habitat. This can occur on both public and private land.

2.6 Habitat Management Status

See section 2.6 in the Shrubland profile.

2.7 Sources or Information

Sources of information for element 2 include journal articles, websites, GIS data, and white papers.

2.8 Extent and Quality of Information

The extent and quality of data for woodcock population information are quite good. However, information on habitat abundance and distribution is lacking.

Element 3: Species Threat Assessment

3.1.1 Development (Habitat Loss and Conversion)

Refer to "Development (Habitat Loss and Conversion)" threat in the ruffed grouse profile.

3.1.2 Altered Natural Disturbance (Natural Succession)

Refer to threats in the ruffed grouse profile.

Element 4: Conservation Actions

4.1.1 Habitat Conservation, Habitat Protection

Refer to "Habitat Conservation, Habitat Protection" strategy in the ruffed grouse profile.

4.1.2 Vegetation Management, Restoration, and Management

Refer to "Vegetation Management, Restoration and Management" strategy in the ruffed grouse profile. In addition to the strategies outlined in the ruffed grouse profile, protection and maintenance of scrub-shrub wetlands will be important for maintaining woodcock populations in New Hampshire. This can be done by maintaining natural establishment, occupancy, and abandonment of beaver flowages (see strategies in the Marsh and Shrub Wetlands profile). In some instances, regeneration of alder stands may be necessary.

Element 5: References

Dessecker, D.R., and D.G. McAuley. 2001. Importance of early successional habitat to ruffed grouse and American woodcock. Wildlife Society Bulletin 29(2):

Dwyer, T.J., D.G. McAuley, and E.L. Derleth. 1983. Woodcock singing-ground counts and habitat changes in the northeastern United States. Journal of Wildlife Management 47:772-779.

Hart, B., and D. Tripp-Taylor. 2002. Saving special places: Community funding for land conservation. Society for the Protection of New Hampshire Forests and Center of Land Conservation Assistance.

Kelley, J.R. Jr. 2004. American Woodcock population status, 2004. United States Fish and Wildlife Service, Laurel, Maryland, USA.

Keppie, D.M., and R.M. Whiting, Jr. 1994. American Woodcock (*Scolopax minor*). *In* The Birds of North America, No. 100, A. Poole and F. Gill, editors. Philadelphia: The Academy of Natural Sciences; Washington, D.C.: The American Ornithologists' Union.

Lacaillade, H.C. 1994. American Woodcock. Pages 90-92 *in* Atlas of Breeding Birds in New Hampshire, C.R. Foss, editor. Arcadia, Dover, New Hampshire, USA.

Mendall, H.L., and C.M. Aldous. 1943. The ecology and management of the American woodcock. Maine Cooperative Wildlife Research Unit. University of Maine, Orono, Maine, USA.

Silver, H. 1957. A History of New Hampshire game and furbearers. New Hampshire Fish and Game Department, Survey Rep 6. Concord, New Hampshire, USA.

Straw, J.A., D.G. Krementz, M.W. Olinde and G.F. Sepik. 1994. American woodcock. Pages 97-114 in Migratory shore and upland game bird management in north America, T.C. Tacha and C.E. Braun editors. International Association of Fish and Wildlife Agencies, Washington D.C, USA.

SPECIES PROFILE

Non-Breeding Birds

Federal Listing: Not listed
State Listing: Not listed
Global Rank: Not ranked
State Rank: Not ranked
Authors: Pamela D. Hunt, Rebecca W. Suomala, and Carol R. Foss, New Hampshire Audubon

Element 1: Distribution and Habitat

1.1 Habitat Description

Habitat for non-breeding birds includes nearly all habitats in the state, from offshore waters to high elevation conifer forests. For this document, 11 focal areas where birds tend to concentrate have been identified (see section 1.4). In general, birds use critical habitats within focal areas in the following ways:

- Grasslands and agricultural areas are used extensively by waterfowl, seed-eating passerines, and some raptors during spring and fall migration. Depending on location and snow cover, these areas may also be used by a reduced set of species during the winter. Flooded fields are particularly important to waterfowl during spring and to a lesser extent to shorebirds during spring and fall. A few shorebirds (plovers, upland sandpiper) also congregate in dry fields in the fall.
- Early successional, scrub-shrub, and edge habitats—including forest-agricultural boundaries—often leaf-out earlier in the season and often retain both foliage and fruit later into the fall. They are important to early spring and late fall migrant land birds, as well as to frugivores in fall (Parrish 1997, 2000; Suthers et al. 2000, Rodewald and Brittingham 2004).
- Riparian forests provide important stopover habitat to migrating land birds and waterfowl (e.g., wood duck. Such areas tend to be phenologically ahead of upland forests, and thus provide a more reliable food supply—particularly for insectivorous birds—during the early phase of spring migration (mid-April through mid-May).
- Open water is important for waterfowl and waterbirds, as well as for some shorebirds, at all times of year. Some species seek open water during winter and spring migration, including by non-breeding bald eagles. Offshore salt water remains open year round, and habitat suitability here probably depends more on currents, water depth, degree of shelter, and substrate. Among passerines, swallows are particularly dependant on open water—and its associated flying insects—in spring and fall.
- Fresh-water wetlands (ponds, emergent marshes, etc.) are used by waterfowl and some waterbirds (coots, grebes, herons) primarily during spring and fall migration. Rails, bitterns, and snipe may also use marshes during migration.
- Salt marshes and tidal flats are critical feeding and roosting habitats for migrating shorebirds. Marshes and flats are also used extensively by non-breeding herons from April through October, and by post-breeding terns, gulls, and cormorants in late summer and early fall. Large numbers of salt marsh sparrows use salt marshes during migration, particularly in the fall.
- Coastal dunes habitats serve a similar function to some grasslands. These habitats are used by several species of seed-eating passerines during fall and winter, and occasionally raptors. Some shorebirds roost in dunes or on adjacent beaches at high tide.
- Rocky shorelines are used by shorebirds, gulls, cormorants, and some waterfowl throughout the year.

1.2 Justification

Birds are most vulnerable during the non-breeding

season, when the stresses of migration and weather are added to the need to find food and avoid predators. Because migratory birds often spend much time away from breeding grounds, the conservation of non-breeding individuals and their habitats is critical. Conversely, if factors limit a species during winter or migration, then management on breeding grounds may not have the desired effect. Migrating birds need places to feed, rest, reorient, avoid adverse weather, and minimize other stress (predation, dehydration, etc.). Some migrant taxa, particularly shorebirds and waterfowl, regularly use the same staging areas each year, and alteration of these sites may have significant effects on populations (Moore et al. 1995, Brown et al. 2001). Even in passerines and other species with limited stopover site fidelity, broad alteration of stopover habitat may have similar effects (Sherry and Holmes 1995, Hutto 2000). Similarly, use of wintering grounds may ultimately affect breeding success (Norris et al. 2004). Non-breeding and breeding habitats are often different, forcing managers to consider multiple habitats to protect a species.

Additional threats covered in this profile include climate change, cat predation, collisions with man-made structures, and effects of pesticides and other contaminants. Their effects on migrant bird populations remain largely unknown and thus warrant future study.

1.3 Protection and Regulatory Status

There are no provisions to protect non-breeding bird habitat, except when the bird is federally listed. However, some protection is offered by many existing statutes, including the Shoreland Protection Act, conservation of agricultural lands, and wetland protection measures.

1.4 Population and Habitat Distribution

Although non-breeding habitat is distributed across the state, birds are known to concentrate in certain areas. These 11 focal areas, and the reasons for their selection, are as follows (see also table 1).

Connecticut River Valley
The open water and agricultural lands along the Connecticut River provide stopover habitat for several species of waterfowl. The north-south orientation of the valley and the presence of extensive areas of edge or early successional habitat make it an important flyway for southbound fall migrants and for northbound land birds in spring. Shorebirds comprise a minor component of the area's migrant pool, but some species may reach high densities at larger reservoirs or agricultural fields. Finally, open water provides winter habitat for bald eagles and several species of waterfowl.

Merrimack River Valley
This valley is important for the same reasons as the Connecticut River, although waterfowl and shorebird diversity is somewhat lower.

Contoocook River Valley
Because of its north-south orientation, the Contoocook may be valuable to passerines in much the same way as are the Connecticut and Merrimack valley. Yet the relative narrowness of this valley and lack of extensive farmland preclude large concentrations of migratory waterfowl, and the absence of open water precludes wintering eagles and waterfowl.

Bowman Notch
This low saddle that follows part of the Israel River valley marks one of the few east-west routes through the mountainous areas of northern New Hampshire. Some data suggest that birds moving north up the Connecticut use this gap to reach breeding areas in the Androscoggin River watershed.

Lake Umbagog/Pontook Reservoir
The extensive marshes and open water in this area attract some of the largest concentrations of loons and diving ducks in the state, as well as lower numbers of dabbling ducks. Large concentrations of shorebirds have been reported in this area. Many species of land birds use shoreline habitats, primarily in spring, and swallows often concentrate over open water. Bald eagles are attracted to open water in the winter and during fall migration.

Lakes Region
This region is similarly important, although there is less evidence of its importance to migrating land birds. Larger areas of open water make it attractive to wintering waterfowl, and many species of diving ducks reach their highest winter densities here.

Powwow River
This small area, consisting primarily of Powwow Pond, regularly hosts the state's largest spring and fall concentrations of ring-necked ducks, ruddy ducks, pied-billed grebes, and American coots.

Great Bay
Great Bay is valuable to many species throughout the non-breeding period. It supports most of New Hampshire's wintering American black ducks, Canada geese, and greater scaup. Many other waterfowl species use the Bay during spring and fall. Some species rely on nearby agricultural lands or grasslands at Pease Air Force Base for foraging. Herons, gulls, cormorants, some shorebirds, and perhaps rails use the extensive wetlands that border the bay. The extensive shoreline is important to wintering bald eagles.

Coast
Salt marshes, mudflats, dunes, and coastal thickets support significant numbers of non-breeding birds. Salt marshes and mudflats provide the most important stopover habitat in the state for shorebirds. Herons, gulls, cormorants, and terns forage in coastal wetlands from spring to early winter, and salt marsh sparrows rely on salt marshes in the fall. Sparrows and other seed-eating passerines also congregate in coastal dunes and similar open habitats.

Many species of migrant land birds congregate along coastlines, and in this heavily developed area of New Hampshire, suitable stopover habitat is limited. Habitats with fruit-bearing shrubs may be particularly important in fall, whereas forests and early successional habitats are important in spring. Large, forested wetlands are roost sites for blackbirds and other flocking species. Several species of waterfowl and waterbirds—many of which do not breed in New Hampshire—use nearshore waters, include sea ducks, gulls, terns, loons, grebes, and cormorants.

Isles of Shoals
In some ways, the Isles of Shoals are similar to the mainland coast. They are used by various migrant land birds, non-breeding or post-breeding waterbirds (cormorants, gulls, terns), and some species of shorebirds and waterfowl. A few species are far more common there than on the mainland, including common eider, purple sandpiper, and ruddy turnstone.

Offshore Waters
Offshore waters support several species not covered by any other part of this Strategy. These deeper waters between the mainland and Isles of Shoals, or beyond the islands, are used by several species of alcids and pelagic seabirds (shearwaters, storm-petrels, phalaropes, northern gannet, jaegers) that are rarely seen from land. There are also smaller numbers of gulls, loons, grebes, and sea ducks. This habitat has been included in this profile because state bird conservation needs to consider offshore species.

1.5 Town Distribution Map

Not completed for these species.

1.6 Habitat Map

The non-breeding focal areas mapped for this profile are based on focal areas originally identified for New Hampshire in the late 1990s for Partners in Flight and the Atlantic Coast Joint Venture. These areas were chosen based on bird sighting data and personal experience. The original focal areas were delimited independently for waterfowl, shorebirds, waterbirds, and land birds, and the current areas have been modified to incorporate overlap between the 4 sets where appropriate. All areas of the state support birds during migration or winter, and only areas of high concentrations or significance are addressed in this profile. Explanations of how each focal area was mapped are included in table 1.

1.7 Sources of Information

Focal areas were based on those created in the late 1990s as discussed above. Data on habitat use by non-breeding birds in New Hampshire were compiled from New Hampshire Bird Records and the authors' personal experiences. Many of these data were originally summarized under the auspices of the New Hampshire Important Bird Area program. General information on the importance of certain habitat types was obtained from the scientific literature. Many proposed research or monitoring actions are based on projects previously identified through regional bird conservation planning.

1.8 Extent and Quality of Data

Extensive data are available for some parts of the identified focal areas, but very few areas have data for the entire geographic scope, the full complement of species, or for all times of year. In many cases, the mapped focal area reflects an extrapolation of available data on species behavior to the broader landscape.

1.9 Distribution Research

Detailed research on non-breeding bird habitat is extremely limited in New Hampshire. The research projects below have been identified by in-state interests or through broader regional conservation planning (BCR 14, BCR 30).

- Conservation of habitat for wintering bald eagles will be aided by mapping (or otherwise modeling) the distribution of open water along river corridors. Habitat conservation projects could then focus on areas that are most likely to support wintering eagles. Such a project would also potentially benefit wintering waterfowl.
- In the Mid-Atlantic States, there is increasing interest in the use of RADAR to identify important stopover habitat for migrating passerines. Little is known about the factors that govern the distribution and abundance of non-breeding sea ducks and other marine species in the Northeast. Such data will be extremely valuable in the event of offshore oil spills or wind farm developments.
- There has been no consistent effort to quantify the seasonal and spatial distribution of New Hampshire's shorebirds. New Hampshire could adopt proven techniques for measuring shorebird concentrations (e.g., PRISM).
- Non-breeding distributions of many species are largely unknown, including rails, bitterns, nightjars, and owls that tend to be highly secretive or nocturnal. New Hampshire should participate in regional migration monitoring projects. Current efforts include northern saw-whet owl banding (e.g., Clayton 2004) and common nighthawk migration monitoring (Robinson and Robinson 2001).

Element 2: Species/Habitat Condition

2.1 Scale

Non-breeding bird habitat will be treated in this Strategy at the level of habitat types within focal areas.

2.2 Relative Health of Populations

Given the many habitats and species treated in this profile, and the complexities inherent to studies of bird migration, assessing the health of non-breeding birds and their habitats is beyond the scope of this profile.

2.3 Population Management Status

Only game birds—particularly waterfowl—are specifically managed during the non-breeding season in New Hampshire. Refer to state waterfowl regulations and data for more information on this subject. Management of wintering eagle populations—largely through protection of critical roosting areas—has been implemented in the Great Bay and Merrimack River areas.

2.4 Relative Quality of Habitat Patches

Non-breeding habitat can vary in mortality risk, food resources, protection from weather, and degree of human disturbance. These factors are often correlated with habitat type or extent of anthropogenic alteration. Given the complexities involved in assessing habitat quality, and the broad scale chosen for this profile, it is impossible to discuss habitat quality at the scale of individual patches. Within a given focal area, any activity that influences non-breeding birds or their habitat should be viewed in the context of migrant needs and threats on a case-by-case basis.

2.5 Habitat Patch Protection Status

Table 1 shows the percentage of each focal area that is protected by fee-simple or conservation easement. This does not include open ocean and "great ponds" which are not subject to private or public ownership in the traditional sense.

2.6 Habitat Management Status

It is not feasible to address management status at the level of either focal areas or habitat patches within them. See section 2.4 above. See also form 3 for an overview of which threats are most important in each focal area.

2.7 Sources of Information

General information on the importance of certain habitat types was obtained from the scientific literature. Many proposed research or monitoring actions are based on projects previously identified through regional bird conservation planning.

2.8 Extent and Quality of Data

Given the broad scale of the areas treated in this profile, the quality of data supporting any particular assessment of varies. For this reason, most discussion of habitat condition is highly generalized.

2.9 Condition Ranking

2.10 Condition Assessment Research

Several projects to determine the quality of non-breeding habitat have been proposed at the regional level, and the following are applicable to New Hampshire.

- **Research the effects of impoundment management on shorebirds, waterfowl, and waterbirds:** Depending on when these drawdowns occur, they can be beneficial to shorebirds or detrimental to species that require deeper or more extensive water bodies. Research could provide information about how birds use impoundments and how management could improve stopover habitat for multiple species.
- **Shorebird stopover monitoring:** Research is needed on how resource levels vary among shorebird stopover sites during the migration season. This may allow biologists and land planners to identify, protect, or restore critical areas.
- **Offshore food resource levels:** Non-breeding seabird distribution in the Gulf of Maine (and other marine areas) is greatly influenced by the abundance of plankton and baitfish (Callaghan 2003). Participation in a regional research effort may inform conservation of priority breeding species such as terns.
- **Effects of invasive plants on non-breeding songbirds:** Non-native fruiting shrubs may provide less valuable food than do native species. Habitats that appear to contain abundant food may in fact be sub-optimal habitat for migratory birds. Research on energy content and use of these species by songbirds might support programs that encourage native fruit-bearing plants in landscaping and increase support for removal of invasive plants.
- **Passerine stopover habitat:** Not all stopover habitat are equally valuable to migratory birds (Duncan et al. 2002), largely because of variability in food resources, shelter, or predation risk. Measurable indicators of habitat value for birds include mass gain, residency time, and physiological condition.

Element 3: Species and Habitat Threat Assessment

3.1.1 Unsustainable Harvest (Forestry Operations and Management), Development (Habitat Loss and Conversion), Unregulated Take, Non-Point Source Pollution (Chemical Contaminants), Agriculture

A) Exposure Pathway
Because bird migration occurs on a hemispheric scale, the birds we protect during the breeding season may face their greatest threats well beyond New Hampshire, the United States, or even the Northern Hemisphere. Three broad classes of threats that occur outside New Hampshire are identified below.

1. Deforestation and habitat conversion in Latin America and the Caribbean have long been suspected in declines of many North American land birds that migrate to the tropics. Current declines of many species that winter on the eastern slope of the Andes (Canada warbler, cerulean warbler, olive-sided flycatcher, etc.) may be partially the result of deforestation in this region (Robbins et al. 1992). As in the United States, habitat conversion, fire suppression, intensive agriculture,

pine monocultures, and development can have deleterious effects on bird populations elsewhere on their migratory route.

2. Over-harvesting. Species that occur in high concentrations, including shorebirds, terns, waterfowl, and flocking passerines (e.g., bobolink) are particularly susceptible to human consumption in parts of the developing world. Birds are particularly vulnerable at key staging or wintering areas. The extinction of formerly abundant species like the passenger pigeon and Eskimo curlew is testament to the effects of unregulated hunting on populations of migratory birds.
3. Poisoning. In many areas south of the United States, chemicals such as DDT are still in use for agriculture or mosquito control. There is increasing evidence that many chemicals used in Latin America can cause high levels of direct mortality (e.g., Swainson's hawk, Goldstein et al. 1996), and they may cause population decline in species that winter in south-temperate agricultural areas. Although the threat is probably greater in the developing world, agricultural activities in the southern United States—particularly blackbird control—may harm populations of birds that winter in these habitats, including rusty blackbird, swallows, and several sparrow species.

B) Evidence
There is an extensive literature on non-breeding season limitations on migratory birds, and only a few references have been included in this profile to illustrate specific points.

3.1.2 Development (Habitat Loss and Conversion)

A) Exposure Pathway
During migration, birds require habitat where they can rest and feed after strenuous periods of sustained flight. When such habitat is limited, as in heavily urbanized areas, birds are forced into smaller patches, which may be further compromised by predators, light pollution, contaminants, and human disturbance. Many migratory species are affected by loss or degradation of river valleys, coastal areas, and even ridgelines (used by migrating hawks). In addition, some migrants are known to be area sensitive during migration and may suffer reduced fitness in heavily fragmented landscapes.

B) Evidence
There is an extensive literature documenting the importance of stopover habitat to migrating birds. Much of the recent research on this topic has been summarized in Moore 2000 and the references therein.

3.1.3 Predation and Herbivory (Subsidized or Introduced Predators)

A) Exposure Pathway
As landscapes become more urbanized, birds are threatened by domestic or feral cats. Birds in a weakened condition, or otherwise disoriented by windows or lights, may be especially vulnerable.

B) Evidence
Evidence suggests that cats kill several hundred million birds each year in the United States (American Bird Conservancy). The indirect effects of cat predation on migratory birds are poorly understood, and there are few data on how predation varies seasonally. Nonetheless, when combined with other sources of mortality caused by human activity (window and tower kills), cat predation could be a significant drain on breeding populations.

3.1.4 Agriculture (Land/Crop Conversion)

Not all agricultural areas are equally suitable for migrating birds. Broad types are arranged from most to least suitable as follows: grains, row crops, hayfields, fallow fields, and sod farms. Economic pressures often result in farmland conversion from more suitable to less suitable types, and this conversion may have immediate detrimental effects on local congregations of birds (especially waterfowl) that rely on waste grain during migration.

3.1.5 Recreation (Boats and Jet Skis)

Extensive use of boats and jet skis on water bodies used by migrating birds may cause repeated flushing or may otherwise reduce the time birds spend resting or foraging. Increased energy use and decreased food intake may affect seasonal migration, and thus have indirect effects on individual fitness and population health.

3.1.6 Recreation

The effects of human foot traffic on migrating birds are similar to those discussed above. The best examples are disturbance of bald eagles at winter roost sites and shorebirds at beach roosts. For example, repeated disturbance of roosting shorebirds has been shown to reduce the birds' ability to put on fat and concomitantly reduce their chances of surviving migration (Pfister et al. 1998).

3.1.7 Energy and Communication Infrastructure

There is extensive evidence that birds experience large mortality events at television and radio towers (Shire et al. 2000, www.towerkill.com), and all such structures cause regular low levels of mortality. Nocturnal birds tend to be attracted to lights on such towers, and sometimes they become disoriented and crash into the towers or their associated guy wires. The proliferation of towers for cellular communication will increase this risk, and towers located near migration routes may be particularly dangerous. As of 1999, there were roughly 60 towers in New Hampshire over 200 feet tall, the height at which towers start posing a greater threat (Braile 1999). Although large mortality events have not been recorded in New Hampshire (but see Sawyer 1961), the issue has received little study, and its overall magnitude remains unknown.

Although there are no wind power facilities in New Hampshire, evidence from elsewhere suggests that they can sometimes cause high levels of avian mortality (Birdlife International 2003, Schwartz 2004). Mortality appears important in raptors in the West, whereas limited data from the East suggest that migrating bats may be more at risk than birds (Kerns and Kerlinger 2004). Offshore wind power may pose a threat to waterfowl or waterbirds depending on location, and may include direct mortality and behavioral modification (Yulp et al. 1999).

3.1.8 Climate Change, Altered Natural Disturbance

Although the habitat-level effects of climate change (sea level rise being the exception for shorebirds and other coastal taxa, Galbraith et al. 2002) are not likely to influence migrating birds (they are adapted to using multiple habitats), disruption of seasonal patterns may be detrimental. Many species of migratory birds have shifted their arrival dates as much as 3 weeks earlier over the last several decades (Price and Root 2002). Such shifts in migration phenology can decouple bird migration peaks from peaks in food supply (e.g., McCarthy 2004), though effects on migrants' survival and ability to put on fat are unknown. Similarly, shifts in weather patterns may influence migratory behavior.

3.1.9 Development (Light Pollution)

Heavily lit urban areas can attract nocturnal migrants (many songbirds, cuckoos, owls, rails) that become disoriented and may die in collisions with structures. Disoriented birds, in turn, may be more susceptible to predation, or may find themselves in inhospitable environments with limited foraging opportunities. Some researchers estimate that upwards of 100 million birds are killed annually in this manner in North America (FLAP).

3.2 Sources of Information

Information on habitat-based threats was obtained largely from the scientific literature and summaries thereof. For broad-based but still poorly understood threats such as collisions and cat predation, most information came from reports written by bird conservation organizations available on the web.

3.3 Extent and Quality of Data

Effects of habitat loss and alteration on the winter grounds are well documented in scientific literature. Stopover habitat issues are also becoming better understood, although there are fewer direct connections between stopover events and population dynamics. Data on mortality (cats and towers), effects of climate change, and light pollution are rarely collected in a consistent manner across numerous locations, and extrapolations of these data to the broader scale are necessarily rough.

3.4 Threat Assessment Research

For some of the "low" threats discussed above (particularly climate change, cats, towers, wind power,

and light pollution), one of the main reasons for their low rank is a lack of information on the timing and severity of the threat. New Hampshire could participate in ongoing monitoring occurring elsewhere in the region.

There are also very few data with which to evaluate the effects of habitat loss or fragmentation on birds that migrate through New Hampshire. RADAR, in conjunction with data on landscape characteristics, can determine whether fragmented or degraded areas are used to the same degree as more intact habitats.

Other research would focus on the effects of human disturbance on non-breeding birds. Some such studies are planned or underway (bald eagles) or are already completed (shorebirds), but they lack for small land birds and aquatic birds.

It is critical to identify and research potential threats to priority species on their winter grounds (in Latin America, the Caribbean, and the southern United States). Research may include the effects of habitat conversion, pesticides, and agricultural practices.

Element 4: Conservation Actions

4.1.1 Outreach on cross-border and diffuse effects (coffee, pesticides, PIF, etc.), Education and Outreach

Threat addressed: Out-of-state Activities

In the early 1990s, Partners in Flight (PIF) and its partner organizations raised awareness of the effects of extra-national activities on North America's breeding birds. In the decade since, initiatives such as the promotion of shade-grown coffee have been relatively successful in 'bringing home" the connections between breeding and wintering areas, but more work needs to be done. Important issues that may be particularly suitable for grassroots activism include pesticide use in South America, climate change, and mortality associated with towers and lighted structures. At stopover sites, initiatives such as the Important Bird Area program, Western Hemisphere Shorebird Reserve Network, and others can galvanize local support for land conservation, which in turn can increase local awareness of other issues affecting migrant birds.

4.1.2 Land Conservation in Priority Corridors, Habitat Protection

Threats addressed: Loss of stopover habitat

Available research indicates that migrants need multiple stopover sites and a wide variety of habitats (Petit 2000, R. Suomala unpubl. data). For many land birds, important habitat features include fruit-bearing shrubs and large enough habitat patches to attract area-sensitive species. Edge habitats should be maintained or enhanced to manage or restore habitat for migratory songbirds (Suthers et al. 2000). Habitat protection (or management/restoration) at this scale will require more baseline data on the primary species or species groups that use the landscape.

4.1. 3 Local Stopover Habitat Education, Education, and Outreach (with potential to include Regulation and Policy)

Threats addressed: Loss of stopover habitat

Local communities can encourage or implement land use policies that benefit migratory birds (Mabey and Watts 2000). Such policies could include landscaping with fruit-bearing shrubs or shelter-providing conifers (C. Foss, personal observation), bird-friendly zoning, and tax incentives to maintain critical habitats. Attempt to influence local land use should be combined with outreach pertaining to an area's value to migratory birds (along lines of 4.1.1) and, where appropriate, discussion of the potential "nature tourism" value of maintaining migrant habitats.

4.1.4 Cats Indoors Campaign, Education and Outreach

Threats addressed: Cat predation

The American Bird Conservancy has initiated an outreach campaign directed toward minimizing the hazards posed by cats to native wildlife. To be broadly successful, such an effort should be supported by multiple conservation organizations and pet-advocacy groups (Humane Societies, SPCA). There may be considerable resistance to control of feral cats by some parties, which only a concerted outreach campaign is likely to overcome. In addition, state and

local governments should consider the feasibility of legislation prohibiting cats outdoor without a leash, much as with current leash laws for dogs.

4.1.5 Management agreements with farmers, Restoration and Management OR Education and Outreach

Threats addressed: Change in crops

The Farm Bill, Current Use, and the Conservation Reserve Program encourage existing agricultural practices (or discourage conversion of agricultural lands). These tools should be applied in situations where there is greatest risk of farmland conversion to less suitable land use as described in section 3.1.4. In situations where income is not the primary purpose of agricultural land (e.g., "gentleman farmers"), there is an opportunity to encourage land use compatible with the needs of migratory birds.

4.1.6 Outreach on (or regulation of) impacts of human disturbance (especially on eagles and shorebirds), Education and Outreach OR Regulation and Policy

Threats addressed: Human disturbance (both aquatic and terrestrial)

Changing human behavior will benefit non-breeding birds during important resting or feeding periods. These include:

- Limiting access to critical roosting (shorebirds, eagles) and feeding (shorebirds) areas
- Providing "limited disturbance areas" at major waterfowl concentration areas (this may need to be implemented in the context of existing hunting regulations)

4.1.7 Adopt bird-friendly tower siting and design policies, Regulation and Policy

Threats addressed: Mortality at communication towers

FCC regulations require that all towers over 199 feet tall be lighted, as well as those near airports or along major highways. Provisions guiding tower placement and lighting that would reduce their threat to migrating birds need to be addressed, especially in areas where migrants are known to be relatively concentrated (e.g., focal areas). Shire et al. (2000) list several recommendations that would help minimize bird mortality at communications towers, including:

- When possible, use existing towers or structures for placement of new antennae
- Make new towers under 200 feet tall so lighting is not required
- If lighting is necessary, use the minimum amount and intensity allowed under FCC regulations
- Dismantle inactive towers as soon as possible
- Minimize lighting for on-ground facilities associated with towers
- Existing evidence suggests that use of white strobes may result in less circling behavior by nocturnal migrants and thus cause fewer mortalities than red pulsating lights. However, additional research is needed before implementing this recommendation

4.1.8 Establish Wind Power Facility Site Review Regulations, Regulation and Policy

Threats addressed: Mortality at wind farms

Data on the effects of wind power are limited (but see section 3.1.7), so first steps in addressing this threat should include consideration of siting regulations. Wind farms should not be built in areas where they will pose a high risk to birds, and proposals should thus include provision for detailed pre-construction assessment of bird use. When possible, facilities should follow any "best design practices" that may be developed as research progresses on the effects of wind farm affects on birds and bats. In the event that any wind farms are constructed, it is imperative that provisions be included for monitoring of bird and bat mortality for comparison to pre-construction use patterns.

4.1.9 Reduce light pollution, Education and Outreach OR Regulation and Policy

Threats addressed: Light pollution

Some North American cities (Toronto, Chicago) have implemented "lights out" programs during peak migration periods. Under these programs, cooperating building owners and managers agree to turn out decorative lights or draw blinds during the evening hours. The overall degree of light pollution can be markedly reduced if buildings comply (see www.lightsout.audubon.org/). In addition, there is growing interest in many municipalities to reorient street lighting so that it is more directed toward the ground and thus less disorienting to birds. All such measures have the benefit of reducing energy use.

4.1.10 Advise Inter-agency Risk Assessment Teams about Risks to Non-breeding Birds, Policy and Regulation

Threats addressed: Wind energy, climate change

NHFG will develop a strategy to initiate Interagency Wildlife Risk Assessments for several broad-based threats that affect the state's wildlife and their habitats. When these Assessments are implemented, it is critical that issues related to non-breeding birds and their habitats are included in discussions of the effects of these threats and the actions that may be needed to address them.

Element 5: References

5.1 Literature

American Bird Conservancy. Cats Indoors Campaign. www.abcbirds.org/cats (February 16. 2005)

Barrow, W.C. Jr., C. Chen, R.B. Hamilton, K. Ouchley, and T.J. Spengler. 2000. Disruption and restoration of en route habitat, a case study: the Chenier Plain. Pages 71-87 *in* Stopover ecology of Nearctic-neotropical landbird migrants: habitat relations and conservation implications (F. R. Moore, ed.). Studies in Avian Biology 20.

Birdlife International. 2003. Windfarms and birds: an analysis of the effects of windfarms on birds, and guidance on environmental assessment criteria and site selection issues. Convention on the conservation of European Wildlife and Natural Habitats, Strasbourg, France, 1-4 December 2003.

Braile, R. 1999. Proliferation of cell towers poses threat to birds. The Boston Globe. May 23, 1999 New Hampshire Weekly, p. 1.

Brown, S., C. Hickey, B. Harriington, and R. Gill, eds. 2001. The U.S. Shorebird Conservation Plan, 2nd ed. Manomet Center for Conservation Sciences, Manomet, MA.

Callaghan, C. 2003. Fundy's phalaropes. Passages: the Long and Brier Island News, October 2003. (www.bofep.org/phalaropes.htm).

Clayton, K. 2004. Banding northern saw-whet owls in the Blackstone River valley. Bird Observer 32: 287-297.

Cox, J. 1988. The influence of forest size on transient and resident bird species occupying maritime hammocks of northeastern Florida. Florida Field Naturalist 16(2): 25-34.

Duncan, C., B. Abel, D. Ewert, M.L. Ford, S. Mabey, D. Mehlman, P. Paterson, R. Sutter, and M. Woodrey. 2002. Protecting stopover sites for forest-dwelling migratory landbirds. The Nature Conservancy, Arlington, VA. Unpublished report.

Fiore, C.A., and K.B. Sullivan. 2000. Domestic cat (*Felis catus*) predation of birds in an urban environment. Wichita State University. Unpublished report. www.geocities.com/the_srco/Article.html (February 16, 2005).

FLAP. Fatal Light Awareness Program (www.flap.org).

Galbraith, H., R. Jones, R. Park. J. Clough, S. Herrod-Julius, B. Harrington, and G. Page. Global climate change and sea level rise: potential losses of intertidal habitat for shorebirds. Waterbirds 25: 173-183.

Gildstein, M.I., B. Woodbridge, M.E. Zaccagnini, and S.B. Canavelli. 1996. An assessment of mortality of Swainson's hawk on wintering grounds in Argentina. Journal of Raptor Research 30: 106-107.

Hutto, R.L. 2000. On the importance of en route periods to the conservation of migratory landbirds. Pages 109-114 *in* Stopover ecology of Nearctic-neotropical landbird migrants: habitat relations and conservation implications (F. R. Moore, ed.). Studies in Avian Biology 20.

Kerns, J., and P. Kerlinger. 2004. A study of bird and bat collision fatalities at the Mountaineer Wind Energy Center, Tucker County, West Virginia: Annual Report for 2003. Report to FPL Energy and Mountaineer Wind Energy Center Technical Review Committee, Curry and Kerlinger, LLC.

Langston, R.H.W., and J.D. Pullan. 2003. Wind-

farms and birds: An analysis of the effects of windfarms on birds, and guidelines on environmental assessment criteria and site selection issues. Report written by Birdlife International for the Bern convention (www.birdlife.org/)

Mabey, S.E., and B.D. Watts. 2000. Conservation of landbird migrants: addressing local policy. Pages 99-108 *in* Stopover ecology of Nearctic-neotropical landbird migrants: habitat relations and conservation implications (F. R. Moore, ed.). Studies in Avian Biology 20.

McCarthy, M. 2004. Disaster at sea: global warming hits UK birds. The Independent (UK) 30 July 2004 (news.independent.co.uk/uk/environment/story.jsp?story=546138).

Moore, F.M. 2000. Stopover ecology of Nearctic-neotropical landbird migrants: habitat relations and conservation implications. Studies in Avian Biology 20.

Moore, F.R., S.A. Gauthreaux, Jr., P. Kerlinger, and T.R. Simons. 1995. Habitat requirements during migration: important link in conservation. Pages 121-144 *in* Ecology and Management of Neotropical Migratory Birds: A Synthesis and Review of Critical Issues (T.E. Martin and D.M. Finch eds.), Oxford University Press, New York.

Norris, D.R., P.P. Marra, T.K. Kyser, T.W. Sherry, and L.M. Ratcliffe. 2004. Tropical winter habitat limits reproductive success on the temperate breeding grounds in a migratory bird. Proceedings of the Royal Society of London (Biology) 271:59–64.

Parrish, J.D. 1997. Patterns of frugivory and energetic condition in Nearctic landbirds during autumn migration. Condor 99: 681-697.

Parrish, J.D. 2000. Behavioral, energetic, and conservation implications of foraging plasticity during migration. Pages 53-70 i*n* Stopover ecology of Nearctic-neotropical landbird migrants: habitat relations and conservation implications (F. R. Moore, ed.). Studies in Avian Biology 20.

Petit, D.R. 2000. Habitat use by landbirds along nearctic-neotropicl migration routes: implications for conservation of stopover habitat. Pages 15-33 *in* Stopover ecology of Nearctic-neotropical landbird migrants: habitat relations and conservation implications (F. R. Moore, ed.). Studies in Avian Biology 20.

Pfister, C., M.J. Kasprzyk, and B.A. Harrington. 1998. Body-fat levels and annual return in migrating semipalmated sandpipers. Auk 115: 904-915.

Price, J.T., and T.L. Root. 2002. No orioles in Baltimore? Climate change and Neotropical migrants. Bird Conservation 16:12.

Robbins, C.S., J.W. Fitzpatrick, and P.B. Hamel. 1992. A warbler in trouble: *Dendroica cerulea*. Pages 549-562 *in* Ecology and Conservation of Neotropical Migrant Landbirds (J. M. Hagan and D. W. Johnston, eds.), Smithsonian Institution Press.

Robinson, S., and J. Robinson. 2001. The Pittsfield nighthawk watch: 1993-2001. Bird Observer 29: 446-447.

Rodewald, P.G., and M.C. Brittingham. 2004. Stopover habitats of landbirds during fall: use of edge-dominated and early-successional forests. Auk 121: 1040-1055.

Sawyer, P.J. 1961. Bird mortality at the WENH-TV tower in Deerfield, New Hampshire. New Hampshire Audubon Quarterly 14(2); 46-49.

Schwartz, S.S. (ed.). 2004. Proceedings of the Wind Energy and Birds/Bats Workshop: Understanding and Resolving Bird and Bat Impacts (Washington, DC. May 18-19, 2004). RESOLVE Inc., Washington, D.C.

Sherry, T.W. and R.T. Holmes. 1995. Summer versus winter limitation of populations: what are the issues and what is the evidence. Pages 85-120 i*n* Ecology and Management of Neotropical Migratory Birds: A Synthesis and Review of Critical Issues. (T.E. Martin and D.M. Finch eds.). Oxford University Press, New York.

Shire, G.G., K. Brown, and G. Winegard. 2000. Communication towers: A deadly hazard to birds. American Bird Conservancy. www.abcbirds.org/Towerkills.htm.

Somershoe, S.C., and C.R. Chandler. 2004. Use of oak hammocks by Neotropical migrant songbirds: the role of area and habitat. Wilson Bulletin 116: 56-53.

Suthers, H.B., J.M. Bickal, and P.G. Rodewald. 2000. Use of successional habitat and fruit resources by songbirds during autumn migration in New Jersey. Wilson Bulletin 112: 249-260.

5.2 Data Sources

National Audubon Society (2002). The Christmas Bird Count Historical Results [Online]. Available at http://www.audubon.org/bird/cbc.

NHBR. New Hampshire Bird Records, New Hampshire Audubon, Concord, NH.

Element 6: List of Figures

Table 1. Percentage conserved land in non-breeding bird focal areas and habitats. Because of the way the Great Bay and Coastal focal areas were created in the GIS process, the areas listed below do not necessarily correspond with those listed in Section 1.4. The appropriate focal areas from Section 1.4 are listed for reference in Table 1.

Focal Area	% protected	includes:
Connecticut River Valley	7.57	
Merrimack River Valley	9.85	
Contoocook River Valley	27.33	
Bowman Notch	22.85	
Lake Umbagog/Pontook Reservoir	12.23	
Lakes Region	0.09	
Powwow River	15.25	
Great Bay Grasslands	32.83	Great Bay
Great Bay Wetlands	54.91	Great Bay
Saltmarsh and intertidal flats	6.93	Great Bay, Coast
Coastal shoreline and nearshore waters	1.34	Coast
10 miles inland	11.65	Coast
Combined Great Bay/Coast	11.73	
Offshore Waters	0	Isles of Shoals

Table 1. Percentage conserved land in non-breeding bird focal areas and habitats. Because of the way the Great Bay and Coastal focal areas were created in the GIS process, the areas listed below do not necessarily correspond with those listed in Section 1.4. The appropriate focal areas from Section 1.4 are listed for reference in Table 1.

SPECIES PROFILE

Eastern Meadowlark

Sturnella magna

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S3B
Author: Alina, J. Pyzikiewicz, New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

The breeding habitat of the eastern meadowlark includes fields and open areas with perches, such as trees and fence posts, for singing males to establish and defend territories and to attract mates (Steele 1994, Lanyon 1995, DeGraaf and Yamasaki 2001). The eastern meadowlark forages for insects on the ground, occasionally probes the soil for grubs, and supplements its diet with seeds in the winter (Lanyon 1995). Eastern meadowlarks build their domed nests on the ground in dense vegetation or shallow depressions (Steele 1994, Lanyon 1995). Winter habitats are similar to breeding habitats, with the addition of feedlots and marshes (Lanyon 1995).

1.2 Justification

Populations of eastern meadowlarks have been slowly declining, particularly in the Northeast, where old fields and farmland are being developed or converted to woodland (Steele 1994, Lanyon 1995, Vickery et al. 1999). Surveys in 1994 yielded 14 breeding pairs, and in 2004, only 2 were observed (United States Geological Service Patuxent Wildlife Research Center 2005). Agriculture practices such as mowing during nesting season have reduced productivity of the eastern meadowlark (Lanyon 1995, Vickery et al. 1999). Eastern meadowlarks are also susceptible to brood parasitism by brown-headed cowbirds (*Molothrus ater*) (Laynon 1995).

1.3 Protection and Regulatory Status

The eastern meadowlark is protected under the Migratory Bird Treaty Act and through various grassland bird conservation programs (North American Bird Conservation Initiative, Partners in Flight Northeast Grassland Bird Working Group).

1.4 Population and Habitat Distribution

The range of the eastern meadowlark extends from central Canada eastward through the Atlantic states and provinces down to Florida and Mexico, southward to Texas, and westward to central Arizona (Lanyon 1995).

In New Hampshire, eastern meadowlarks can be found in extensive fields, grasslands, and farmlands, as well as in contemporary habitats such as airport safeways, military installations, and golf courses. Meadowlarks are not found in the extreme north and southwest parts of the state (Steele 1994, Lanyon 1995, New Hampshire Audubon unpublished data). The New Hampshire Natural Heritage Bureau Database (2005) notes 29 locations where eastern meadowlarks have been observed (breeding and nonbreeding), with a concentration of 9 locations in the seacoast region.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

See Grassland habitat profile.

1.7 Sources of Information

Birds of North America, New Hampshire Breeding Bird Atlas, New England Wildlife, breeding bird surveys and other unpublished survey reports.

1.8 Extent and Quality of Data

Eastern meadowlark habitat and population distribution is well studied, but little is known about nutrition, productivity, and wintering ecology (Vickery et al. 1999). Population data in New Hampshire are limited.

1.9 Distribution Research

- Identify and protect key grassland habitat areas
- Continue monitoring grassland habitats to better assess eastern meadowlark abundance trends
- Conduct productivity and survival studies to provide information needed for determining causes of population declines

Element 3: Species Threat Assessment

See Grasslands habitat profile.

Element 4: Conservation Actions

See Grasslands habitat profile.

Element 5: References

5.1 Literature:

DeGraaf, R.M., and M. Yamasaki. 2001. New England wildlife: habitat, natural history, and distribution. University Press of New England, Hanover, New Hampshire, USA.

Lanyon, W.E. 1995. Eastern meadowlark (*Sturnella magna*). *In* The Birds of North America, No 160, A. Poole and F. Gill, editors. The Academy of Natural Sciences, Philadelphia, Pennsylvania, and The American Ornithologists' Union, Washington, D.C., USA.

Steele, F.L. 1994. Eastern meadowlark. Pages 342-343 *in* Breeding bird atlas of New Hampshire, C.R. Foss, editor. Arcadia, Dover, New Hampshire, USA.

Vickery, P.D., P.L. Tubaro, J.M. Cardoso da Silva, B.G. Peterjohn, J.R. Herkert, and R.B. Cavalcanti. 1999. Conservation of grassland birds in the western hemisphere. Studies in Avian Biology 19:2-26.

5.2 Data Sources

New Hampshire Natural Heritage Bureau. 2005. Database of rare species and exemplary natural community occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

USGS Patuxent Wildlife Research Center. 2005. North American Breeding Bird Survey Internet data set. <http://www.pwrc.usgs.gov/bbs/>. Accessed 2 March 2005.

SPECIES PROFILE

Eastern Towhee

Pipilo erythrophthalamus

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S4B
Author: Pamela D. Hunt, Audubon Society of New Hampshire

Element 1: Distribution and Habitat

1.1 Habitat Description

Eastern towhees use a variety of early successional and other shrub-dominated habitats, including pine barrens, old fields, power line corridors, coastal shrub-scrub, and occasionally the shrubby portions of bogs and fens. The species also occurs in forested habitats if overstory trees are scattered (woodland habitat) or the shrub layer is well developed (Greenlaw 1996). In West Virginia, towhees responded positively to defoliation caused by gypsy moth outbreaks (Bell and Whitmore 1997). In Massachusetts pine barrens, towhees occupied habitats at a variety of successional stages and did not appear to select microhabitats within the broader habitat type (Morimoto and Wasserman 1991). In New Hampshire, towhees are sometimes found in the shrubby vegetation on some mountaintops, especially if the area had been burned (Foss 1994).

Fire suppression in southeastern United States pine savannahs results in increasing density and height of hardwood species (Engstrom et al. 1984). At one such site in Florida, towhee numbers increased in the years immediately following initial fire suppression, presumably in response to the increased shrub layer. As succession continued, however, towhee numbers began to decline, and the species was no longer present at the site 15 years after the last burn (Engstrom et al. 1984). These and other data indicate that towhees are often most common in shrubby habitats with low densities of saplings (vs. shrubs), suggesting in turn that not all early successional stages are equally suitable for the species. In addition, Wells (2003) determined that towhee populations inhabiting powerline rights-of-way were not sustainable. Whether this is a result of generally low habitat availability in the study area (southeastern New Hampshire) or specific habitat characteristics is a subject needing further study.

1.2 Justification

Based on Breeding Bird Survey (BBS) data, eastern towhees have been declining over most of their range. The decline has been particularly severe in the Northeast, where towhees have declined at an annual rate of 3.0% since 1966 (Hagen 1993, Sauer et al. 2004). Elsewhere in the East, the long-term decline may have become less severe since the late 1970s, and in some regions formerly declining towhee populations appear stable or perhaps increasing (Sauer et al. 2004). In New Hampshire, the annual decline of 9.2% is the second largest significant decline of any species based on Breeding Bird Survey (BBS) data (behind the brown thrasher). Breeding Bird Survey data from New Hampshire show the most dramatic decrease in the late 1970s, when the average number per route dropped from 15-20 to 5 over a period of only 5 years (figure 1). Since this large drop, populations have continued to decline, although at a slower rate. Because of these significant population declines across most the species' range, the eastern towhee has been listed as a "stewardship species" in the Eastern Avifaunal Biome by Partners in Flight (Rich et al. 2004). Although towhees are not rare enough to be listed in any jurisdiction, their continued decline and absence from areas of seemingly suitable habitat remains cause for concern (Hagen 1993).

1.3 Protection and Regulatory Status

This species is protected under the Migratory Bird Treaty Act, which prevents the killing of most non-game birds and collection of their nests or eggs.

1.4 Population and Habitat Distribution

In New Hampshire, eastern towhees are largely restricted to areas south of the White Mountains. Data from the BBS and the Breeding Bird Atlas (Foss 1994) show occasional records north of the mountains in the Connecticut and Androscoggin River valleys, but the species should not be expected there and BBS data suggest that towhees were extirpated from this part of the range during the decline in the 1970s. Towhees are fairly evenly dispersed over most of their range, with generally lower densities along the northern periphery (including New Hampshire, Sauer et al. 2004). Given the magnitude of decline, it is reasonable to assume that New England formerly supported a much more significant portion of the species' global population than it does today.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

Not applicable

1.7 Sources of Information

Information in this profile was gathered from the relevant scientific literature. Raw BBS data for New Hampshire were obtained via the BBS website.

1.8 Extent and Quality of Data

Because towhees are easily identifiable and widely distributed, data on population distribution and trends are generally assumed to accurately reflect the species' status in the state and across the range as a whole.

1.9 Distribution Research

Very little is known about the demography of this species (Hagen 1993). Data on nest site selection, reproductive success, and response to landscape level habitat change may allow biologists to better understand the mechanisms behind population declines and the absence of towhees from apparently suitable habitat across much of its range in New England.

Element 5: References

5.1 Literature

Bell, J.L., and R.C. Whitmore. 1997. Eastern Towhee numbers increase following defoliation by gypsy moths. Auk 114: 708-716.

Engstrom, R.T., R.L. Crawford, and W.W. Baker. 1984. Breeding bird populations in relation to changing forest structure following fire exclusion: a 15-year study. Wilson Bulletin 96: 437-450.

Foss, C.R. 1994. Atlas of Breeding Birds of New Hampshire. Audubon Society of New Hampshire, Concord, New Hampshire, USA.

Greenlaw, J.S. 1996. Eastern Towhee (*Pipilo erythrophthalmus*). *In* The Birds of North America, No. 262. (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.

Hagen, J.M., III. 1993. Decline of the Rufous-sided Towhee in the eastern United States. Auk 110: 863-874.

Morimoto, D.C., and F.E. Wasserman. 1991. Dispersion patterns and habitat associations of Rufous-sided Towhees, Common Yellowthroats, and Prairie Warblers in the southeastern Massachusetts pine barrens. Auk 108: 264-276.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S.W. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.C. Hunter, E.E. Inigo-Elias, J.A. Kennedy, A.M. Martell, A.O. Panjabi, D.N. Pashley, K.V. Rosenberg, C.M. Rustay, J.S. Wendt, and T.C. Will. 2004. Partners in Flight North American Landbird Conservation Plan. Cornell Lab of Ornithology, Ithaca, New York, USA.

Sauer, J.R., J.E. Hines, and J. Fallon. 2004. The North American Breeding Bird Survey, Results and Analysis 1966-2003. Version 2004.1, USGS Patuxent Wildlife Research Center, Laurel, Maryland, USA.

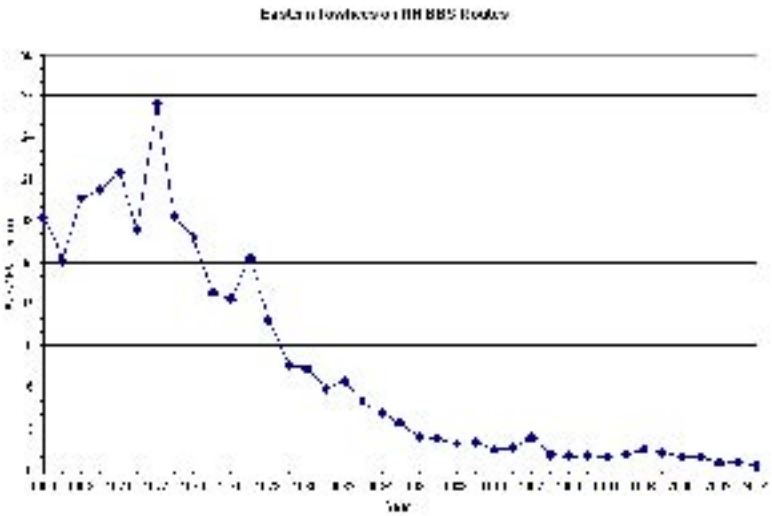
Wells, D.B. 2003. Shrubland bird diversity and productivity along powerline rights-of-way in southeastern New Hampshire. Masters Thesis, University of Vermont, Burlington, Vermont, USA.

5.2 Data Sources

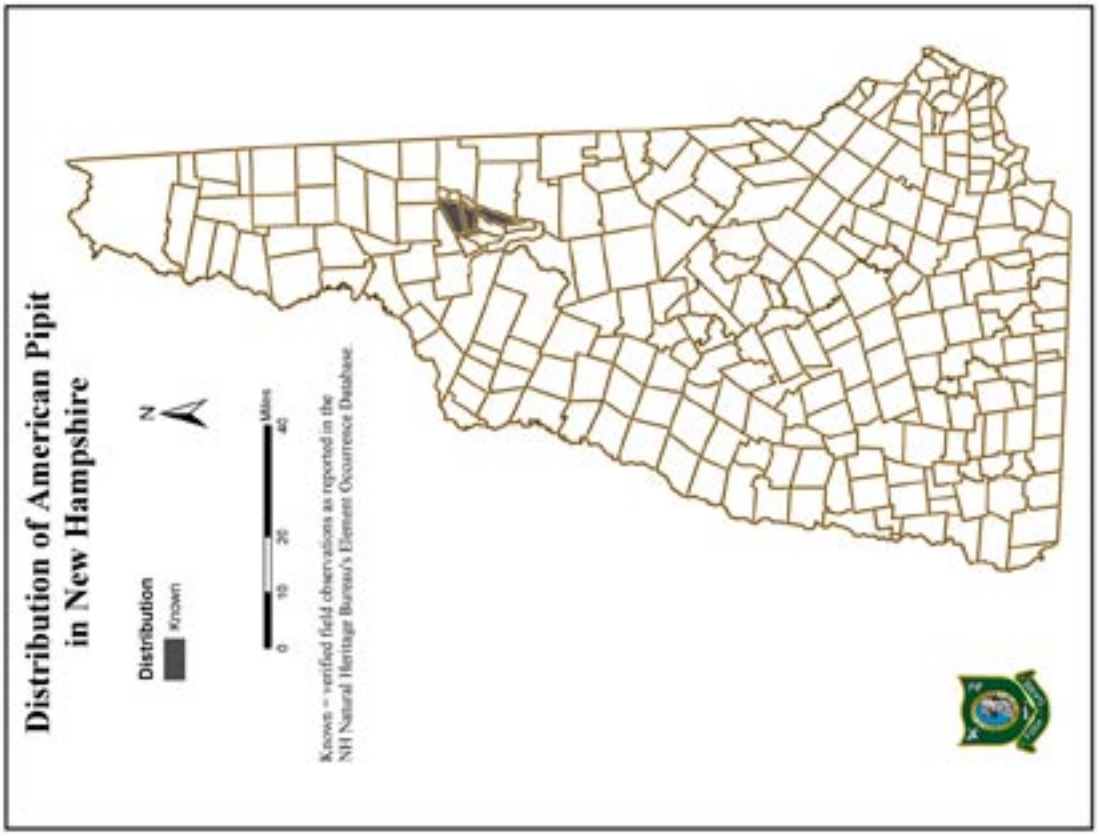
Breeding Bird Survey raw data were obtained from: http://www.pwrc.usgs.gov/bbs/retrieval/menu.cfm

Element 6: List of Figures

Figure 1. Average abundance of the eastern towhee on New Hampshire Breeding Bird Survey Routes, 1966-2004.



Bird Maps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in New Hampshire
Distribution
Known
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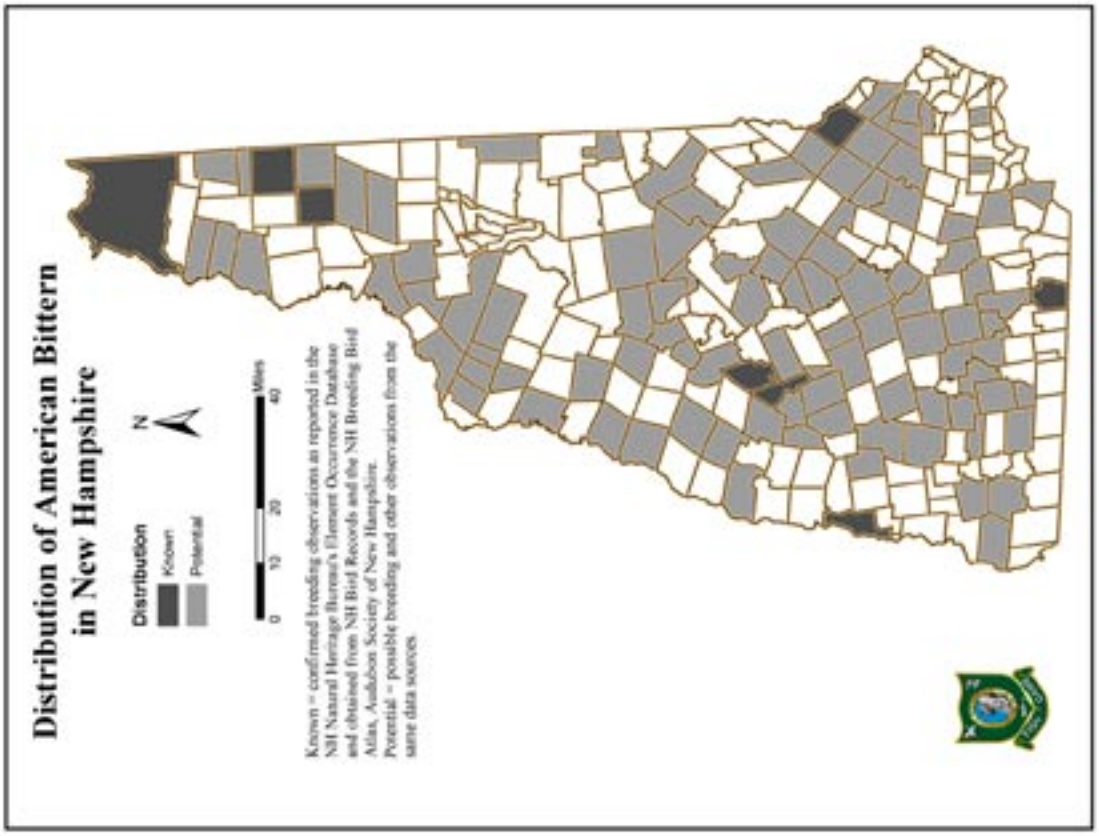
Known = verified field observations as reported in the
NH Natural Heritage Bureau's Element Occurrence Database.


Distribution of American Bittern
in New Hampshire
Distribution
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Potential
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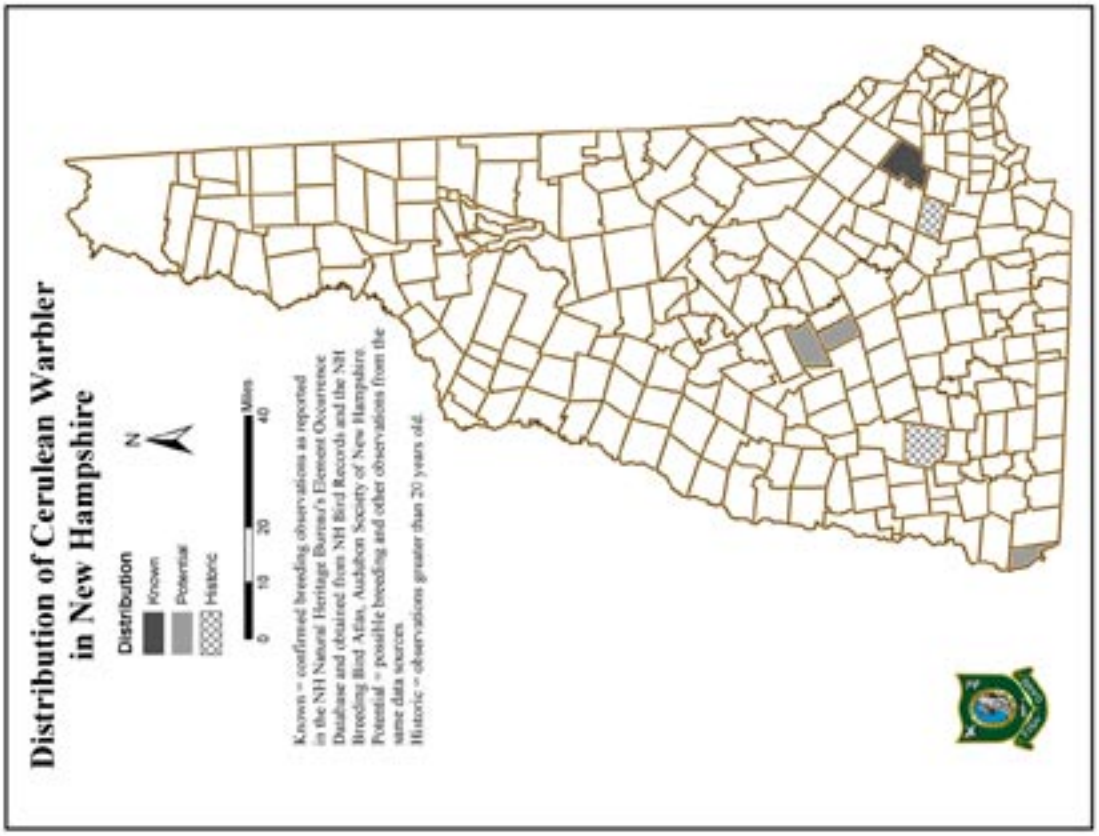
0 10 20 40 Miles
Known = confirmed breeding observations as reported in the
NH Natural Heritage Bureau's Element Occurrence Database
and obtained from NH Bird Records and the NH Breeding Bird
Atlas, Audubon Society of New Hampshire.
Potential = possible breeding and other observations from the
same data sources.


Distribution of Cerulean Warbler
in New Hampshire
Distribution
Known
Potential
Historic
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0
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Miles
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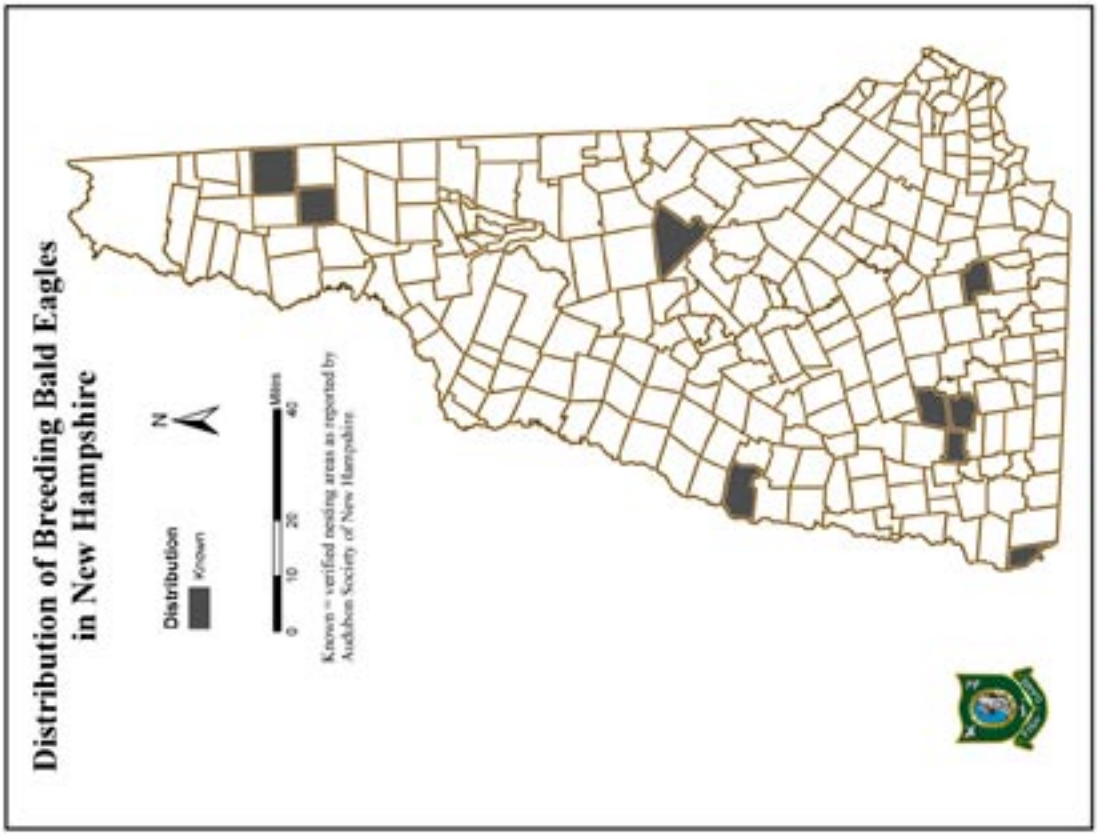
Potential = possible breeding and other observations from the same data sources.
Historic = observations greater than 20 years old.


Distribution of Breeding Bald Eagles
in New Hampshire
Distribution
Known
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0
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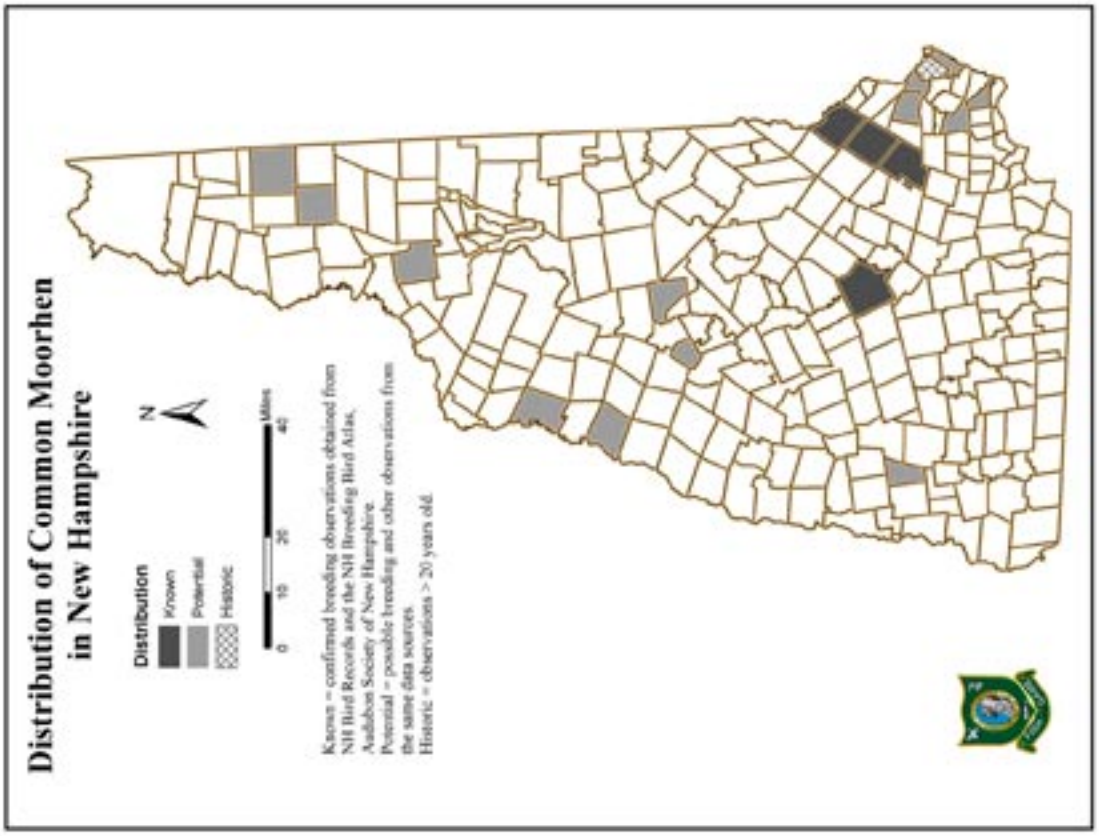
Miles
Known = verified nesting areas as reported by Audubon Society of New Hampshire


Distribution of Common Moorhen in New Hampshire
Distribution
Known
Potential
Historic
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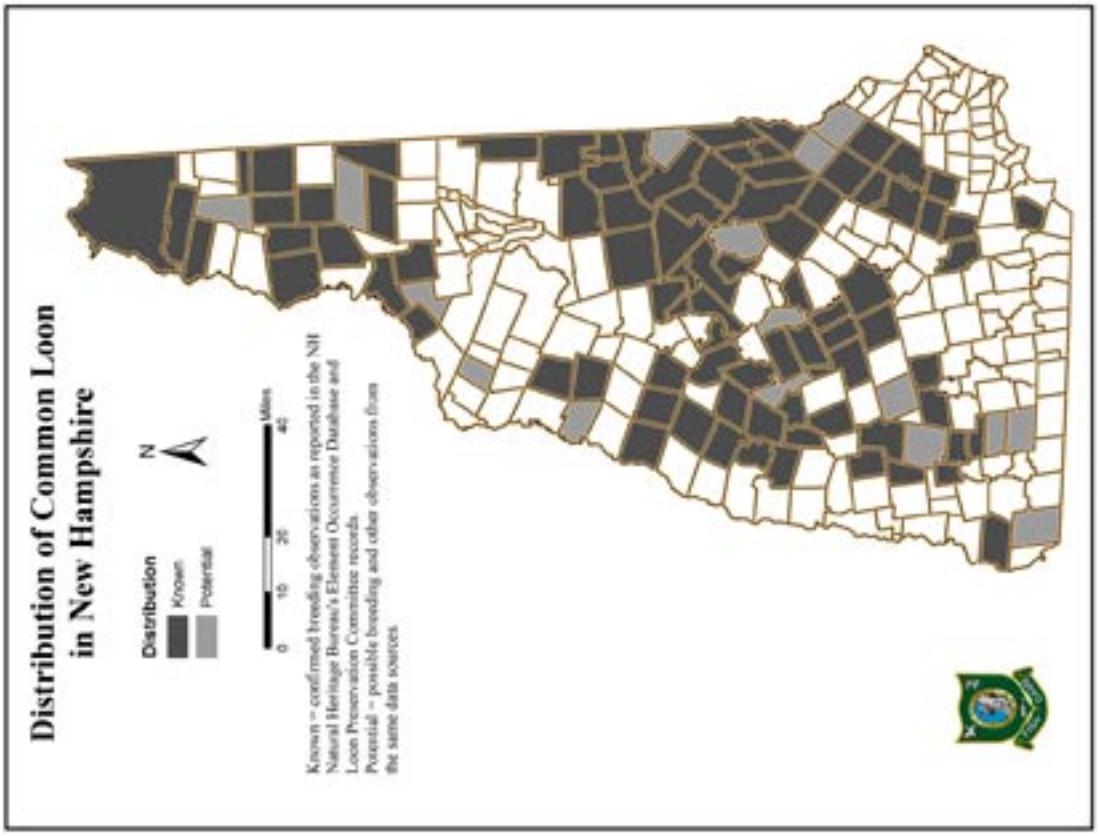
0 13 26 42 Miles
Known = confirmed breeding observations obtained from NH Bird Records and the NH Breeding Bird Atlas, Audubon Society of New Hampshire.
Potential = possible breeding and other observations from the same data sources.
Historic = observations > 20 years old.


Distribution of Common Loon in New Hampshire
Distribution
Known
Potential
N
0 13 26 42 Miles
Known = confirmed breeding observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and Loon Preservation Committee records.
Potential = possible breeding and other observations from the same data sources.

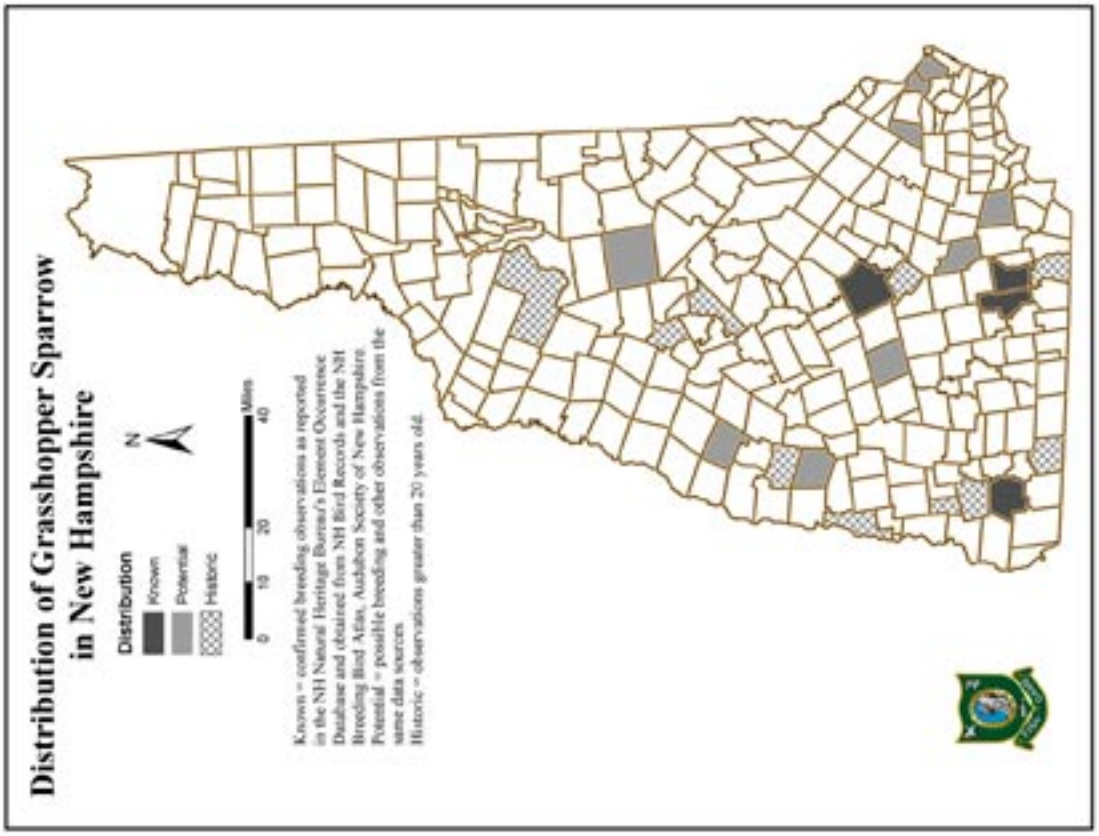
Distribution of Eastern Meadowlark
in New Hampshire
Distribution
Potential
N
0
10
20
40
Miles
Potential = possible breeding and other observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and obtained from NH Bird Records and the NH Breeding Bird Atlas, Audubon Society of New Hampshire.

Distribution of Common Nighthawk
in New Hampshire
Distribution
Known
Potential
N
0
10
20
40
Miles
Known = confirmed breeding observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and obtained from NH Bird Records and the NH Breeding Bird Atlas, Audubon Society of New Hampshire
Potential = possible breeding and other observations from the same data sources.

Distribution of Golden-winged Warbler in New Hampshire
Distribution
Known
Potential
Historic
N
0 10 20 40
Miles
Known = confirmed breeding observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and obtained from NH Bird Records and the NH Breeding Bird Atlas, Audubon Society of New Hampshire
Potential = possible breeding and other observations from the same data sources.
Historic = observations greater than 20 years old.

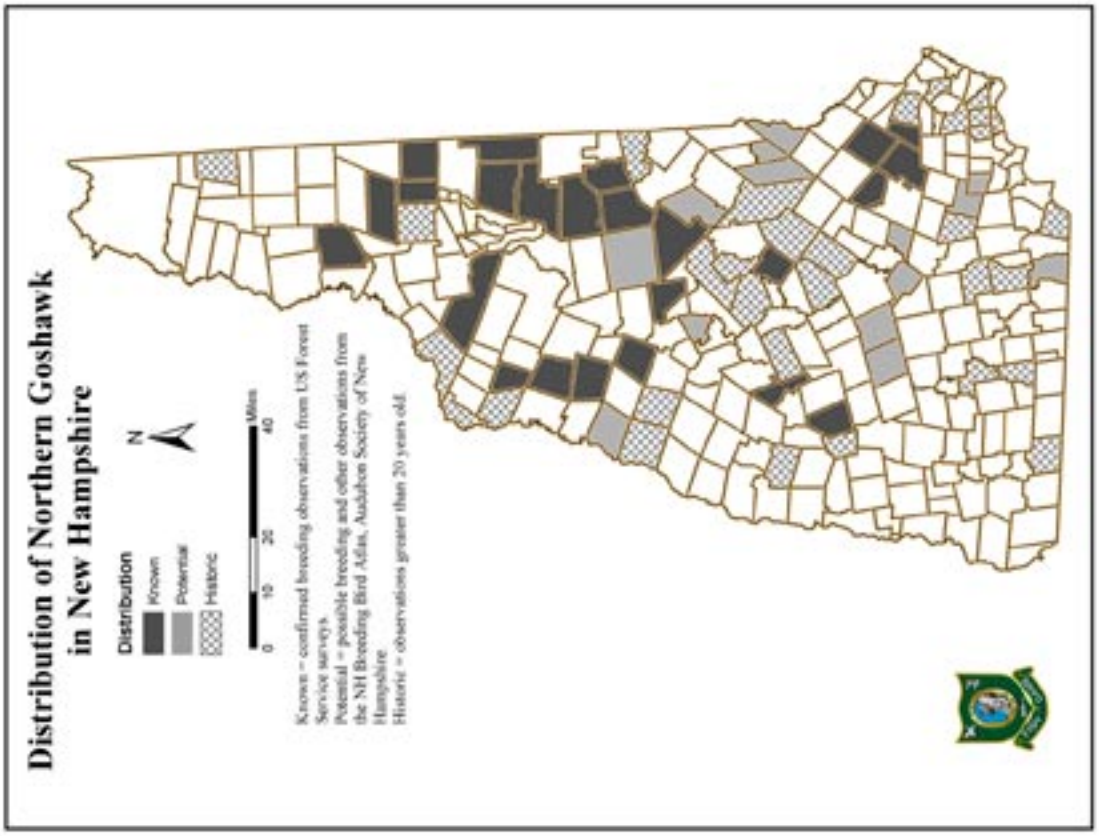
Distribution of Golden Eagles in New Hampshire
Distribution
Potential
Historic
N
0 10 20 40
Miles
Potential = possible breeding and other observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and obtained from NH Bird Records and the NH Breeding Bird Atlas, Audubon Society of New Hampshire.
Historic = observations greater than 20 years old.

Distribution of Great Blue Heron Rookeries in New Hampshire
Distribution
Known
N
0
10
20
40
Miles
Known = confirmed locations of rookeries as reported in the NH Natural Heritage Bureau's Element Occurrence Database.

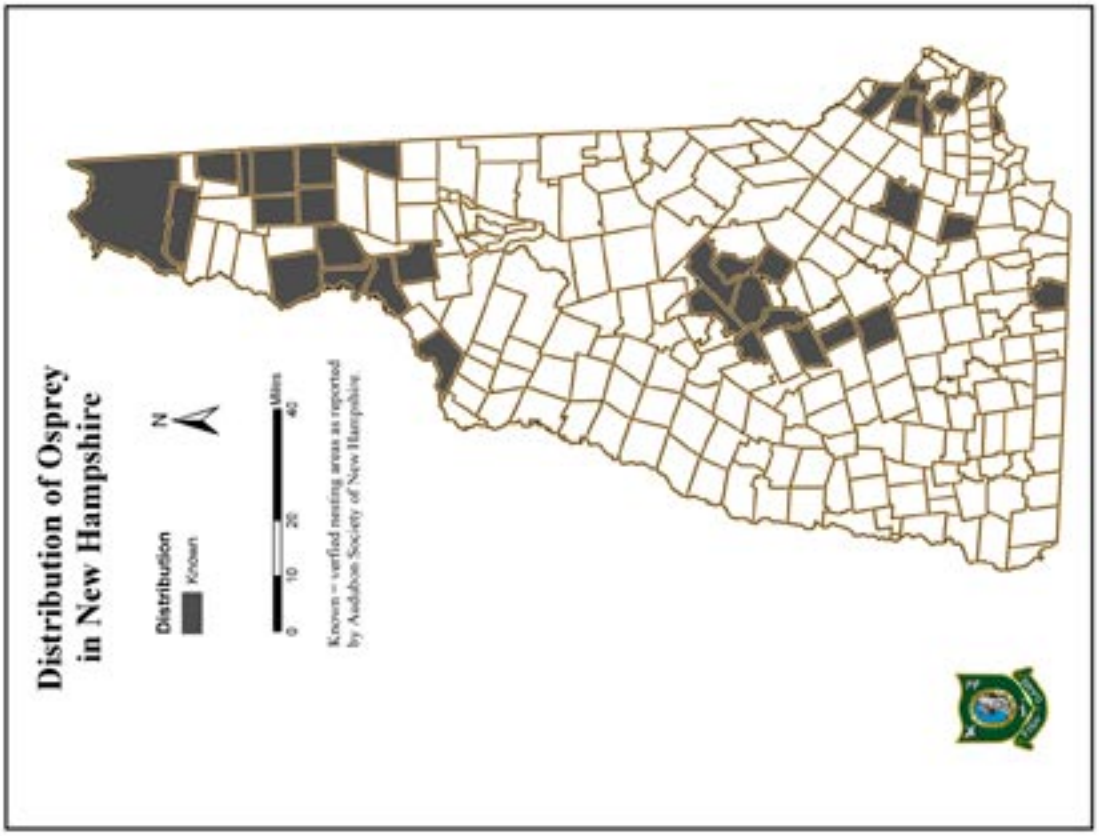

Distribution of Grasshopper Sparrow in New Hampshire
Distribution
Known
Potential
Historic
N
0
10
20
40
Miles
Known = confirmed breeding observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and obtained from NH Bird Records and the NH Breeding Bird Atlas, Audubon Society of New Hampshire.
Potential = possible breeding and other observations from the same data sources.
Historic = observations greater than 20 years old.

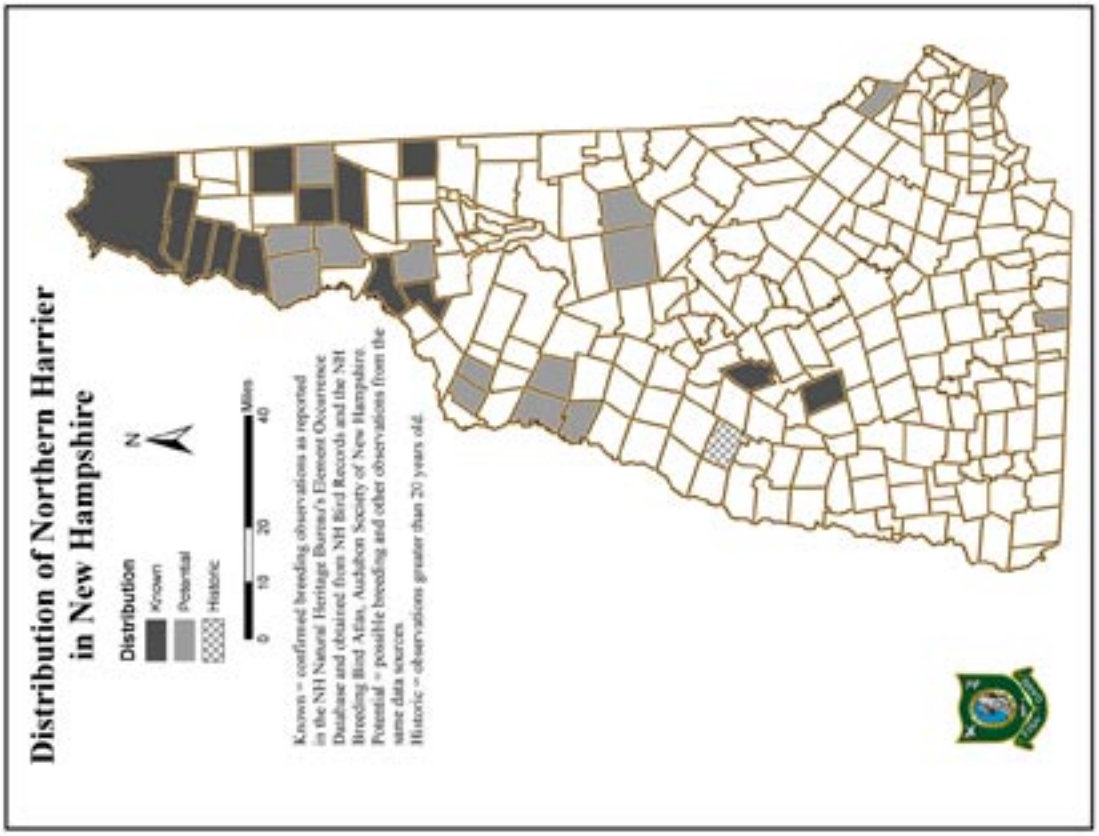
Distribution of Least Bittern
in New Hampshire
Distribution
Known
Potential
N
0
10
20
40
Miles
Known = confirmed breeding observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and obtained from NH Bird Records and the NH Breeding Bird Atlas, Audubon Society of New Hampshire.
Potential = possible breeding and other observations from the same data sources.

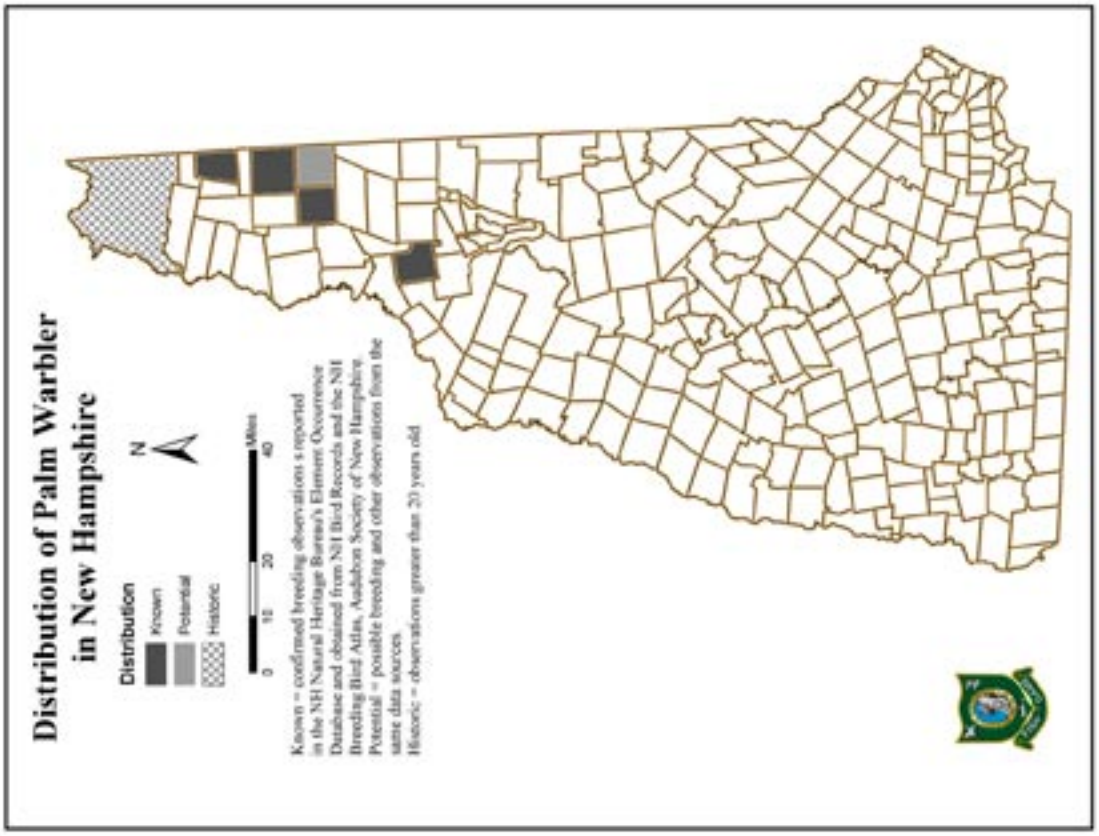
Distribution of Horned Lark
in New Hampshire
Distribution
Potential
Historic
N
0
10
20
40
Miles
Potential = possible breeding and other observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and obtained from NH Bird Records and the NH Breeding Bird Atlas, Audubon Society of New Hampshire.

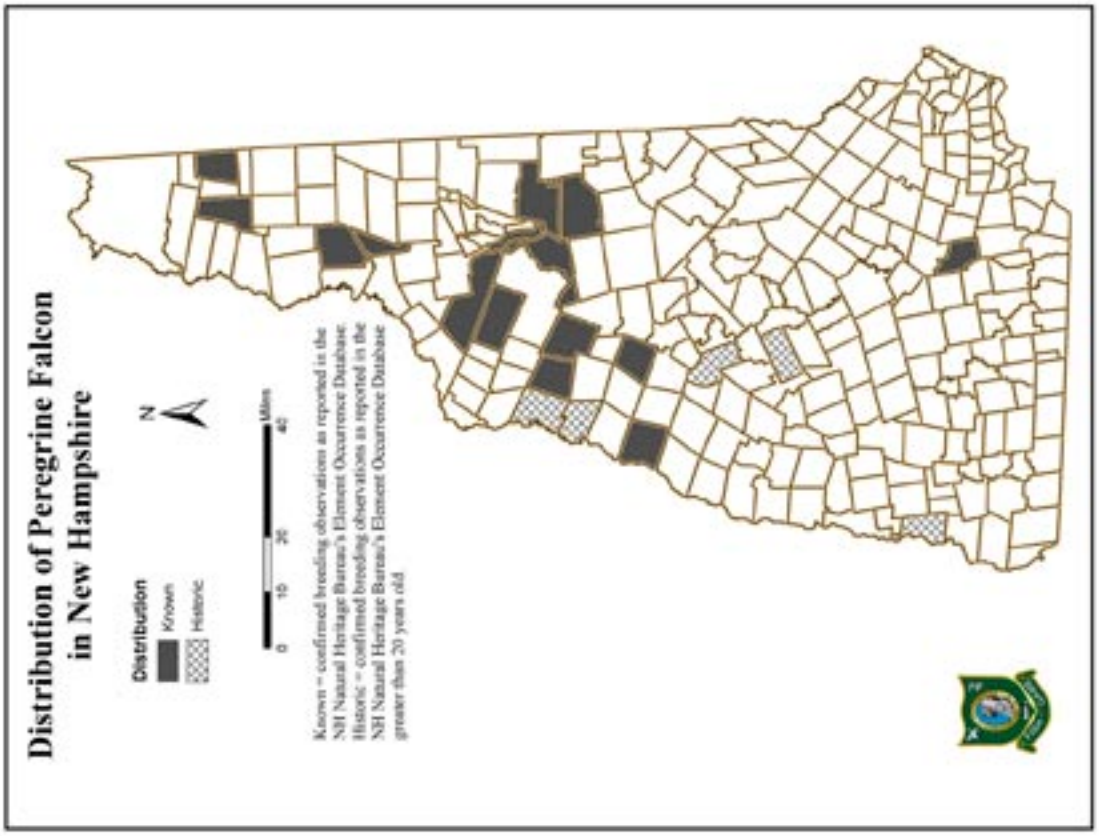

Distribution of Northern Goshawk in New Hampshire
Distribution
Known
Potential
Historic
N
0
10
20
40
Miles
Known = confirmed breeding observations from US Forest Service surveys.
Potential = possible breeding and other observations from the NH Breeding Bird Atlas, Audubon Society of New Hampshire
Historic = observations greater than 20 years old.

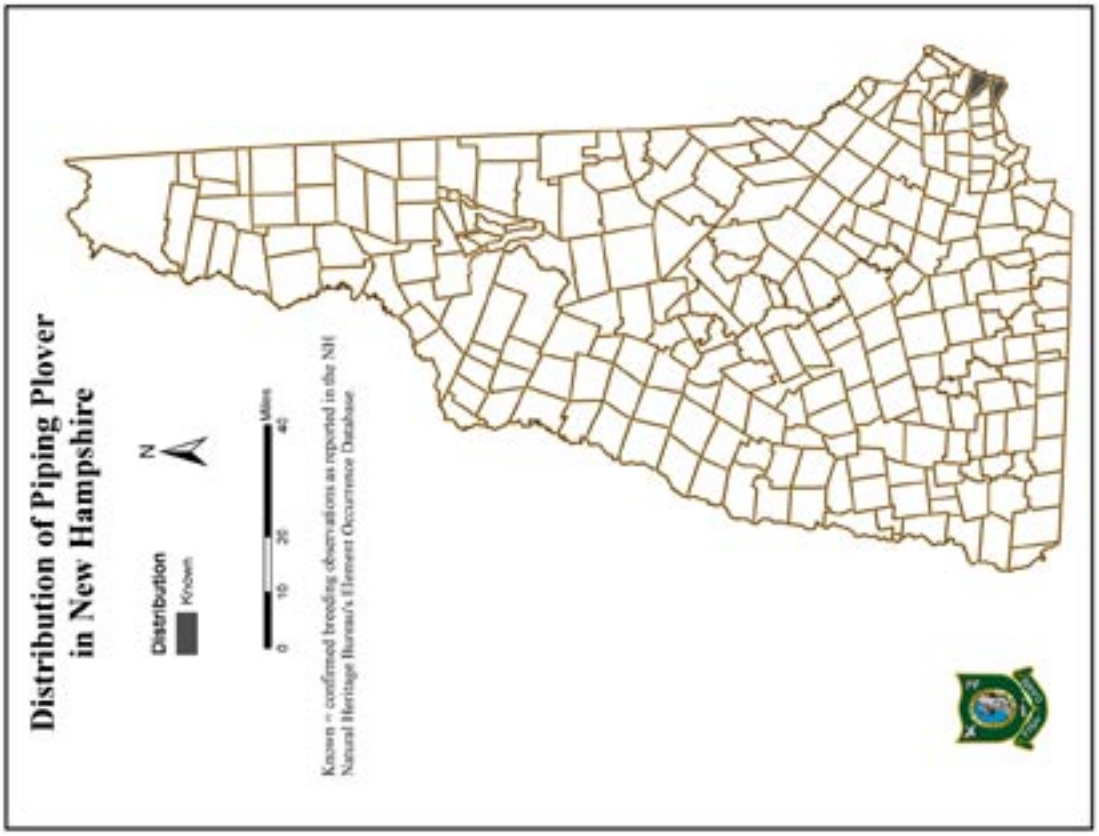
Distribution of Nelson's Sharp-tailed Sparrow in New Hampshire
Distribution
Known
Potential
N
0
10
20
40
Miles
Known = confirmed breeding observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and obtained from a University of New Hampshire survey.
Potential = possible breeding and other observations from the same data sources


Distribution of Osprey
in New Hampshire
Distribution
Known
N
0 10 20 40
Miles
Known = verified nesting areas as reported
by Audubon Society of New Hampshire

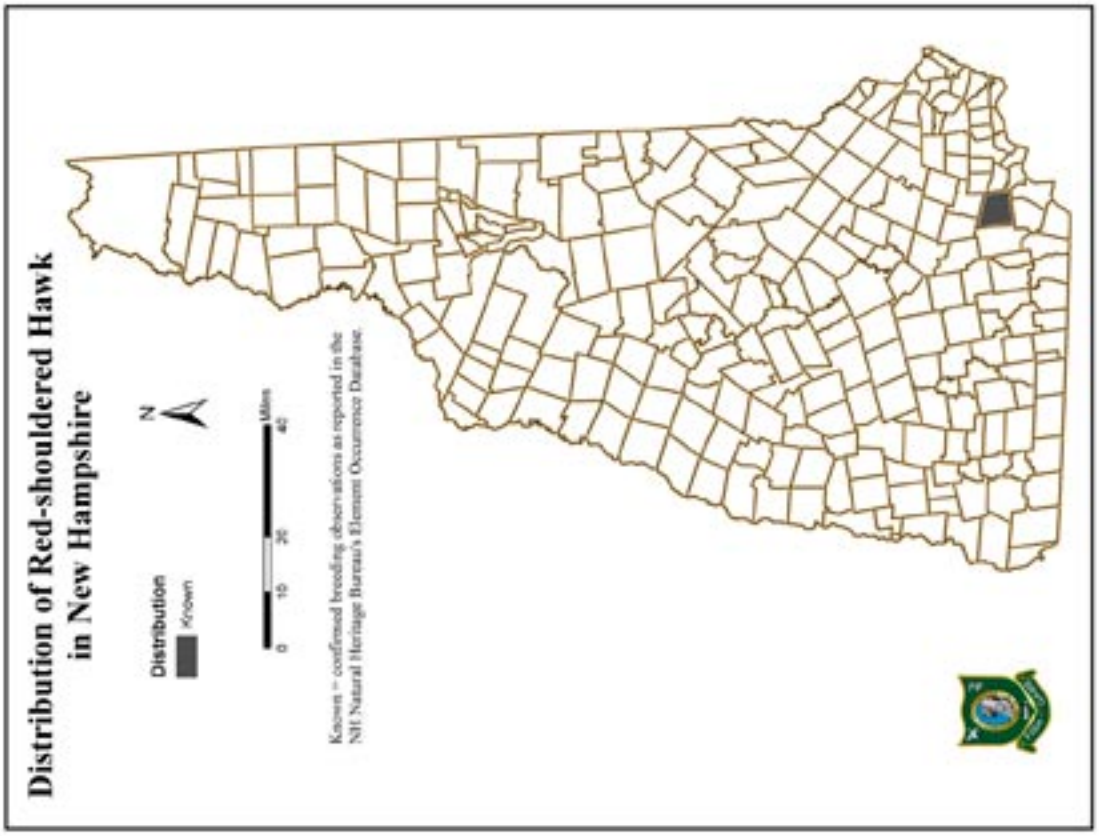

Distribution of Northern Harrier
in New Hampshire
Distribution
Known
Potential
Historic
N
0 10 20 40
Miles
Known = confirmed breeding observations as reported
in the NH Natural Heritage Bureau's Element Occurrence
Database and obtained from NH Bird Records and the NH
Breeding Bird Atlas, Audubon Society of New Hampshire
Potential = possible breeding and other observations from the
same data sources.
Historic = observations greater than 20 years old.

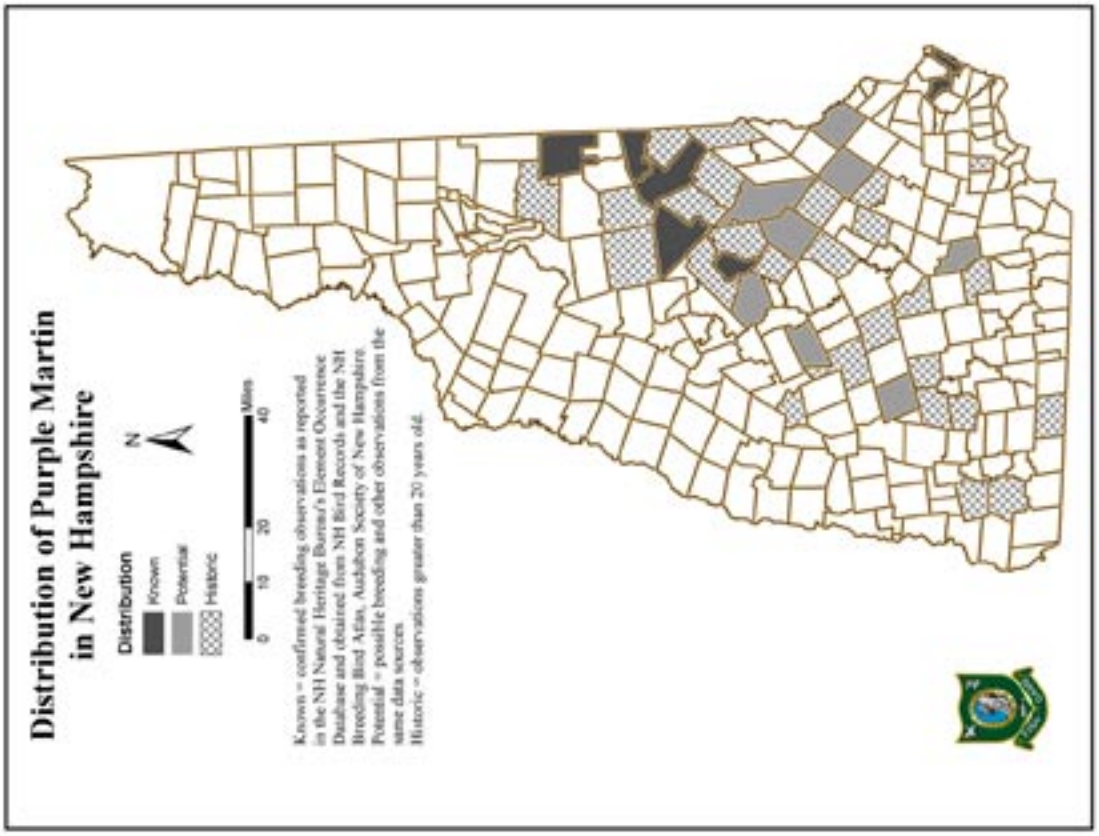

Distribution of Palm Warbler
in New Hampshire
Distribution
Known
Potential
Historic
N
0 10 20 40
Miles
Known = confirmed breeding observations s reported in the NH Natural Heritage Bureau's Element Occurrence Database and obtained from NH Bird Records and the NH Breeding Bird Atlas, Audubon Society of New Hampshire.
Potential = possible breeding and other observations from the same data sources.
Historic = observations greater than 20 years old

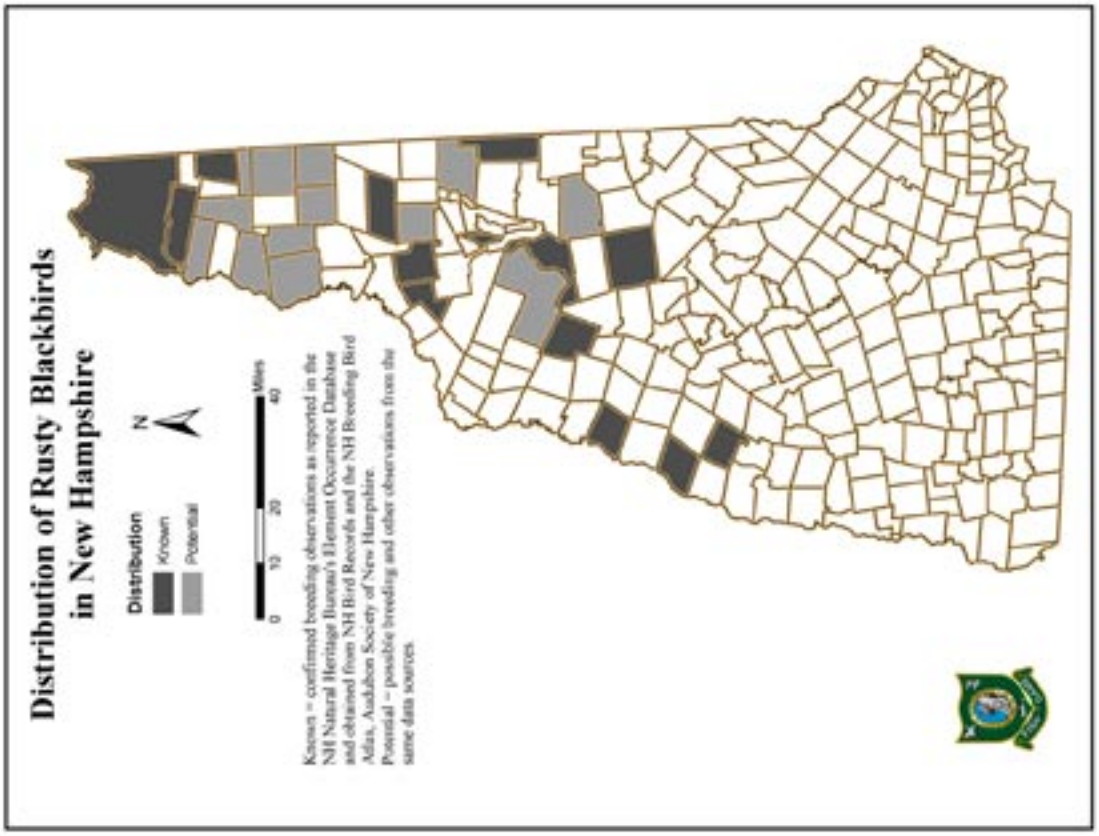

Distribution of Peregrine Falcon
in New Hampshire
Distribution
Known
Historic
N
0 10 20 40
Miles
Known = confirmed breeding observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database.
Historic = confirmed breeding observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database greater than 20 years old


Distribution of Piping Plover
in New Hampshire
Distribution
Known
N
0
10
20
40
Miles
Known = confirmed breeding observations as reported in the NH
Natural Heritage Bureau's Element Occurrence Database

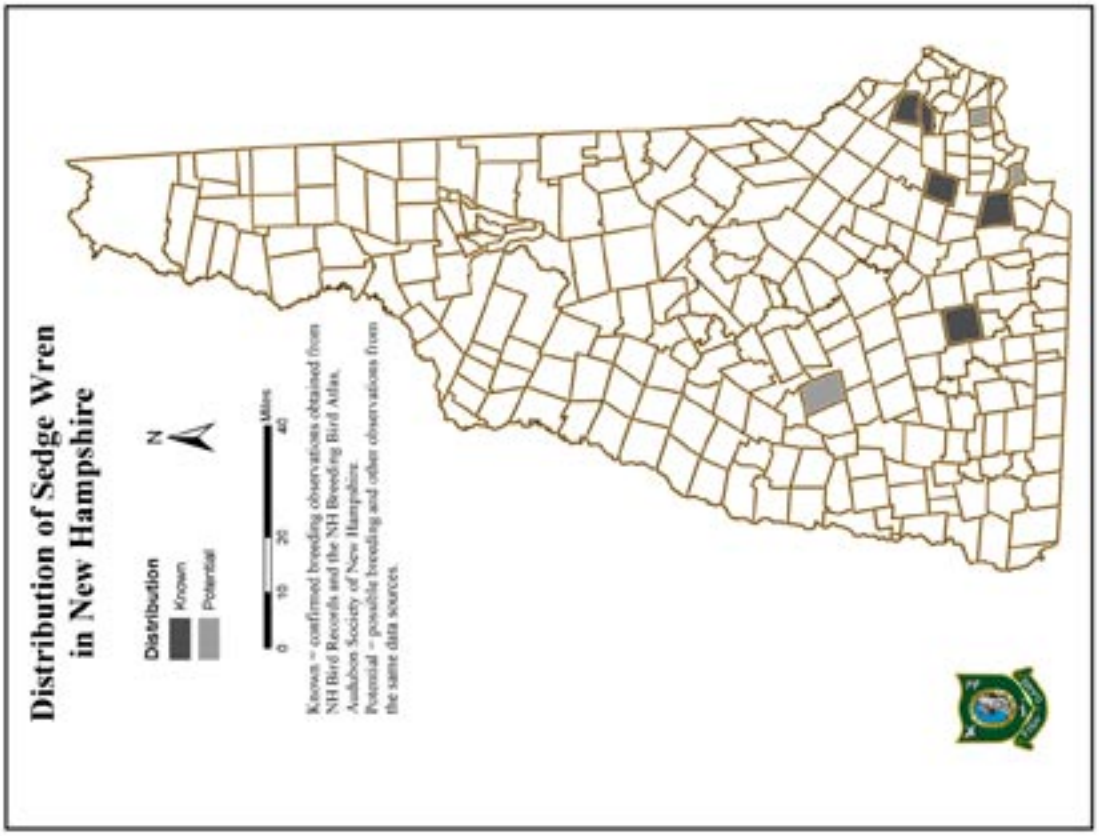
Distribution of Pied-billed Grebe
in New Hampshire
Distribution
Known
Potential
Historic
N
0
10
20
40
Miles
Known = confirmed breeding observations as reported
in the NH Natural Heritage Bureau's Element Occurrence
Database and obtained from NH Bird Records and the NH
Breeding Bird Atlas, Audubon Society of New Hampshire
Potential = possible breeding and other observations from the
same data sources
Historic = observations greater than 20 years old


Distribution of Red-shouldered Hawk
in New Hampshire
Distribution
Known
N
0
10
20
40
Miles
Known = confirmed breeding observations as reported in the
NH Natural Heritage Bureau's Element Occurrence Database.


Distribution of Purple Martin
in New Hampshire
Distribution
Known
Potential
Historic
N
0
10
20
40
Miles
Known = confirmed breeding observations as reported
in the NH Natural Heritage Bureau's Element Occurrence
Database and obtained from NH Bird Records and the NH
Breeding Bird Atlas, Audubon Society of New Hampshire.
Potential = possible breeding and other observations from the
same data sources.
Historic = observations greater than 20 years old.

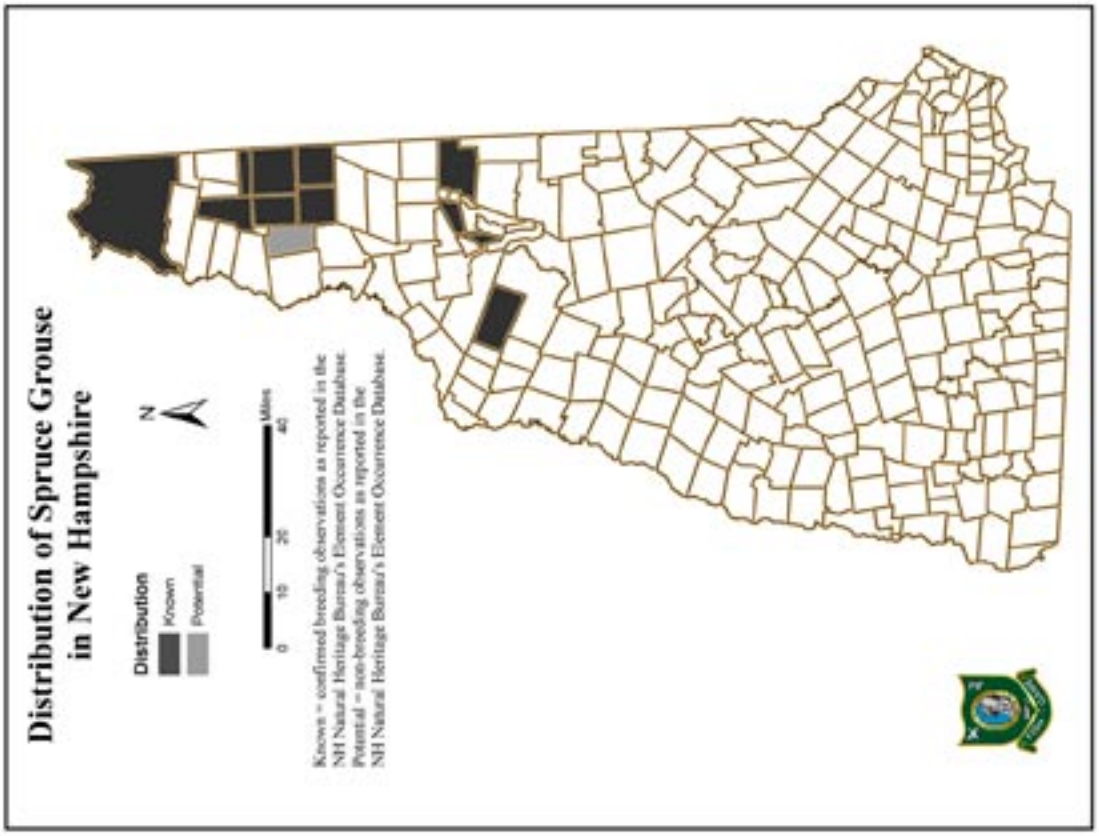

Distribution of Rusty Blackbirds in New Hampshire
Distribution
Known
Potential
N
0 10 20 40
Miles
Known = confirmed breeding observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and obtained from NH Bird Records and the NH Breeding Bird Atlas, Audubon Society of New Hampshire.
Potential = possible breeding and other observations from the same data sources.

Distribution of Saltmarsh Sharp-tailed Sparrow in New Hampshire
Distribution
Known
Potential
N
0 10 20 40
Miles
Known = confirmed breeding observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and obtained from a University of New Hampshire survey.
Potential = possible breeding and other observations from the same data sources.


Distribution of Sedge Wren
in New Hampshire
Distribution
Known
Potential
N
0
10
20
40
Miles
Known = confirmed breeding observations obtained from
NH Bird Records and the NH Breeding Bird Atlas,
Audubon Society of New Hampshire.
Potential = possible breeding and other observations from
the same data sources.

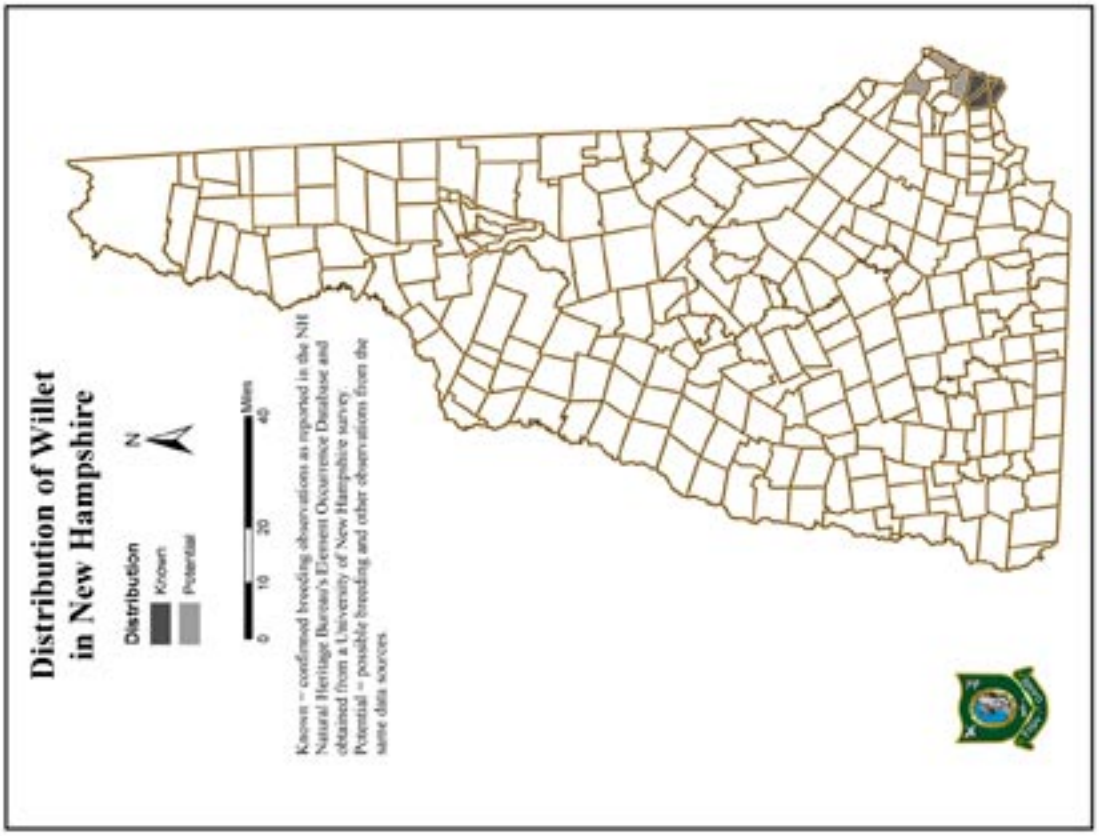
Distribution of Seaside Sparrow
in New Hampshire
Distribution
Known
Potential
N
0
10
20
40
Miles
Known = confirmed breeding observations as reported in the
NH Natural Heritage Bureau's Element Occurrence Database
and obtained from a University of New Hampshire survey.

Distribution of Upland Sandpiper
in New Hampshire
Distribution
Known
Potential
Historic
N
0
10
20
40
Miles
Known = confirmed breeding observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and obtained from NH Bird Records and the NH Breeding Bird Atlas, Audubon Society of New Hampshire.
Potential = possible breeding and other observations from the same data sources.
Historic = observations greater than 20 years old.


Distribution of Spruce Grouse
in New Hampshire
Distribution
Known
Potential
N
0
10
20
40
Miles
Known = confirmed breeding observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database.
Potential = non-breeding observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database.

Distribution of Vesper Sparrow in New Hampshire
Distribution
Potential
Historic
N
0 10 20 40
Miles
Potential = possible breeding and other observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and obtained from NH Bird Records and the NH Breeding Bird Atlas, Audubon Society of New Hampshire.
Potential = observations greater than 20 years old.

Distribution of Whip-poor-will in New Hampshire
Distribution
Potential
Historic
N
0 10 20 40
Miles
Potential = possible breeding and other observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and obtained from NH Bird Records and the NH Breeding Bird Atlas, Audubon Society of New Hampshire.
Historic = observations greater than 20 years old.


Distribution of Willet
in New Hampshire
Distribution
Known
Potential
N
0
10
20
40
Miles
Known = confirmed breeding observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and obtained from a University of New Hampshire survey.
Potential = possible breeding and other observations from the same data sources

APPENDIX A

Species Profiles

Part Two: Fish

Alewife....A-95
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SPECIES PROFILE

Alewife

Alosa pseudoharengus

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S5
Author: Matthew A. Carpenter, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Alewives use various freshwater spawning habitat including riverine oxbows, ponds, and mid-river sites. Juveniles remain in freshwater until late summer and early fall when they migrate into estuaries and eventually to the ocean. When not spawning, adult alewives congregate in areas of the Nantucket Shoals, Georges Bank, and the shores of the Gulf of Maine.

1.2 Justification

Dams severely limit accessible anadromous fish spawning habitat, and alewives must use fish ladders for access to spawning habitat during spring spawning runs. River herring are a key component of freshwater, estuarine, and marine food webs (Bigelow and Schroeder 1953). They are an important prey for many predators, and they contribute nutrients to freshwater ecosystems (Macavoy et al. 2000).

1.3 Protection and Regulatory Status

The taking of river herring in New Hampshire waters is open only to residents, and no fish may be taken on Wednesdays. A harvest permit is required to take river herring by any form of netting. Herring caught at sea are further regulated, and when the season is closed between 21 September and 19 October, the maximum incidental catch is to 2,000 lbs daily. The alewife is protected under the Anadromous Fish Conservation Act.

1.4 Population and Habitat Distribution

The alewife ranges from Newfoundland to South Carolina. Some populations, such as those in the Great Lakes, are landlocked (Atlantic States Marine Fisheries Commission 1999). In New Hampshire, alewives spawn in the Merrimack River and the seacoast drainages (Scarola 1987).

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

Alewives inhabit the lower section of the Merrimack River and the coastal watersheds of New Hampshire. See the Non-Tidal Coastal Watershed, Connecticut River Mainstem Watershed, and Tidal Coastal Watershed profiles.

1.7 Sources of Information

Literature reviews and historical records of fish passage at dams in New Hampshire and Massachusetts were used to identify distribution and habitat requirements.

1.8 Extent and Quality of Data

River herring are monitored annually at fishways on the Connecticut, Merrimack, and coastal rivers.

1.9 Distribution Research

The stream reaches used as spawning habitat by anadromous fish in New Hampshire are relatively unknown. Research in New Hampshire may identify

quality spawning habitat upstream from impassable dams. A GIS map of the stream reaches accessible to anadromous species, combined with a map of potential spawning habitat, would facilitate restoration efforts.

Element 2

Not completed for this species

Element 3

Not completed for this species

Element 4

Not completed for this species

Element 5: References

Atlantic States Marine Fisheries Commission [ASMFC]. 1999. Amendment 1 to the Interstate Management Plan for Shad and River Herring. ASMFC Fishery Management Report No. 35.

Bigelow H., and W. Schroeder. 1953. Fishes of the Gulf of Maine. Fishery Bulletin of the Fish and Wildlife Service. No. 74. Vol 53.

MacAvoy, S.E., S.A. Macko, S.P. McIninch, and G.C. Garman. 2000. Marine nutrient contributions to freshwater apex predators. Oecologia 122:568-573.

Scarola J. 1987. Freshwater Fishes of New Hampshire. New Hampshire Fish and Game Department. 132p.

SPECIES PROFILE

American Eel

Anguilla rostrata

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S5
Author: Matthew A. Carpenter, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

American eels use marine, estuarine, and freshwater habitat (Atlantic States Marine Fisheries Committee (ASMFC) 2000). American eels breed collectively in the Sargasso Sea, a large area of the western Atlantic Ocean. After hatching, larval eels (leptocephali) drift in ocean currents to the shores of eastern North America, northeastern South America, Europe, and North Africa where they transform into glass eels and then pigmented elvers. Elvers migrate into estuaries and freshwater where they remain for most of their lives. Adults spend 10 to 25+ years in freshwater, where they are referred to as yellow eels. Eventually, yellow eels metamorphose into silver eels that then migrate back to the Sargasso Sea to spawn and die.

1.2 Justification

The American eel is in decline throughout its range (Haro et al. 2000), and yellow eel abundance has dropped dramatically in the St. Lawrence River over the past 20 years (Castonguay et al. 1994). Causes of eel declines may include commercial harvest, dams, unfavorable environmental conditions in marine and freshwater environments, pollution, and climate change (Haro et al. 2000). A long life span, combined with extensive migration and a single breeding event, make the American eel population vulnerable to collapse (ASMFC 2000).

1.3 Protection and Regulatory Status

In New Hampshire, there is a creel limit of 50 American eels per day, and each must be 6 inches long. American eels may be taken year-round except downstream from a fishway, where they may be taken only from June 15 to October 1. A harvest permit is required if eels are taken by any other method than angling.

1.4 Population and Habitat Distribution

The American eel is found in coastal watersheds from northeastern South America to Greenland (ASMFC 2000). In New Hampshire, American eels are found in the seacoast watersheds and portions of the Merrimack and Connecticut River watersheds (Scarola 1987).

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

American eels inhabit sections of the Merrimack River, Connecticut River, and the coastal watersheds of New Hampshire. See the Non-Tidal Coastal Watersheds (systems 11 and 12), Connecticut River Mainstem Watersheds (systems 1 and 2), Coastal Transitional Watersheds (systems 10 and 14), Northern Upland Watersheds (systems 5 and 7), and Tidal Coastal Watersheds (system 13) profiles.

1.7 Sources of Information

Little is known about the distribution of American eels in New Hampshire. Data collected at fish ladders during the spring spawning runs of anadromous fish document the accumulation of elvers below dams at the head of tide on coastal rivers.

1.8 Extent and Quality of Data

There has been no comprehensive survey of American eels in New Hampshire waters. Data on American eel distribution are scattered in field notes and records from surveys of other species.

1.9 Distribution Research

Due to the rapid decline in recruitment of American eel, priority should be placed on developing or facilitating upstream and downstream passage at dams rather than on establishing the distribution of the species. Distribution research should be linked to evaluations of efforts to improve access to freshwater habitats.

Element 2

Not completed for this species

Element 3

Not completed for this species

Element 4

Not completed for this species

Element 5: References

Atlantic States Marine Fisheries Commission (ASMFC). 2000. Interstate Fishery Management Plan for American Eel. ASMFC Fishery Management Report No. 36. 79 p.

Atlantic States Marine Fisheries Commission. 2004. Review of the Atlantic States Marine Fisheries Commission Fishery Management Plan for the American Eel (*Anguilla rostrata*). American Eel Review Team.

Castonguay, M., P.V. Hodson, C.M. Couillard, M.J. Eckersley, J.D. Dutil, and G. Verreault. 1994. Why is recruitment of the American eel (*Anguilla rostrata*) declining in the St. Lawrence River and Gulf? Canadian Journal of Fisheries and Aquatic Sciences 51:479–488.

Haro, A., W. Richkus, K. Whalen, A. Hoar, W.D. Busch, S. Lary, T. Brush, and W. Dixon. 2000. Population decline of the American eel: implications for research and management. Fisheries 25: 7–16

Scarola, J. 1987. Freshwater Fishes of New Hampshire (2nd Edition). New Hampshire Fish and Game Department. 132p.

SPECIES PROFILE

American Shad

Alosa sapidissima

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S3
Author: Matthew A. Carpenter, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

American shad are anadromous fish that spawn in moderate to large freshwater rivers along the Atlantic coast. Spawning occurs between 12-20^{0}C and flows of 10-132 cm^2/sec. The nonadhesive eggs drift in the current until they hatch. Dissolved oxygen levels below 5 mg/l are detrimental to shad at all life stages. In the ocean, shad prefer temperatures between 7-13^{0}C and migrate to deeper water during winter. During summer and fall, shad congregate in the Gulf of Maine and the Bay of Fundy (Bigelow and Schroeder 1953).

1.2 Justification

Commercial shad harvests along the U.S. Atlantic coast have declined from an estimated peak of 50,499,000 lbs in 1896 to around 8,134,000 lbs in 1960 (Weiss-Glanz et al. 1986). Catches have continued to decline over the past 40 years due to the cumulative effect of dams, pollution, and over-fishing (Weiss-Glanz et al. 1986). Impassable dams have reduced available river spawning habitat in Maine by 95%, and in New Hampshire dams restrict shad to a fraction of their historical spawning habitat.

1.3 Protection and Regulatory Status

In New Hampshire, there is a 2-fish daily limit that must be caught by angling. There are no length or weight limits. American shad taken by any other method must be released. There is no commercial fishery for American shad in New Hampshire, and incidental catch of shad in other fisheries cannot exceed 5% of the total landing per trip (Atlantic States Marine Fisheries Commission 1999). The American shad is protected under the Anadromous Fish Conservation Act.

1.4 Population and Habitat Distribution

American shad spawn in rivers from Florida to Newfoundland, though they are most abundant from Connecticut to North Carolina. They were recently introduced to the Pacific coast. In New Hampshire, the largest historic populations spawned in the Connecticut and Merrimack rivers. The distribution of historical shad spawning areas in the coastal rivers is not well documented.

1.5 Town Distribution Map

Not completed for this species

1.6 Habitat Map

American shad inhabit the lower section of the Merrimack River and the coastal watersheds of New Hampshire. See the Non-Tidal Coastal Watersheds (systems 11 and 12), Mainstem Watersheds (systems 1 and 2), and Tidal Coastal Watersheds (system 13) profiles.

1.7 Sources of Information

Literature reviews and historical records of fish passage at dams in New Hampshire and Massachusetts were used to identify distribution and habitat requirements.

1.8 Extent and Quality of Data

Shad returns are monitored annually at fishways on the Connecticut, Merrimack, and coastal rivers.

1.9 Distribution Research

Spawning habitats for anadromous fish in New Hampshire are relatively unknown. Research may identify quality spawning habitat upstream from impassable dams. A GIS map of the stream reaches currently accessible to each anadromous species, combined with a map of potential spawning habitat that is inaccessible, would facilitate restoration efforts.

Element 2

Not completed for this species

Element 3

Not completed for this species

Element 4

Not completed for this species

Element 5: References

ASMFC (Atlantic States Marine Fisheries Commission). 1985. Fishery Management Plan for the Anadromous Alosid Stocks of the Eastern United States: American Shad, Hickory Shad, Alewife, and Blueback Herring: Phase II in Interstate Management Planning for Migratory Alosids of the Atlantic Coast. Washington, D.C. XVIII + 347 pp.

ASMFC [Atlantic States Marine Fisheries Commission]. 1999. Amendment 1 to the Interstate Management Plan for Shad & River Herring. ASMFC Fishery Management Report No. 35. 77 p.

Bigelow, H., and W. Schroeder. 1953. Fishes of the Gulf of Maine. Fishery Bulletin of the Fish and Wildlife Service. 74(53)

United States Fish and Wildlife Service. 2004. Fish Facts- American Shad. Available http://www.fws.gov/r5crc/Fish/zb_alsa.html. (Accessed May 2005).

Weiss-Glanz, L.S., J.G. Stanley, and J.R. Moring. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (North Atlantic)--American shad. United States Fish and Wildlife Service Biol. Rep. 82(11.59). U.S. Army Corps of Engineers, TR EL-82-4. 16 pp.

SPECIES PROFILE

Atlantic Salmon

Salmo salar

Federal Listing: Partial Status
State Listing: Not listed
Global Rank: G5
State Rank: S4
Author: Matthew A. Carpenter, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Young Atlantic salmon inhabit cool, swift moving streams with riffles and gravelly cobble substrates. As Atlantic salmon mature, they also use areas of slower moving water with pools and vegetation (DeGraff and Bain 1986). Atlantic salmon spend 2 to 3 years in freshwater before descending to the Atlantic Ocean. At least 1 year is spent feeding in the ocean before returning to spawn. Spawning occurs between October and November in riffle habitats over gravel substrate.

1.2 Justification

Atlantic salmon have a complex life cycle, and can be harmed by overharvest, predation, pollution, and impoundments. Atlantic salmon were abundant in pre-colonial times) and were declared extirpated from both the Connecticut and Merrimack rivers in the early nineteenth century. The loss was attributed to the construction of impassable dams (Connecticut River Atlantic Salmon Commission 1998, Merrimack River Policy and Technical Committees 1990).

1.3 Protection and Regulatory Status

In the Pemigewasset River and its tributaries, Atlantic salmon cannot be taken upstream of Ayers Island Dam in Bristol. Only tagged Atlantic salmon (brood stock release) can be taken in the Merrimack River and lower Pemigewasset River. The Connecticut River is closed to taking Atlantic salmon. Sea-run Atlantic salmon may be taken by angling in coastal watersheds. Fish must be at least 15 inches long, and only 2 may be taken daily.

1.4 Population and Habitat Distribution

The Atlantic salmon is native to the North Atlantic Ocean. In North America, historical spawning runs of adult Atlantic salmon occurred in rivers from northern Quebec to the Connecticut River (Scott and Crossman 1973). Spawning runs in the Connecticut River watershed included tributaries as far upstream as Beecher Falls in West Stewartstown, New Hampshire (Connecticut River Atlantic Salmon Commission 1998). Spawning adult Atlantic salmon migrated as far upstream as Profile Lake (Franconia, New Hampshire) in the Merrimack River watershed (Greenwood 2005). Salmon restoration projects involve annually stocking of Atlantic salmon of various ages as far upstream as the Mohawk River in Colebrook (Connecticut River watershed) and the headwaters of the Pemigewasset River in Franconia (Merrimack River watershed) (Dianne Emerson, New Hampshire Fish and Game (NHFG), personal communication and Jon Greenwood, NHFG, personal communication).

1.5 Town Distribution Map

Not completed for this species

1.6 Habitat Map

Atlantic salmon populations were historically scattered throughout Merrimack, Connecticut, and coastal watersheds of New Hampshire. See the Northern Upland Watersheds (refer to the systems 5 and 7), Mainstem Watersheds (systems 1 and 2), Southern Upland Watersheds (systems 3 and 9),

Montane Watersheds (systems 4, 6, and 8), Coastal Transitional Watersheds (systems 10 and 14), and Non-Tidal Coastal Watersheds (systems 11 and 12) profiles.

1.7 Sources of Information

Published literature, a recovery plan for Atlantic salmon, and consultations with fisheries biologists were used to determine distribution and habitat requirements of the species.

1.8 Extent and Quality of Data

The abundance and extent of Atlantic salmon spawning migrations in pre-colonial times is speculative, and it is possible that spawning runs were exaggerated. During these times, fishery science techniques to quantify fish abundances were not available (Connecticut River Atlantic Salmon Commission 1998). Selected rivers and streams that receive stocked Atlantic salmon have been identified and are annually monitored.

1.9 Distribution Research

Rivers and streams that receive stocked Atlantic salmon are well known and monitored.

Element 2

Not completed for this species

Element 3

Not completed for this species

Element 4

Not completed for this species

Element 5: References

Connecticut River Atlantic Salmon Commission. 1998. Strategic Plan for the Restoration of Atlantic Salmon to the Connecticut River. 109p.

DeGraff, D., and L. Bain. 1986. Habitat use by and preference of juvenile Atlantic salmon in two Newfoundland rivers. Transactions of the American Fisheries Society. 115:671-681.

Greenwood J. 2005. Anadromous Fisheries in New Hampshire. http://www.wildlife.state.nh.us/Fishing/fisheries_management/anadromous.htm>. Accessed 2005.

Merrimack River Policy and Technical Committees. 1990. Strategic Plan for the Restoration of Atlantic Salmon to the Merrimack River 1990 through 2004. 56p.

Scott, W., and E. Crossman. 1973. Freshwater Fishes of Canada. Fisheries Research Board of Canada. 966p.

SPECIES PROFILE

Atlantic Sturgeon

Acipenser oxyrhynchus

Federal Listing: N3
State Listing: Not listed
Global Rank: G3
State Rank: S1
Author: Benjamin J. Nugent, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The Atlantic Sturgeon is anadromous, living in marine waters and entering fresh and brackish waters during spawning migrations. Spawning runs are from February to July depending on the location of the river (Scott and Crossman 1973). In Maine, spawning occurs in July. Migration activity during spawning periods has been observed at depths of 10 to 42 feet and temperatures of 13.3° to 18.4°C (Scott and Crossman 1973, Everhart 1976, Kieffer and Kynard 1993). The return migration of spent adults to marine waters appears to be somewhat random, and the highest concentrations of adults return between September and November (Scott and Crossman 1973). Spawning substrates consist of hard clay, small rubble, and gravel (Everhart 1976). Eggs are adhesive when dispensed, attaching to vegetation and stones. Juveniles will spend up to 4 years in riverine or tidal habitats (Scott and Crossman 1973).

1.2 Justification

Over-harvest, habitat degradation, and barriers all contributed to the population declines that were first noticed at the beginning of the twentieth century (Smith 1995). More studies of Atlantic sturgeon in New Hampshire are needed.

1.3 Protection and Regulatory Status

Participating states of the Atlantic States Marine Fisheries Commission's Interstate Fishery Management Plan have prohibited fishing for Atlantic sturgeon. The Atlantic sturgeon was a candidate species for the endangered or threatened species list (1988 and 1998) but was later denied. The possession of sturgeon is prohibited in New Hampshire.

1.4 Population and Habitat Distribution

Evidence from colonial times suggests that the species existed in the Connecticut, Merrimack, and Coastal watersheds, though little is known about the extent of the species' range in these watersheds (Kieffer and Kynard 1993). Amoskeag Falls (Manchester, New Hampshire) is believed to have been the historical limit for Atlantic sturgeon in the Merrimack River. Currently, the species is believed not to exist in the Connecticut and Merrimack watersheds within New Hampshire. Two Atlantic Sturgeon have been found upstream of the Great Bay Estuary System since 1981 (Doug Grout, NHFG, personal communication). The Great Bay area is potentially used by sub adults (younger than 2) for nursery habitat, though it is not believed that spawning occurs in the bay (NMFS 1998).

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

Atlantic sturgeon historically inhabited the lower sections of the Connecticut and Merrimack rivers and the coastal watershed of New Hampshire. See the Lower Connecticut (systems 1 and 2), Lower Merrimack (systems 11 and 12), and Coastal Rivers (system 13) watershed profiles.

1.7 Sources of Information

Published literature was used to define habitat characteristics and historical distribution. Fisheries professionals provided additional information on recent sightings.

1.8 Extent and Quality of Data

Atlantic sturgeon cannot reach historic spawning areas in the Connecticut and Merrimack watersheds (Micah Kieffer, United States Geological Survey (USGS), personal communication), and only 2 recent (1981 and 1991) observations of the species have occurred in the coastal waters of New Hampshire. A monitoring project for shortnose sturgeon (*Acipenser brevirostrum*) from 1987 to 1988 lacked any incidental catches of Atlantic Sturgeon (NHFG unpublished data).

1.9 Distribution Research

Habitat assessments of coastal watersheds may reveal areas of potential Atlantic sturgeon spawning habitat. Results from these habitat assessments may identify barriers and other factors that prevent the species from reaching preferred spawning grounds.

Element 2

Not completed for this species

Element 3

Not completed for this species

Element 4

Not completed for this species

Element 5: References

Everhart W. 1976. Fishes of Maine. Maine Department of Inland Fisheries and Wildlife. 96p.

Kieffer, M., and B. Kynard. 1993. Annual Movements of Shortnose and Atlantic Sturgeons in the Merrimack River, Massachusetts. Transactions of the American Fisheries Society 122:1088-1103.

National Marine Fisheries Service (NMFS). 1998. Status Review of Atlantic Sturgeon (*Acipenser oxyrhynchus oxyrhynchus*). United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Smith T. 1995. The Fishery, Biology, and management of Atlantic Sturgeon, *Acipenser oxyrhynchus*, in North America. Environmental Biology of Fishes 14:61-72.

SPECIES PROFILE

Banded Sunfish

Enneacanthus obesus

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S3
Author: Matthew, A. Carpenter, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Banded sunfish prefer vegetated areas of ponds, lakes, and the backwaters of lowland streams (Scarola 1987). Banded sunfish are highly tolerant of acidic water and can withstand pH levels as low as 4.0 (Gonzales and Dunson 1989). Tolerance for acidic water may be an adaptation that provides banded sunfish with access to habitats unavailable to other fish species (Graham and Hastings 1984, Gonzales and Dunson 1991) and may provide the banded sunfish with refuge from both native and introduced species of predaceous fish (Graham 1993).

1.2 Justification

Little is known about the ecology or distribution of the banded sunfish in New Hampshire. Most records are from the southeastern part of the state where human populations are rapidly increasing. Of 37 known records, 16 were collected in a statewide biological inventory conducted in the late 1930s by NHFG (Gordon 1937, Bailey 1938, Bailey and Oliver 1939).

1.3 Protection and Regulatory Status

Banded sunfish may not be used as bait in New Hampshire.

1.4 Population and Habitat Distribution

Banded sunfish inhabit the Atlantic coastal plain from southern New Hampshire to Florida (Scarola 1987). In New Hampshire they are found in lowland areas of the Merrimac River and in coastal watersheds (Scarola 1987). A population has also been documented in the upper Millers River system, which drains into the Connecticut River (Bailey and Oliver 1939). Though populations may be locally abundant, they are not widely distributed.

1.5 Town Distribution Map

Before 20 years ago, banded sunfish occurred in the towns of Hudson, Manchester, Merrimack, Nashua, New Ipswich, Nottingham, Pelham, Rindge, Salem, South Hampton, and Windham. Within the last 20 years, sightings have occurred in Amherst, Bedford, Brookline, East Barrington, Hampton, Hollis, Lee, Londonderry, Madbury, Manchester, Merrimack, Milford, New Ipswich, North Hampton, Peterborough, and Rindge.

1.6 Habitat Map

More research will be necessary to determine the current distribution and habitat requirements of this species in New Hampshire. A map of low-gradient streams and pond habitat in the coastal watersheds (refer to system 13), the Merrimac watersheds (refer to system 11 and system 12), and the Millers River watershed in the Connecticut River drainage (refer to system 9), would facilitate future surveys.

1.7 Sources of Information

Records of banded sunfish came from Biological Surveys by NHFG from 1937 to 1939, NHFG) Fishing

For the Future project, the Environmental Protection Agency EMAP pilot fish sampling summary from the Northeast Lakes Monitoring Project, the New Hampshire Department of Environmental Services Biomonitoring Program, and reports from independent biologists.

1.8 Extent and Quality of Data

Records of banded sunfish were gathered from federal, state, and private monitoring projects. The distribution of the species cannot be established with available data because none of these projects specifically targeted banded sunfish or their habitat. Available records may be used to guide future surveys of the banded sunfish in New Hampshire.

1.9 Distribution Research

Survey work from the 1930s and the NHFG Fishing for the Future project provide evidence for the presence of banded sunfish in certain water bodies. The first priority should be to check for the presence of the species at sites with historic records. Once historical records are verified, a more conclusive statewide distribution of the species can be established by sampling waters in close proximity to known populations.

Studies of the factors that limit the distribution and abundance of banded sunfish will likewise be helpful. Data collected from sites with known populations may be used to recommend new survey sites. Data should be entered into a GIS database to help identify variables that may predict the presence of banded sunfish and to track the distribution of the species over time.

Element 2

Not completed for this species

Element 3

Not completed for this species

Element 4

Not completed for this species

Element 5: References

5.1 Literature

Bailey J.R., and J.A. Oliver. 1939. The fishes of the Connecticut watershed. In: A biological survey of the Connecticut watershed. New Hampshire Fish and Game Dept., Survey Report No. 4:150-189.

Bailey, R.M. 1938. The fishes of the Merrimack watershed. In: A biological survey of the Merrimack watershed. New Hampshire Fish and Game Department Survey Report No. 3:149-185.

Gonzales, R.J., and W.A. Dunson. 1989. Differences in low pH tolerance among closely related sunfish of the genus *Enneacanthus*. Environmental Biology of Fishes 26(4):303-310.

Gonzales, R.J., and W.A. Dunson. 1991. Does water pH control habitat segregation of sibling species of sunfish *Enneacanthus*? Wetlands 11(2):313-324.

Gordon, M. 1937. The fishes of eastern New Hampshire. In: A biological survey of the Androscoggin, Saco, and Coastal watersheds. New Hampshire Fish and Game Department, Survey Report No. 2:101-118.

Graham, J.H., and R.W. Hastings. 1984. Distributional patterns of sunfishes on the New Jersey coastal plain. Environmental Biology of Fishes 10: 137-148.

Graham, J.H. 1993. Species diversity of fishes in Naturally acidic lakes in New Jersey. American Fisheries Society. 122:1043-1057.

Scarola J. 1987. Freshwater Fishes of New Hampshire. New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

5.2 Data Sources

Biomonitoring Program. 1995-2005. New Hampshire Department of Environmental Services, Watershed Management Bureau. www.des.state.nh.us/wmb/biomonitoring/sites/index.html >. Accessed 2004 December 12

SPECIES PROFILE

Blueback Herring

Pomolobus aestivalis

Federal Listing: Not listed
State Listing: Not listed
Affected Species: Not listed
Global Rank: G5
State Rank: S4
Author: Matthew A. Carpenter, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Blueback herring are anadromous fish that spawn over various substrata in fast and slow rivers and streams (United States Fish and Wildlife Service 2001). Adults return to the ocean after spawning, and young of the year migrate to the ocean by autumn. Little is known about ocean movements, but both blueback herring and alewives (*Pomolobus pseudoharengus)* have been known to congregate on Georges Bank, the Nantucket Shoals, and the perimeter of the Gulf of Maine during the fall (Bigelow and Schroeder 1953).

1.2 Justification

Dams severely limit accessible spawning habitat, and river herring (alewives and blueback herring) depend on fish ladders to ascend dams and reach spawning habitat. River herring are a key component of freshwater, estuarine, and marine food webs. They are an important prey item of many marine predators and they contribute nutrients to freshwater ecosystems (Durbin et al. 1979, Macavoy et al. 2000).

1.3 Protection and Regulatory Status

The taking of river herring is open only to New Hampshire residents, and no fish may be taken by any method on Wednesdays. A harvest permit is required to take river herring by any form of netting. Herring caught at sea are further regulated, and between September 21 and October 19, the maximum incidental catch is limited to 2000 lbs per day. The blueback herring is protected under the Anadromous Fish Conservation Act.

1.4 Population and Habitat Distribution

The blueback herring is found along the Atlantic coastal plain from Florida to Nova Scotia (Atlantic States Marine Fisheries Commission 1999). In New Hampshire the blueback herring spawning runs occur in the Connecticut River, the Merrimack River, and the seacoast drainages (New Hampshire Fish and Game 2004, Greenwood 2005).

1.5 Town Distribution Map

Not completed for this species

1.6 Habitat Map

Blueback herring inhabit the lower section of the Merrimack River and the coastal watersheds of New Hampshire. See the Non-Tidal Coastal Watersheds (systems 11 and 12), Mainstem Watersheds (systems 1 and 2), and Tidal Coastal Watersheds (system 13) profiles.

1.7 Sources of Information

Literature reviews and historical records of fish passage at dams in New Hampshire and Massachusetts were used to identify distribution and habitat requirements.

1.8 Extent and Quality of Data

River herring returns are monitored at fishways on the Connecticut, Merrimack, and coastal rivers.

1.9 Distribution Research

Spawning habitats for New Hampshire's anadromous fish are relatively unknown. Research may identify quality spawning habitat upstream of impassable dams. A GIS map of the stream reaches accessible to each anadromous species, combined with a map of the potential spawning habitat that is currently inaccessible, would facilitate restoration.

Element 2

Not completed for this species

Element 3

Not completed for this species

Element 4

Not completed for this species

Element 5: References

ASMFC (Atlantic States Marine Fisheries Commission). 1985. Fishery Management Plan for the Anadromous Alosid Stocks of the Eastern United States: American Shad, Hickory Shad, Alewife, and Blueback Herring: Phase II in Interstate Management Planning for Migratory Alosids of the Atlantic Coast. Washington, D.C. XVIII + 347 pp.

ASMFC [Atlantic States Marine Fisheries Commission]. 1999. Amendment 1 to the Interstate Management Plan for Shad & River Herring. ASMFC Fishery Management Report No. 35. 77 p.

Bigelow H., and W. Schroeder. 1953. Fishes of the Gulf of Maine. Fishery Bulletin of the Fish and Wildlife Service. No. 74. Vol 53.

Durbin, A.G., S.W. Nixon, and C.A. Oviatt. 1979. Effects of the spawning migration of the alewife on freshwater ecosystems. Ecology 60:8-17.

Greenwood J. 2005. Anadromous Fisheries in New Hampshire. http://www.wildlife.state.nh.us/Fishing/fisheries_management/anadromous.htm>. Accessed 2005.

New Hampshire Fish and Game Department. 2004. New Hampshire Marine Fisheries Investigations. Grant F-61-R. 171p.

United States Fish and Wildlife Service (USFWS). 2001. River Herring Habitat Model. Available http://www.fws.gov/r5gomp/gom/habitatstudy/metadata/river_herring_model.htm.

United States Fish and Wildlife Service (USFWS). 2004. Anadromous fish returns – Merrimack River [Internet]. Central New England Fishery Resource Office. Available: http://www.fws.gov/r5cneafp/returns.htm

United States Fish and Wildlife Service (USFWS). 2005. Management Plan for River Herring in the Connecticut River Basin. Available http://www.fws.gov/r5crc/herring_plan.html. (Accessed May 2005)

SPECIES PROFILE

Bridle Shiner

Notropis bifrenatus

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G3
State Rank: S3
Author: Matthew, A. Carpenter, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Bridle shiners inhabit backwater streams and ponds with little or no current (Harrington 1948b; Finger 2001). They feed and spawn among submerged and emergent vegetation in shallow water (Harrington 1948*a*; Harrington 1948*b*).

1.2 Justification

The bridle shiner is declining over most of its range (Sabo 2000). In Pennsylvania, where the bridle shiner is listed as endangered, its range has been reduced to 1 site out of 31 historical sites (Finger 2001). Although the reasons for the decline of the bridle shiner are poorly understood, the long-term effects of urbanization, such as increased turbidity and changes in hydrology, have been attributed to the decline of other cyprinids (Weaver and Garman 1994, Fairchild et al. 1997). The range of the bridle shiner in New Hampshire is almost entirely in the southeast, an area undergoing the fastest rate of urbanization in New England.

1.3 Protection and Regulatory Status

The bridle shiner is listed as a legal bait species in New Hampshire.

1.4 Population and Habitat Distribution

The bridle shiner was once widely distributed throughout the Atlantic coastal plain from North Carolina north to the St. Lawrence River and eastern Ontario (Scott and Crossman 1973). Records of the bridle shiner in New Hampshire are limited to the Merrimack and coastal watersheds. The current distribution of the bridle shiner in New Hampshire is not well known.

1.5 Town Distribution Map

Canterbury, Concord, Conway, Durham, Eaton, Epping, Epsom, Farmington, Freedom, Hillsborough, Hooksett, Lee, Loudon, Madison, Meredith, Merrimack, Middleton, Milton, Moultonborough, New Hampton, Nottingham, Northwood, Pittsfield, Rochester, Salem, Sanborton, South Hampton, Strafford, Webster, Windham

1.6 Habitat Map

More research is necessary to determine the distribution and habitat requirements of this species in New Hampshire. A map of low-gradient streams and pond habitat in the coastal watersheds (refer to the system 13) and the Merrimac watersheds (systems 10, 11, 12, and 14) would help target future survey work.

1.7 Sources of Information

Bridle shiners have been caught during the Fishing for the Future Project conducted by New Hampshire Fish and Game (NHFG) and the Biomonitoring Program of the New Hampshire Department of Environmental Services. Historical records are from biological surveys conducted by the NHFG from 1937 to 1939.

1.8 Extent and Quality of Data

Twenty-nine of 49 records come from biological surveys by NHFG in the 1930s. No surveys have specifically targeted bridle shiners or their habitat in New Hampshire. A systematic survey will be necessary to establish the range of the species in the state.

1.9 Distribution Research

Habitat studies are needed to better understand the potential distribution of bridle shiners in New Hampshire. Resurveying historical sampling sites may show changes in the range of this species. All data on the distribution of bridle shiner, as well as other fish species native to New Hampshire, should be consolidated into a central database.

The bridle shiner is one of 4 fish species of concern—including redfin pickerel, banded sunfish, and swamp darter—that depend on vegetated stream and pond habitats of southeastern New Hampshire. The ecology of this aquatic system is poorly understood. Fish surveys in these habitats can be used as a baseline for monitoring the effects of urbanization and for measuring the success of future restoration or protection efforts.

Element 2

Not completed for this species

Element 3

Not completed for this species

Element 4

Not completed for this species

Element 5: References

5.1 Literature

Bailey, R.M. 1938. The fishes of the Merrimack watershed. In: A biological survey of the Merrimack watershed. New Hampshire Fish and Game Dept., Survey Report No. 3:149-185

Fairchild, G.W., R.J. Horwitz, D.A. Nieman, and M.R. Boyer. 1998. Spatial variation and historical change in fish communities of the Schuylkill River drainage, southeastern Pennsylvania. American Midland Naturalist 139:282-295.

Finger, B.L. Life History and Range of Pennsylvania's endangered Bridle Shiner. 2001. M.S. Thesis, Pennsylvania State University, University Park.

Harrington, R.W. 1946. A contribution to the biology of the bridled shiner, *Notropis bifrenatus* (Cope). M.S. Thesis, Cornell University, Ithaca.

Harrington, R.W. 1948a. The food of the bridled shiner, *Notropis bifrenatus* (Cope). American Midland Naturalist 40:353-361.

Harrington, R.W. 1948b. The life cycle and fertility of the bridled shiner, *Notropis bifrenatus* (Cope). American Midland Naturalist 39(1):83-92.

Sabo, M.J. 2000. Threatened fishes of the world: *Notropis bifrenatus* (Cope, 1867) (Cyprinidae). Environmental Biology of Fishes 59:384

Scott W., and E. Crossman. 1973. Freshwater Fishes of Canada. Fisheries Research Board of Canada. 966p.

Weaver, L.A., and G.C. Garman. 1994. Urbanization of a watershed and historical changes in a stream fish assemblage. Transaction of the American Fisheries Society 123:162-172

5.2 Data Sources

Biomonitoring Program. 1995-2005. New Hampshire Department of Environmental Services, Watershed Management Bureau. < www.des.state.nh.us/wmb/biomonitoring/sites/index.html >. Accessed 2004 December 12

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: February 2, 2005).

SPECIES PROFILE

American Brook Lamprey

Lampetra appendix

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G4
State Rank: S2
Author: Matthew, A. Carpenter, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The American brook lamprey lives in cool freshwater streams and small rivers. Adults spawn at the head of riffle areas over coarse sand and gravel substrate with stones less than 7 cm wide (Mundahl 1996). Spawning adults construct small nests by moving stones with their disc-shaped mouths (Hoff 1988). After hatching, larvae (ammocoetes) drift downstream to areas of slower flow where they burrow into the sediment and filter feed on organic detritus for about 5 years (Beamish and Lowartz 1996). Ammocoetes prefer to burrow in medium to fine grained sand mixed with organic matter (Beamish and Lowartz 1996).

1.2 Justification

The American brook lamprey has a complex life cycle that depends on 2 specific habitat types within a stream. Alteration or fragmentation of one or both of these habitats could result in local extirpations of brook lamprey populations. The presence of the American brook lamprey has been recorded in only 2 streams in New Hampshire. The species has not been monitored since it was last observed in the late 1980s.

1.3 Protection and Regulatory Status

The American brook lamprey is not specifically regulated, but is indirectly affected by regulations covered under the Southern Upland Watersheds and the Non-Tidal Coastal Watersheds profiles..

1.4 Population and Habitat Distribution

The American brook lamprey is found in rivers along the Atlantic coast from North Carolina to New Hampshire and throughout the Great Lakes drainages (Scott and Crossman 1973). In New Hampshire, where the species reaches the northern extent of its coastal range, records are restricted to 2 river systems: Baboosic Brook in the Merrimack River watershed and the Oyster River in the Great Bay watershed. No surveys of American brook lamprey have been conducted in New Hampshire.

1.5 Town Distribution Map

In the last 20 years, American brook lamprey have been observed in Lee and Merrimack; earlier sightings were limited to Durham.

1.6 Habitat Map

More research will be necessary to determine the current distribution and habitat requirements of this species in New Hampshire. Within the coastal watersheds (refer to the system 13) and the Merrimac watersheds (refer to systems 10, 11, and 12), a map of low gradient streams with access to riffle and pools habitat upstream would facilitate future surveys.

1.7 Sources of Information

Records of the American brook lamprey in New Hampshire are from 2 sources: Sampling data from the Fishing for the Future Project conducted by New Hampshire Fish and Game (NHFG) and collections by Dr. Phil Sawyer, a zoology professor at the Univer-

sity of New Hampshire (NHFG unpublished data, Sawyer 1960). All records have been compiled into a database maintained by NHNHB.

1.8 Extent and Quality of Data

The Fishing for the Future project was initiated in 1983 with the recognition of a need to base fish stocking efforts on more quantifiable measures of stream characteristics (NHFG unpublished data). Data on the physical and biological characteristics of streams were collected at over 264 sites throughout New Hampshire (NHFG unpublished data). The sampling data are of high quality, but the sampling sites were chosen based on known salmonid stocking locations and did not represent the full diversity of New Hampshire stream habitat. Therefore the American brook lamprey may be more widespread in New Hampshire than current records indicate. There is historical evidence of an American brook lamprey population in the Oyster River (Sawyer 1960).

1.9 Distribution Research

In New Hampshire, initial surveys should focus on the 2 streams with records of the species, after which data collected at confirmed spawning areas could be used to identify potential spawning areas in other streams. The locations of known and potential spawning sites should be entered into a GIS database as part of a larger effort to record the distribution of native fish species and their habitats in New Hampshire.

Once the distribution of the American brook lamprey in New Hampshire is better understood, certain spawning sites may be selected for long term monitoring.

Surveys of spawning adult American brook lampreys have been used to establish the distribution of the species in Minnesota (Mundahl 1996). Modified fyke nets have also been used to capture lampreys as they migrate upstream to spawning areas (Harvey and Cowx 2000). In addition, electrofishing surveys downstream of known spawning areas may identify stream reaches with a high density of ammocoetes (Beamish and Lowartz 1996). Conservation strategies for protecting the American brook lamprey population in New Hampshire will be developed after the population and status of the species have been established.

Element 2

Not completed for this species

Element 3

Not completed for this species

Element 4

Not completed for this species

Element 5: References

5.1 Literature

Beamish, F.W.H., and S. Lowartz. 1996. Larval habitat of American brook lamprey. Canadian Journal of Fisheries and Aquatic Science 53:693-700.

Mundahl, N.D. 1996. Population status and habitat requirements of the American brook lamprey in southeastern Minnesota. Final report to the Minnesota Department of Natural Resources Division of Fish and Wildlife, Natural Heritage and Nongame Research Program, St. Paul, Minnesota, USA.

Harvey, J., and I. Cowx. 2000. Monitoring the river, brook, and sea lamprey. English Nature: Conserving Natura 2000 Rivers Monitoring Series No. 5. http://www.english-nature.org/. Accessed 2004 December 21.

Hoff, J.G. 1988. Some aspects of the ecology of the American brook lamprey, *Lampetra appendix,* in the Mashpee River, Cape Cod, Massachusetts. The Canadian Field-Naturalist 102:735-737.

Richter, D.R., D.B. Braun, M.A. Mendelson, and L.L. Master. 1997. Threats to imperiled freshwater fauna. Conservation Biology 11(5):1081-1093.

Sawyer, P. J. 1960. New geographic record for the American brook lamprey. Copeia 2:136-137.

Scarola J. 1987. Freshwater Fishes of New Hampshire. Second edition. New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

SPECIES PROFILE

Brook Trout

Salvelinus fontinalis

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S5
Author: Matthew A. Carpenter, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Brook trout can survive in almost any clean, cold, well-oxygenated aquatic habitat, though they are unable to tolerate prolonged periods of water temperature over 20^{0}C (Scarola 1987). In areas of swift flow, brook trout prefer the shelter of pools created by boulders and woody debris (Curry et al. 2002). Brook trout spawn over gravel substrate in spring-fed headwater tributaries and along lakeshores with upwelling groundwater (Scarola 1973, Quinn 1995).

1.2 Justification

Records suggest that brook trout were once far more abundant in New Hampshire than they are today (Noon 2003), and their popularity among anglers has resulted in a long history of government stocking programs (Noon 2003). For over 100 years, New Hampshire Fish and Game (NHFG) has augmented native brook trout populations with fish raised in hatcheries (NHFG unpublished data). Wild brook trout may develop unique adaptations to local conditions over time, and the continuous introduction of hatchery-raised brook trout can wipe out these local adaptations (Hayes et al. 1996). There has been recent interest in identifying and protecting native strains of brook trout that have not experienced genetic introgression by hatchery-raised fish (Trout Unlimited 2003-2004).

1.3 Protection and Regulatory Status

Though there is no size limit or closed season, there is a daily limit of 5 fish or 5 pounds (2 fish through ice) when taking brook trout from a lake or pond. The same rules apply to taking brook trout from rivers and streams except that no fish may be taken from 16 October to 31 December. However, many water bodies managed for trout have site-specific rules that further limit the take of fish or the type of gear that can be used.

1.4 Population and Habitat Distribution

Brook trout are found in cold-water habitat throughout New Hampshire. The species is native to eastern North America, although it has been introduced into most western states (NatureServe 2005). The natural range of the brook trout includes the southern Appalachians, the upper Mississippi, and Great Lakes drainages, all of the northeastern United States, and eastern Canada (Scarola 1987). Some remote streams in the White Mountains and northern New Hampshire may contain wild brook trout populations that have never mixed with hatchery-raised trout (Scott Decker, NHFG biologist, personal communication).

1.5 Town Distribution Map

Brook trout are found throughout New Hampshire, though the locations of native populations are unknown.

1.6 Habitat Map

Future research will be necessary to map the locations of native brook trout populations (see Conservation Actions).

1.7 Sources of Information

Published literature and NHFG unpublished data.

1.8 Extent and Quality of Data

The distribution of native strains of brook trout in New Hampshire is not well documented. Many sites are stocked with brook trout and periodically surveyed by the NHFG. Recently a distinction has been made between "wild trout" populations that reproduce naturally and populations that would decline if no longer stocked. Wild trout populations are carefully monitored to ensure that they remain healthy enough to support angling pressure without the addition of cultured fish.

1.9 Distribution Research

Federal, state, and non-government agencies are collaborating on the Eastern Brook Trout Joint Venture, a project designed to assess the status of brook trout populations throughout the eastern United States (Mark Hudy, United States Department of Agriculture Forest Service, unpublished proposal). The project will compile a variety of brook trout related data into a GIS database based on USGS sixth level Hydrological Unit (HU) watersheds. Locally, NHFG will continue its efforts to identify and monitor naturally reproducing trout populations. A further distinction should be made between locations with a history of brook trout stocking and isolated locations where brook trout populations may never have mixed with cultured fish.

Element 2

Not completed for this species

Element 3

Not completed for this species

Element 4

Not completed for this species

Element 5: References

5.1 Literature

Curry, R.A., D. Sparks, and J. van de Sande. 2002. Spatial and temporal movements of a riverine brook trout population. Transactions of the American Fisheries Society 131:551-560.

Hayes, J.P., Z.G. Stanley, F.J. Kriegler, G.F. McCracken, C.R. Parker. 1996. The Genetic Diversity of Native, Stocked, and Hybrid Populations of Brook Trout in the Southern Appalachians. Conservation Biology 10(5):1403-1412.

Noon, Jack. Fishing in New Hampshire: a history. MooseCountry Press, Warner, New Hampshire, USA.

Quinn, N.W.S. 1995. General features of brook trout (*Salvelinus Fontinalis*) spawning sites in lakes in Algonquin Provincial Park, Ontario. Canadian Field-Naturalist 109:205-209.

Trout Unlimited. 2003-2004. Threats and Solutions: Hatcheries. http://www.tu.org/conservation/threats-hatcheries.asp > Accessed 2005 February 15

Scarola, J.F. 1973. Freshwater Fishes of New Hampshire. New Hampshire Fish and Game Department. 131 pp.

5.2 Data Sources

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. <http://www.natureserve.org/explorer.> (Accessed: February 4, 2005).

SPECIES PROFILE

Burbot

Lota lota

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S5
Author: Benjamin, J. Nugent, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Burbot are found in rivers and lakes. They prefer deep, large lakes (Scarola 1987) and are commonly found in the littoral zone during winter. During the summer, burbot are thermally restricted to the profundal zone, and may make night migrations to the littoral zone (Hoffman and Fischer 2002). In rivers, burbot prefer areas with woody debris, vegetation, pools, rocky riffles, and cool temperatures (Paulsen and Hatch 2002). Nighttime spawning occurs in February at shallow depths over sand or gravel substrates (Scott and Crossman 1973, Roy 2001).

1.2 Justification

Burbot are one of a few self-sustaining native species targeted by anglers in New Hampshire. However, due to the small size of individuals encountered in lotic environments, the majority of harvest occurs in large lakes (John Viar, New Hampshire Fish and Game (NHFG), personal communication). The species was tied with brook trout (fourth) during a survey of angler preference during the ice-fishing season (Duda and Young 1996). Lake populations of burbot are restricted to a small number of water bodies.

Anthropogenic eutrophication limits dissolved oxygen at depth, where burbot seek thermal refuge during summer. Therefore, the species may be an indicator for the condition of oligotrophic lakes (Kelso et al. 1996). Lotic populations also appear to be isolated to particular rivers or streams. The degradation of these habitats may be detrimental to the survival of the species.

1.3 Protection and Regulatory Status

The burbot is a game fish and may be harvested from lakes and rivers. No regulations limit weight, length, or number of burbot taken. "Set lines" (up to 6) may be used to harvest burbot during the ice-fishing season on lakes. In rivers, open season lasts from 1 January to 15 October.

1.4 Population and Habitat Distribution

Burbot populations are found in almost all suitable habitats in the northern part of North America (Scott and Crossman 1973), and have been reported in all major watersheds (Connecticut, Androscoggin, Merrimack, and Coastal) in New Hampshire (Gordon 1937, Bailey 1938, Bailey and Oliver 1939). Although burbot have been sampled in rivers throughout the state, sampling data indicate that riverine populations are more prevalent in northern New Hampshire. There appears to be no clear distribution of populations found in lake habitats (NHFG unpublished data). Known populations exist in several large lakes in central and northern New Hampshire (Bailey and Oliver 1939, Don Miller, NHFG, personal communication).

1.5 Town Distribution Map

1.6 Habitat Map

The burbot inhabit cold lakes and rivers in several areas of the state. See Habitat Maps for Connecticut and Androscoggin Headwaters (systems 5 and 7),

Lakes Region (systems 10 and 14), Western Hills (systems 3 and 9), Coastal (system 13), and Lower Merrimack (systems 11 and 12).

1.7 Sources of Information

Peer-reviewed literature was used for defining the global distribution and habitat requirements of burbot. NHFG unpublished data, NHFG biological surveys (1937-1939), New Hampshire Department of Environmental Services (NHDES) biomonitoring data, and a fisheries biologist helped define the New Hampshire range.

1.8 Extent and Quality of Data

Most information on burbot distribution in New Hampshire is from creel surveys and projects related to trout and salmon management (e.g., stream electrofishing surveys). The NHDES Biomonitoring project provides an up-to-date source for the presence of burbot in certain streams.

1.9 Distribution Research

Burbot have received less research attention than other game fish in New Hampshire. Although the population is considered stable enough to sustain a fishery, there has been no direct investigation of the burbot population in the state.

Sampling of burbot is difficult in deepwater lakes (Halliwell et al. 2001). The most effective way to track the distribution of burbot would be to enter existing burbot records into a centralized GIS database. This database would form the framework of a more thorough assessment of the burbot population status in New Hampshire. Better record keeping on NHFG surveys that target trout and salmon would increase the amount of data on lakes and streams that are occupied by burbot. Research on burbot ecology and habitat requirements would help identify potential burbot populations in water bodies with less fishing or sampling effort.

Element 2

Not completed for this species

Element 3

Not completed for this species

Element 4

Not completed for this species

Element 5: References

5.1 Literature

Bailey J., and J. Oliver. 1939. The Fishes of the Connecticut Watershed. In: A Biological Survey of the Connecticut Watershed. New Hampshire Fish and Game Dept., Survey Report No. 4:150-189.

Bailey R. 1938. The Fishes of the Merrimack Watershed. In: A Biological Survey of the Merrimack Watershed. New Hampshire Fish and Game Dept., Survey Report No. 3:149-185.

Duda M., and K. Young. 1996. New Hampshire Freshwater Angler Survey. New Hampshire Fish and Game Department. 166p.

Gordon M. 1937. The Fishes of Eastern New Hampshire. In: A Biological Survey of the Androscoggin, Saco and Coastal Watersheds. New Hampshire Fish and Game Dept., Survey Report No. 2:101-118.

Halliwell, D.B., T.R. Whittier, and N.H. Ringler. 2001. Distributions of lake fishes of the Northeast USA - III. Salmonidae and associated coldwater species. Northeastern Naturalist 8(2): 189-206.

Hoffman N., and P. Fischer. 2002. Temperature preferences and thermal limits of burbot: implications for habitat selection and ontogenetic habitat shift. Transactions of the American Fisheries Society 131: 1164-1172.

Kelso J., R. Steedman, and S. Stoddart. 1996. Historical causes of change in Great Lakes fish stocks and the implications for ecosystem rehabilitation. Canadian Journal of Fisheries and Aquatic Sciences 53(Suppl. 1):10-19.

Roy S. 2001. Burbot Management Plan. Maine Department of Inland Fisheries and Wildlife. Division of Fisheries and Hatcheries. 26p.

Scarola J. 1987. Freshwater Fishes of New Hampshire. New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

Scott W., and E. Crossman. 1973. Freshwater Fishes of Canada. Fisheries Research Board of Canada. 966p.

5.2 Data Sources

Biomonitoring Program. 1995-2005. New Hampshire

Department of Environmental Services, Watershed Management Bureau. www.des.state.nh.us/wmb/biomonitoring/sites/index.html>. Accessed 2004 December 12

Paulsen N. and Hatch J. 2002. Burbot *Lota lota* (Linnaeus, 1758) Member of the Cuskfish Family (Lotidae) <http://www.gen.umn.edu/research/fish/fishes/burbot.html>. Accessed 2005.

SPECIES PROFILE

Finescale Dace

Phoxinus neogaeus

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S2
Author: Benjamin, J. Nugent, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Finescale dace inhabit ponds, streams, and lakes with cool temperatures (Scott and Crossman 1973) and have been found to concentrate in areas with silt and large woody debris (Isaak et al. 2002). The species has an affinity for beaver ponds and is often found with northern redbelly dace (*Phoxinus eos*) (Paulsen and Hatch 2002). Finescale dace have been found in stained boggy ponds with neutral or slightly acidic (7.0-6.9) pH (Scott and Crossman 1973). Spawning occurs under logs and other debris between April and June (NatureServe 2005).

1.2 Justification

The species is considered imperiled in New Hampshire (NatureServe 2005) and appears to be isolated to specific waters in the far north. Contemporary data regarding the species within New Hampshire are extremely limited and may indicate low population levels. Habitat degradation and introduction of non-native piscivorous (e.g., sunfish, black bass) fish have seriously harmed finescale dace populations (Isaak et al. 2002).

1.3 Protection and Regulatory Status

Finescale dace may not be used for bait.

1.4 Population and Habitat Distribution

Finescale dace in New Hampshire are at the southeastern corner of the species' global range (Scarola 1987), and they occur in the extreme northern section of the state. Within this region, finescale dace populations are relatively isolated (Bailey and Oliver 1939, Gordon 1937, New Hampshire Fish and Game (NHFG) unpublished data). No populations have been confirmed south of the White Mountains.

1.5 Town Distribution Map

Within the last 20 years, finescale dace have been observed in Clarksville and Pittsburg; before then, dace were observed in Millsfield and Wentworth.

1.6 Habitat Map

More research will be necessary to determine the current distribution and habitat requirements of this species in New Hampshire. A map of pond, stream, and lake habitat in the Connecticut and Androscoggin Headwaters (refer to the systems 5 and 7) would facilitate future surveys.

1.7 Sources of Information

Published literature and Internet sources were used to define the species global distribution and habitat descriptions. NHFG unpublished data and historical biological surveys provided locations of finescale dace in New Hampshire.

1.8 Extent and Quality of Data

Data are qualitative and are too few to identify population trends, though some information dates to the 1930s and 1950s. Data should be treated cau-

tiously, for the northern redbelly dace is very similar in appearance to the finescale dace (Dianne Emerson, NHFG, personal communication).

1.9 Distribution Research

Distribution data for finescale dace in New Hampshire are needed. Resurveying historical sample sites may reveal changes in distribution that have occurred since past surveys (recognizing limitations stated in section 1.8). Surveying additional waters in the Androscoggin and upper Connecticut watersheds would provide more conclusive information on the statewide distribution of the species. Studies of factors that limit the distribution and abundance of the species would also aid in identifying potential survey sites.

Hybrids of finescale dace and northern redbelly dace have been found in New Hampshire (Bailey and Oliver 1939, Goddard et al. 1998), warranting a study of the effects of hybridization on the distribution and abundance of the 2 species. A better effort should be made to record observations of finescale dace, as well as other nongame fish, during surveys that target other species. Records of finescale dace should be entered into a GIS database as part of an effort to track the distribution and status of all New Hampshire fish species.

Element 2

Not completed for this species

Element 3

Not completed for this species

Element 4

Not completed for this species

Element 5: References

5.1 Literature

Bailey, J., and J. Oliver. 1939. The Fishes of the Connecticut Watershed. In: A Biological Survey of the Connecticut Watershed. New Hampshire Fish and Game Dept., Survey Report No. 4:150-189.

Goddard, K., O. Megwinoff, L. Wessner, and F. Giaimo. 1998. Confirmation of gynogenesis in *Phoxinus eos-neogaeus* (Pisces: Cyprinidae). Journal of Hereditary 89:151-157.

Gordon, M. 1937. The fishes of eastern New Hampshire. In: A biological survey of the Androscoggin, Saco, and Coastal watersheds. New Hampshire Fish and Game Dept., Survey Report No. 2:101-118.

Isaak, D., W. Hubert, and C. Berry. 2002. Conservation Assessment for Lake Chub, Mountain Sucker, and Finescale Dace in the Black Hills National Forest, South Dakota and Wyoming. Black Hills National Forest, Custer, South Dakota, USA.

Scarola J. 1987. Freshwater Fishes of New Hampshire. New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

Scott, W., and E. Crossman. 1973. Freshwater Fishes of Canada. Fisheries Research Board of Canada. 966p.

5.2 Data Sources

Biomonitoring Program. 1995-2005. New Hampshire Department of Environmental Services, Watershed Management Bureau. www.des.state.nh.us/wmb/biomonitoring/sites/index.html >. Accessed 2004 December 12

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. Available <http://www.natureserve.org/explorer>. Accessed 2005 Feb 8.

Paulsen N. and Hatch J. 2002. Finescale Dace *Phoxinus neogaeus* Cope, 1869 Member of the Minnow Family (Cyprinidae). <http://www.gen.umn.edu/research/fish/fishes/habitat>. Accessed 2005.

SPECIES PROFILE

Lake Trout

Salvelinus namaycush

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S5
Author: Benjamin, J. Nugent, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Lake trout inhabit lakes with large reservoirs of deep water, rocky shorelines, and diversely contoured bottoms. During the summer lake trout are restricted to thermal refuges below 60-65°F with preferred water temperatures around 50°F. The species will frequent surface waters in the spring, fall, and winter if temperature permits. Dissolved oxygen levels must exceed 6 parts per million (Scarola 1987, Scott and Crossman 1973, Johnson 2001). Spawning habitat consists of rocky shoals, reefs, and shorelines with substrate consisting of large rocks and rubble (Johnson 2001). Spawning depths range from 40 feet to a few inches (Scott and Crossman 1973, Johnson 2001).

1.2 Justification

Native populations of lake trout are restricted to 7 water bodies in New Hampshire, though stocking success has resulted in self-sustaining populations in several other water bodies (Scarola 1987). Lake trout face several habitat and non-habitat related threats. Anthropogenic eutrophication decreases dissolved oxygen at depths where trout take refuge from summer heat (Kelso et al. 1996). Thus, the species may be an indicator for the water quality of oligotrophic lakes (Halliwell et al. 2001). A healthy population of forage fish is important for the persistence of lake trout in a given lake. The introduction of nonindigenous fish may alter the food web in a lake ecosystem, reducing the amount of prey available to lake trout (Pazzia et al. 2002). Lake trout were rated second and sixth, respectively, for species preference in an ice fishing and an open-water angler survey (Duda and Young 1996). Lake trout populations, especially low density, self-sustaining populations, have been found to be vulnerable to angling pressure (Towne 1959).

1.3 Protection and Regulatory Status

Daily harvest of lake trout is restricted to 2 fish. Seasons for lake trout fishing consist of 1 January to 31 March (ice fishing) and 1 April to 30 September (open water). Minimum length limits vary between water bodies, ranging from 15 to 18 inches. Anglers are restricted to 2 fishing devices during the open water season in all water bodies. During the ice-fishing season, 2 or 6 fishing devices are allowed, depending on the particular water body. Some lakes and ponds are managed for trout fishing and have no closed season.

1.4 Population and Habitat Distribution

Lake trout are widely distributed throughout northern North America, and populations are found in several oligotrophic water bodies in New Hampshire. Native populations exist in both central and northern New Hampshire (Squam Lake, Winnipesaukee Lake, Newfound Lake, First Connecticut Lake and Second Connecticut Lake). Successful stocking programs have introduced self-sustaining populations of lake trout in 17 additional water bodies, increasing their distribution to include more water bodies in the central, southwestern, and northern parts of the state. Stocking hatchery-reared lake trout was discontinued in 1981 after it was determined to have a minimal affect on angler success (Perry 1991).

1.5 Town Distribution Map

Maps for native and stocked populations are provided.

1.6 Habitat Map

A map of deep and cold lake habitat in the Connecticut and Androscoggin Headwaters (refer to the systems 5 and 7), the Western Hills (refer to systems 3 and 9), and the Lakes Region (refer to systems 10 and 14) would facilitate future surveys.

1.7 Sources of Information

Peer-reviewed literature, state lake trout management plans (New Hampshire and Maine), and New Hampshire Fish and Game (NHFG) stocking records were used to define distribution and habitat.

1.8 Extent and Quality of Data

The distribution and status of lake trout in New Hampshire have been well documented in reports by NHFG.

1.9 Distribution Research

The distribution of lake trout in New Hampshire is well known.

Element 2

Not completed for this species

Element 3

Not completed for this species

Element 4

Not completed for this species

Element 5: References

5.1 Literature

Duda, M., and K. Young. 1996. New Hampshire Freshwater Angler Survey. New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

Halliwell, D.B., T.R. Whittier, and N.H. Ringler. 2001. Distributions of lake lishes of the Northeast USA - III. Salmonidae and associated coldwater species. Northeastern Naturalist 8(2):189-206.

Johnson P. 2001. Lake Trout Management Plan. Maine Department of Inland Fisheries and Wildlife. Division of Fisheries and Hatcheries and Planning, Augusta, Maine, USA.

Kelso, J., R. Steedman, and S. Stoddart. 1996. Historical causes of change in Great Lakes fish stocks and the implications for ecosystem rehabilitation. Canadian Journal of Fisheries and Aquatic Sciences 53(Suppl. 1): 10-19.

Pazzia, I., M. Trudel, M. Ridgway, and J.B. Rasmussen. 2002. Influence of food web structure on the growth and bioenergetics of lake trout (*Salvelinus namaycush*). Canadian Journal of Fisheries and Aquatic and Sciences 59:1593-1605

Perry, S. 1991. Lake Trout (*Salvelinus namaycush*) A Revised Management Plan. New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

Scarola, J. 1987. Freshwater Fishes of New Hampshire (2nd Edition). New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

Scott, W., and E. Crossman. 1973. Freshwater Fishes of Canada. Fisheries Research Board of Canada.

Towne, R. 1959. Fisheries investigations at the Squam Lakes, New Hampshire. New Hampshire Fish and Game Department. Federal Aid Project: F-6-R. 289p.

SPECIES PROFILE

Lake Whitefish

Coregonus clupeaformis

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S3
Author: Benjamin, J. Nugent, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Lake whitefish are a pelagic, cool water species requiring either large rivers or deep, cold, clear lakes (Scarola 1987, Scott and Crossman 1973). Lake whitefish seek the cooler waters of the hypolimnion during summer months and are occasionally found along shoals in spring (Scott and Crossman 1973). Spawning habitats consists of shallow water reefs or tributary streams with hard or rocky substrates (Scarola 1987, Scott and Crossman 1973). Spawning occurs at temperatures ranging from 40° to 50°F (Scarola 1987) at depths typically less than 25 feet (Scott and Crossman 1973). Newly hatched larvae congregate along steep shorelines and move to deeper water by early summer (Scott and Crossman 1973).

1.2 Justification

The lake whitefish is considered vulnerable in New Hampshire, and is believed to be limited to 6 water bodies in the state. Information about these populations is limited, though historical creel surveys and reports indicate populations with good health and high abundance (Towne 1959, Noon 1999). Current information pertaining to lake whitefish almost solely comes from occasional captures by anglers. Further studies on the population's health and status are warranted.

1.3 Protection and Regulatory Status

In New Hampshire, the lake whitefish is regulated by a 2 fish daily harvest limit with no length or weight restrictions. A closed season on lake whitefish is in effect from 1 October to 31 December in some water bodies. The use of whitefish as bait for cusk (*Lota lota*) is prohibited.

1.4 Population and Habitat Distribution

Lake whitefish are distributed throughout Canada and the northern United States. Populations in New Hampshire are at the southern extent of the species' global range (Scarola 1987). Scarola (1987) maintains lake whitefish were native to 2 New Hampshire lakes (Umbagog and Winnipesaukee lakes), whereas Gordon (1937) believes lake whitefish were introduced in the Androscoggin watershed (e.g., Umbagog Lake). Two lake whitefish, possible stocked, were found in Umbagog Lake in 1905, and none has been found since (Basley 2001). It is currently believed that populations exist in Winnipesaukee, Big Squam, Wentworth (Scarola 1987), Winnisquam, Silver (Madison) (D. Miller, New Hampshire Fish and Game (NHFG), personal communication), First Connecticut, and Francis Lakes (M. Garabedian, NHFG, personal communication, Bailey and Oliver 1939). The species has also been reported in several other water bodies within the state through stocking programs (Newfound Lake, Island Pond (Hampstead), Ossipee Lake, Sunapee Lake, Little Squam Lake, and Second Connecticut Lake) (NHFG, unpublished data).

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

More research will be necessary to determine the current distribution and habitat requirements of this species in New Hampshire. A map of lake habitat in the Connecticut and Androscoggin Headwaters (refer to the systems 5 and 7) and Lakes Region (refer to the systems 10 and 14) would facilitate future surveys.

1.7 Sources of Information

Peer-reviewed literature was used to define species' distribution and habitat. NHFG unpublished data, published literature, and personal communications with a NHFG conservation officer and fisheries biologist were used to define statewide distribution. Historical distribution data were verified through samples of lake whitefish contained in a museum database.

1.8 Extent and Quality of Data

Recent data for the species are scarce, with the majority of information available dating to the 1930s. Population distribution data are based on historical sampling data and recent angler reports to biologists and conservation officers. Data should be treated cautiously, for the round whitefish (*Prosopium cylindraceum*) may have been misidentified as the lake whitefish (Normandeau 1963).

1.9 Distribution Research

Sampling locations presumed to hold populations of lake whitefish should be prioritized (Winnipesaukee, Big Squam, Winnisquam, Silver (Madison), First Connecticut, Francis and Wentworth lakes). Attempts should also be made to sample water bodies once known or presumed to have held the species (Umbagog Lake, Island Pond, Newfound Lake, Second Connecticut Lake, Sunapee Lake, Little Squam Lake and Ossipee Lake). Confirming the distribution of lake whitefish in New Hampshire will be the first step toward assessing the population status.

Element 2: Species/Habitat Condition

2.1 Scale

Seven polygons will be used as conservation planning units. Habitat units will consist of individual lakes believed to hold lake whitefish populations. Winnipesaukee, Big Squam, Winnisquam, Silver (Madison), First Connecticut, Francis, and Wentworth lakes are such planning units.

2.2 Relative Health of Populations

Abundant populations of lake whitefish were historically seen in some of New Hampshire's waterbodies. Scarola (1987) noted that anglers once eagerly targeted the lake whitefish. A creel census in 1952 and 1953 indicated lake whitefish were highly targeted by ice fishermen in the Squam lakes, with estimated annual harvest yields of 500 pounds (Towne 1959). Lake whitefish have been observed in tributaries of both First Connecticut Lake and Lake Francis, and were noted for size ("three pounds or more") and fight (M. Garabedian, NHFG, personal communication). There have been reports of recent angler catches from Silver Lake (Madison) (Don Miller, NHFG, personal communication). Populations significantly declined due to "overexploitation and abuse" (Scarola 1987). The status of the relative health of populations in not known.

2.3 Population Management Status

At this time, it is unlikely that the 2 fish daily harvest limit affects existing populations. A recent survey of resident and nonresident anglers indicated that the lake whitefish is very rarely, if at all, caught (Duda and Young 1996). Accounts of accidental captures of lake whitefish are rare. No other direct management effort exists at this time.

2.4 Relative Quality of Habitat Patches:

See Connecticut and Androscoggin Headwaters (refer to the systems 5 and 7) and Lakes Region (refer to the systems 10 and 14) habitat profiles. All seven units are classified as oligotrophic (NHDES Lakes and Ponds Inventory). Thermal stratification exists within these 6 lakes, providing necessary well-oxygenated thermal

refuges during summer months. Substrate selection appears only to be a factor during spawning periods (Bradbury et al. 1999). Tributary streams are available for spawning runs within all habitat units.

Competition for habitat and forage food exists between lake whitefish and a variety of other fish species (Hart 1931). Rainbow smelt, lake trout (*Salvelinus namaycush*), and yellow perch (*Perca flavescens*) share similar aspects of habitat and diet selection with the lake whitefish (Kerr and Grant 2000). Burbot have been documented to prey on lake whitefish populations (Lasenby et al. 2001). Winnipesaukee, Winnisquam and Big Squam lakes contain populations of rainbow smelt, lake trout, burbot, and yellow perch (Towne 1959, Gordon 1937, Bailey 1938); yellow perch have been documented in Wentworth Lake (Bailey 1938). First Connecticut Lake and Lake Francis contain populations of rainbow smelt, burbot, and lake trout (Bailey and Oliver 1939, NHFG unpublished data).

2.5 Habitat Patch Protection Status

See Connecticut and Androscoggin Headwaters (refer to the systems 5 and 7) and Lakes Region (refer to the systems 10 and 14) habitat profiles.

2.6 Habitat Management Status

Results of restoration and management of the habitat patches in relation to the lake whitefish are unknown.

2.7 Sources of Information

Literature reviews and personal communications with a fisheries biologist and a conservation officer were conducted to define locations of existing populations and relative condition of habitat units. Internet sources were used to identify protection status of the mapped units.

2.8 Extent and Quality of Data

Information describing the condition of the species is extremely limited. Current available data regarding the species should only be used to indicate where a population once existed and may still be present today. Some populations were once abundant and highly valued by sport fishermen (Scarola 1987), but the lack of current data makes it difficult to establish the health and abundance of present populations.

2.9 Condition Assessment Research

Recent information on the species is very limited. Fall and early winter sampling presumed locations of the species should be of highest priority (Winnipesaukee, Big Squam, Winnisquam, Silver (Madison), First Connecticut, Francis and Wentworth lakes). Sampling of spawning adults over multiple years will reveal trends in population abundance. Length, weight, sex ratio, and fecundity data can be used to assess the condition, growth rates, and potential yield of the lake whitefish in each water body. Observations can be made at the spawning locations to identify possible predators affecting recruitment success. Information obtained from sampling will determine the scope of action needed to protect the species.

Element 3

Not completed for this species

Element 4

Not completed for this species

Element 5: References

5.1 Literature cited

Bailey, J., and J. Oliver. 1939. The Fishes of the Connecticut Watershed. In: A Biological Survey of the Connecticut Watershed. New Hampshire Fish and Game Dept., Survey Report No. 4:150-189.

Bailey, R.M. 1938. The Fishes of the Merrimack Watershed. In: A Biological Survey of the Merrimack Watershed. New Hampshire Fish and Game Dept., Survey Report No. 3:149-185.

Basley, D. 2001. Whitefish Management Plan. Maine Department of Inland Fisheries and Wildlife. Division of Fisheries and Hatcheries and Planning, Augusta, Maine, USA.

Bradbury, C., M. Roberge, and C. Minns. 1999. Life history characteristics of freshwater fishes occuring in Newfoundland and Labrador, with major emphasis on lake habitat characteristics. Canadian Manuscript Report of Fisheries and Aquatic Sciences. No. 2485.

Duda, M., and K. Young. 1996. New Hampshire Freshwater Angler Survey. New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

Gordon, M. 1937. The Fishes of Eastern New Hampshire. In: A Biological Survey of the Androscoggin, Saco and Coastal Watersheds. New Hampshire Fish and Game Dept., Survey Report no. 2:101-118.

Hart, J. 1931. The Food of the Whitefish *Coregonus clupeaformis* (Mitchill) in Ontario Waters, with a Note on the Parasites. University of Toronto Press, Toronto, Ontario, Canada.

Kerr, S., and R. Grant. 2000. Ecological Impacts of Fish Introductions: Evaluation of the Risk. Ministry of Natural Resources, Fish and Wildlife Branch, Ontario, Canada.

Lasenby, T., S. Kerr, G. Hooper. 2001. Lake Whitefish Culture and Stocking: An Annotated Bibliography and Literature Review. Fish and Wildlife Branch, Ontario. Ministry of Natural Resources, Peterborough, Ontario, Canada.

Noon, J. 1999. The Bassing of New Hampshire. How Black Bass Came to the Granite State. Moose Country Press, Warner, New Hampshire, USA.

Normandeau, D. 1963. The Life History of the Round Whitefish *Prosopium cylindraceum* Pallas, of Newfound Lake, N.H.

Scarola, J. 1987. Freshwater Fishes of New Hampshire. New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

Scott W., and E. Crossman. 1973. Freshwater Fishes of Canada. Fisheries Research Board of Canada. 966p.

Towne R. 1959. Fisheries Investigations at the Squam Lakes, New Hampshire. New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

5.2 Data Sources

1990. New Hampshire Lakes and Ponds Inventory. Volume VI NHDES.

1996. New Hampshire Lakes and Ponds Inventory. Volume XII NHDES.

2001. New Hampshire Lakes and Ponds Inventory. Volume XVII NHDES.

2003. New Hampshire Lakes and Ponds Inventory. Volume XIX NHDES.

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: January 3, 2005).

University of Michigan Museum of Zoology (UMMZ). 2005. Fish Collection Search. http://141.211.243.52/UMMZ/. (Accessed: January 3, 2005).

SPECIES PROFILE

Northern Redbelly Dace

Phoxinus eos

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S3
Author: Benjamin, J. Nugent, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The northern redbelly dace inhabits acidic lakes, ponds, and backwater streams in areas with minimal water velocity. Spawning occurs in algae masses within these habitats (Scarola 1987). Spawning times range from May to August and are dependent on latitude and local environment (Scott and Crossman 1973).

1.2 Justification

The species is considered vulnerable in New Hampshire (NatureServe 2005) and appears to be limited to 2 regions of the state. Water flow alteration, sedimentation, and erosion may severely effect northern redbelly dace populations within New Hampshire (Massachusetts Division of Fisheries and Wildlife 2003). There is little information available on the status of northern redbelly dace in New Hampshire.

1.3 Protection and Regulatory Status

No specific protection for this species. Species may be used for live bait.

1.4 Population and Habitat Distribution

Populations in New Hampshire occupy the southeastern corner of the global range of northern redbelly dace (Scarola 1987). The New Hampshire population of northern redbelly dace appears to be concentrated within the northern region of the state. Populations of northern redbelly dace exist throughout the upper Connecticut River and Androscoggin River watersheds. The species is known to be present in the Sugar River watershed south of the White Mountains of New Hampshire (Gordon 1937, Bailey and Oliver 1939, Scarola 1987, NHFG unpublished data).

1.5 Town Distribution Map

Within the last 20 years, redbelly dace have been observed in Clarksville, Columbia, Newport, and Pittsburg; before then, they were observed in Berlin, Claremont, Clarksville, Colebrook, Columbia, Lancaster, and Pittsburg.

1.6 Habitat Map

More research will be necessary to determine the current distribution and habitat requirements of this species in New Hampshire. A map of pond, stream, and lake habitat in the Connecticut and Androscoggin Headwaters (refer to the systems 5 and 7) and the Western Hills (refer to systems 3 and 9) would help target future survey work.

1.7 Sources of Information

Published literature was used to define the global distribution and habitat requirements of northern redbelly dace. New Hampshire Fish and Game (NHFG) unpublished data, New Hampshire Department of Environmental Services (NHDES) Biomonitoring data, and biological surveys by the NHFG from 1937 to 1939 were used to identify known populations of northern redbelly dace within the state. Historical distribution information was confirmed using sam-

ples contained in a museum database (University of Michigan Museum of Zoology 2005).

1.8 Extent and Quality of Data

There are very few records of redbelly dace in New Hampshire. It is not known whether the paucity of records is due to low population levels or to the lack of surveys targeting the species. Data on the species are qualitative and insufficient to identify population trends over time. Records should be treated cautiously, for the northern redbelly dace is very similar in appearance to the finescale dace (*Phoxinus neogaeus*), which may lead to misidentification (Dianne Emerson, NHFG, personal communication).

1.9 Distribution Research

Distribution data for the redbelly dace in New Hampshire need to be obtained. Resurveying historical sample sites may reveal changes in distribution that have occurred since past surveys. Surveying additional waters within the watersheds of the Androscoggin and upper Connecticut rivers would provide more conclusive information on the statewide distribution of the redbelly dace. Studies of the factors that limit the distribution and abundance of the species would also aid in choosing survey sites.

Because hybrids of redbelly dace and finescale dace have been found in New Hampshire (Bailey and Oliver 1939, Goddard et al. 1998), a study of the effects of hybridization on the distribution and abundance of the 2 species is also warranted. A better effort should be made to record observations of redbelly dace, as well as other nongame fish, during surveys that target other species. Records of redbelly dace should be entered into a GIS database as part of an effort to track the distribution and status of all New Hampshire fish species.

Element 2

Not completed for this species

Element 3

Not completed for this species

Element 4

Not completed for this species

Element 5: References

5.1 Literature

Bailey, J., and J. Oliver. 1939. The Fishes of the Connecticut Watershed. In: A Biological Survey of the Connecticut Watershed. New Hampshire Fish and Game Department, Survey Report No. 4:150-189.

Goddard, K., O. Megwinoff, L. Wessner, and F. Giaimo. 1998. Confirmation of gynogenesis in *Phoxinus eos-neogaeus* (Pisces: Cyprinidae). Journal of Hereditary 89:151-157.

Gordon, M. 1937. The fishes of eastern New Hampshire. In: A biological survey of the Androscoggin, Saco, and Coastal watersheds. New Hampshire Fish and Game Department, Survey Report No. 2:101-118.

Scarola, J. 1987. Freshwater Fishes of New Hampshire. New Hampshire Fish and Game Department. 132p.

Scott, W., and E. Crossman. 1973. Freshwater Fishes of Canada. Fisheries Research Board of Canada. 966p.

Massachusetts Division of Fisheries and Wildlife. 2003. Northern Redbelly Dace. <http://www.mass.gov/dfwele/dfw/nhesp/nhfacts/phoxinus_eos.pdf>. Accessed 2005.

5.2 Data Sources:

Biomonitoring Program. 1995-2005. New Hampshire Department of Environmental Services, Watershed Management Bureau. <http://www.des.state.nh.us/wmb/biomonitoring/sites/index.html> (Accessed 2004 Dec 12).

University of Michigan Museum of Zoology (UMMZ). 2005. Fish Collection Search. http://141.211.243.52/UMMZ/. (Accessed: 2005 Jan 3).

SPECIES PROFILE

Rainbow Smelt

Osmerus mordax

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: G5
Author: Matthew, A. Carpenter, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Marine smelt concentrate in estuaries and harbors. Coastal smelt populations move into rivers shortly after the break up of ice to spawn at the head of tide. During spawning they seek out gravel substrate with swift current (Scarola 1987). Freshwater smelt populations are mainly found in deep, cold, clear lakes. Some freshwater populations are found in unstratified warm-water ponds. Landlocked populations will spawn up tributary rivers of lakes and ponds or along lakeshores with sand, gravel, or fallen leaves (Scarola 1987).

1.2 Justification

Rainbow smelt populations are important forage bases for several marine and freshwater fishes as well as for a variety of bird species (Scarola 1987, National Marine Fisheries Service (NMFS) 2004). Barriers, sedimentation, and water quality degradation can affect smelt recruitment success (NMFS 2004). Recent data suggest rainbow smelt populations are declining in the Great Bay system and other waterbodies of New Hampshire (NHFG 2004, John Viar, NHFG, personal communication).

1.3 Protection and Regulatory Status

A fishing license is required for the taking of rainbow smelt inland of Memorial Bridge in Newington-Portsmouth. There is a daily limit of 10 liquid quarts with heads and tails intact. Handheld bow nets and dip nets may be used on the Oyster, Squamscott, Bellamy, and Lamprey Rivers between 16 December and 28 February. Nets and weirs are prohibited from 1 March to 15 December inland of Memorial Bridge.

Two different methods can be used to take freshwater smelt. Both methods (angling and dip netting) have a daily limit of 2 liquid quarts. Angling seasons for rainbow smelt vary by waterbody management type. A limited number of waterbodies are open to dip net fishing. The season for taking smelt with a dip net is between 15 March and 30 April between sunset and midnight.

1.4 Population and Habitat Distribution

Rainbow smelt are found along the coast of North America in both the north Atlantic and the north Pacific Oceans (Scarola 1987). Great Bay, and the rivers that flow into it, are important spawning areas and nursery habitat for coastal smelt populations. Native landlocked populations are believed to exist in Winnipesaukee, Winnisquam, and Squam lakes (Scarola 1987). Several other waterbodies throughout New Hampshire are believed to contain introduced smelt populations. As many as 105 waterbodies currently have or once held smelt populations (NHFG unpublished data).

1.5 Town Distribution Map

Maps for native and stocked freshwater smelt populations are provided.

1.6 Habitat Map

Anadromous rainbow smelt inhabit rivers, harbors, and estuaries of southeastern of New Hampshire.

See the Tidal Coastal Watersheds profile (system 13). Freshwater landlocked populations of rainbow smelt are residents in several lakes and ponds scattered throughout New Hampshire. See the Northern Upland Watersheds (systems 5 and 7), Mainstem Watersheds (systems 1 and 2), Southern Upland Watersheds (systems 3 and 9), Montane Watersheds (systems 4, 6, and 8), Coastal Transitional Watersheds (systems 10 and 14), and Non-Tidal Coastal Watersheds(systems 11 and 12) profiles.

1.7 Sources of Information

Published literature, a rainbow smelt profile from the National Marine Fisheries Service, and NHFG unpublished data were used to determine distribution and habitat requirements of the species.

1.8 Extent and Quality of Data

Distribution of rainbow smelt is well known but the population status is not. Ice-angling creel and egg deposition surveys would provide a good measure of relative abundance over time.

1.9 Distribution Research

- Determine the presence or absence of rainbow smelt populations that are not already monitored
- Monitor known populations of anadromous and landlocked populations for trend data
- Identify factors that may limit the spawning productivity of smelt populations within coastal watersheds

Element 2

Not completed for this species

Element 3

Not completed for this species

Element 4

Not completed for this species

Element 5: References

Scarola, J. 1987. Freshwater Fishes of New Hampshire (2nd Edition). New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

National Marine Fisheries Service [NMFS]. 2004. Rainbow Smelt Profile. Available <http://www.nmfs.noaa.gov/pr/species/concern/profiles/rainbow_smelt.pdf>. (Accessed April 2005).

New Hampshire Fish and Game Department [NHFGD]. 2004. New Hampshire Marine Fisheries Investigations. Grant F-61-R. 171p.

SPECIES PROFILE

Redfin Pickerel

Esox americanus americanus

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5T5
State Rank: S4
Author: Benjamin, J. Nugent, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Redfin pickerel inhabit slow-moving, acidic, tea-colored streams with dense vegetation. The species is commonly found within brush piles or beneath overhanging vegetation (Scarola 1987, Fishbase 2005). Redfin pickerel also have been observed in brackish waters and swampy areas with low dissolved oxygen levels (Steiner 2004). Spawning occurs in shallow flood margins of stream habitats with thick vegetation. Redfin pickerel spawn mainly in the early spring, but there is some indication of spawning in the fall (Scott and Crossman 1973, Scarola 1987). Wintering habitat is often associated with leaf litter (Fishbase 2005).

1.2 Justification

Scarce data on this species may indicate low population levels. Redfin pickerel appear to be restricted to southeastern New Hampshire, and rapid urbanization in this region makes the species susceptible to poor water quality and other habitat related threats (Richter et al. 1997). The introduction of other Esox species into aquatic systems with low redfin pickerel populations may compromise the genetic identity of the species. Kramer (2002) recognizes the importance of the redfin pickerel as a top-level predator in certain aquatic communities.

1.3 Protection and Regulatory Status

There are no specific protection or regulations for this species.

1.4 Population and Habitat Distribution

The redfin pickerel inhabits watersheds in the Atlantic coastal plain of the eastern United States and southeastern Canada (Scarola 1987). All evidence suggests that the species occurs exclusively in the coastal and lower Merrimack watersheds within New Hampshire (Gordon 1937, Bailey 1938, New Hampshire Fish and Game (NHFG) unpublished data, New Hampshire Department of Environmental Services (NHDES) Biomonitoring data).

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

More research will be necessary to determine the current distribution and habitat requirements of this species in New Hampshire. A map of low gradient streams and pond habitat in the coastal watersheds (refer to the system 13) and the Merrimac watersheds (System 11 and system 12) would facilitate future surveys.

1.7 Sources of Information

Published literature provided information on distribution and habitat requirements. NHFG unpublished data, NHDES Biomonitoring data, and watershed biological surveys conducted by NHFG from 1937 to 1939 were used in defining population locations of the species within New Hampshire.

1.8 Extent and Quality of Data

Data on the distribution of the redfin pickerel in New Hampshire were collected in other studies and monitoring projects. No surveys have been conducted that specifically target redfin pickerel or their habitat. The NHDES Biomonitoring program provides the most recent information on the presence of redfin pickerel at certain sampling sites in southeastern New Hampshire. All records of redfin pickerel should be viewed with caution because the species is easily mistaken for a juvenile chain pickerel (Scarola 1987).

1.9 Distribution Research

Distribution data for redfin pickerel in New Hampshire should be obtained. The NHDES Biomonitoring data could be used to guide future sampling efforts to establish the range of the species. Studies of factors that limit the distribution and abundance of redfin pickerel would be helpful. Habitat data collected from sites with known populations may be used to identify new survey sites. Data should be entered into a GIS database to help identify variables that may predict the presence of redfin pickerel and to track the distribution of the species over time.

Element 2

Not completed for this species

Element 3

Not completed for this species

Element 4

Not completed for this species

Element 5: References

5.1 Literature

Bailey R.M. 1938. The Fishes of the Merrimack Watershed. In: A Biological Survey of the Merrimack Watershed. New Hampshire Fish and Game Department, Survey Report No. 3:149-185.

Gordon, M. 1937. The Fishes of Eastern New Hampshire. In: A Biological Survey of the Androscoggin, Saco and Coastal Watersheds. New Hampshire Fish and Game Department, Survey Report no. 2: 101-118.

Kramer, N. 2002. Nonsport and Commercial Management Plan. Maine Division of Inland Fisheries and Wildlife, Division of Fisheries and Hatcheries, Augusta, Maine, USA.

Richter, B.D., D.P. Braun, M.A. Mendelson, and L.L. Master. 1997. Threats to imperiled freshwater fauna. Conservation Biology 11:1081-1093.

Scarola, J. 1987. Freshwater Fishes of New Hampshire. New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

Scott, W., and E. Crossman. 1973. Freshwater Fishes of Canada. Fisheries Research Board of Canada. 966p.

Steiner L. 2004. Pennsylvania Fishes. http://sites.state.pa.us/PA_Exec/Fish_Boat/pafish/fishhtms/chap14.htm (Accesed 2005 Feb 8)

5.2 Data Sources:

Biomonitoring Program. 1995-2005. New Hampshire Department of Environmental Services, Watershed Management Bureau. www.des.state.nh.us/wmb/biomonitoring/sites/index.html >. Accessed 2004 December

Fishbase. 2005. Redfin pickerel species summary page. < www.fishbase.se/Summary/SpeciesSummary.cfm?genusname=Esox&speciesname=americanus%20americanus>. Accessed 2005 Dec.

SPECIES PROFILE

Round Whitefish

Prosopium cylindraceum

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S3
Author: Benjamin, J. Nugent, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Round whitefish inhabit deep, clear, cold water lakes and their tributaries (Scarola 1987). The species prefers relatively shallow water, rarely exceeding depths of 150 feet (Scott and Crossman 1973). Spawning occurs in lake shallows, reefs, and river mouths with gravelly or rocky substrate when surface temperatures reach 40°F. Peak spawning activity occurs during the second week of December in Newfound Lake (Scott and Crossman 1973, Normandeau 1963). Round whitefish in Newfound Lake were observed to spawn on the same reef as lake trout (*Salvelinus namaycush*) (Normandeau 1963). Information concerning habitat use of juvenile round whitefish is unavailable.

1.2 Justification

The round whitefish is considered vulnerable in New Hampshire because it is believed to be limited to 3 waterbodies. Although an intense study was conducted on one of the populations (Newfound Lake, Normandeau 1961-1962), no contemporary information about these populations is available. Bouton and Stegemann (1993) have identified tapeworms, over harvest, spawning habitat degradation, siltation, acidification, and predation by yellow perch as threats to round whitefish in New York. Further studies in New Hampshire are warranted to develop a better knowledge of the population's health and status.

1.3 Protection and Regulatory Status

In New Hampshire, the round whitefish is regulated by a 2 fish daily harvest limit with no length or weight restrictions. A closed season on round whitefish is in effect from 1 October to 31 December in some water bodies. The use of whitefish as bait for burbot (*Lota lota*) is prohibited (RSA 211).

1.4 Population and Habitat Distribution

The distribution of the round whitefish is circumpolar, with New Hampshire's population at the southern most part of its range. Round whitefish historically existed in Newfound, First Connecticut, and Winnipesaukee Lakes, as well as the upper Connecticut River (Scarola 1987, Bailey and Oliver 1939). Current populations of the species are believed to exist in both Winnipesaukee and Newfound lakes (Scarola 1987). The status of current Connecticut River and First Connecticut Lake populations is unknown. A population of round whitefish may be present in Lake Francis. Bailey and Oliver (1939) observed round whitefish in the upper Connecticut River, possibly in the area where Lake Francis was later created by impoundment. In 1995, there was an unverified sighting of the species in the upper Connecticut River in the town of Colebrook or Columbia (Scott Decker, New Hampshire Fish and Game (NHFG), personal communication).

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

More research will be necessary to determine the distribution and habitat requirements of this species in

New Hampshire. A map of river and lake habitat in the Connecticut and Androscoggin Headwaters (refer to the systems 5 and 7), the Western Hills (refer to the systems 3 and 9) and the Lakes Region (refer to the systems 10 and 14) would facilitate future surveys.

1.7 Sources of Information

New Hampshire Fish and Game unpublished data, historical watershed biological surveys, and an angler report were used in defining locations of the species within the state. Historical distribution data were confirmed using samples contained in a museum database.

1.8 Extent and Quality of Data

Recent sampling data are very limited. Although literature from Normandeau (1963) provides detailed information on the round whitefish of Newfound Lake, no direct monitoring for the species has been conducted in other water bodies. The existence of round whitefish in Newfound and Winnipesaukee Lakes has been verified by recent angler catches and the discovery of mortalities. Data should be treated cautiously, for the lake whitefish (*Coregonus clupeaformis*) may have been misidentified as the round whitefish (Normandeau, 1963).

1.9 Distribution Research

Recent information on the species is very limited. Sampling presumed locations of the round whitefish should be a priority. Confirming the distribution of the round whitefish in the state will be the first step toward assessing the status of the species. Information obtained from sampling will determine the scope of action needed to protect New Hampshire's round whitefish populations.

Element 2: Species/Habitat Condition

2.1 Scale

Habitat units are based on known populations, historic populations, and areas that potentially hold populations of round whitefish. Newfound Lake, Winnipesaukee Lake, First Connecticut Lake, and Lake Francis are thought to have historic, current or potential round whitefish populations. The upper Connecticut River will also be included because of the likelihood of a population. Newfound and Winnipesaukee Lakes are mapped as individual units. The upper Connecticut River (HUC10) watershed map unit contains First Connecticut Lake and Lake Francis.

2.2 Relative Health of Populations

Current populations trends in all units are unknown. Normandeau (1963) acknowledged the Newfound Lake population of round whitefish as abundant and healthy. In 2001, fisheries biologists observed one round whitefish during fall netting on Newfound Lake, and an angler harvested a new state record round whitefish (457mm, 785g) from Newfound Lake in the winter of 2005. Other round whitefish catches have been reported from Newfound in 2005 (John Viar, NHFG personal communication). The historic population of round whitefish in First Connecticut Lake was also reported to be plentiful (Bailey and Oliver 1939). No historic information about population abundance is available for other units.

2.3 Population Management Status

It is unlikely that the 2 fish daily harvest limit affects populations. A recent survey of anglers indicated that the round whitefish is very rarely, if at all, caught (Duda and Young 1996). Angling pressure is believed to have little effect on round whitefish populations within the state (Normandeau 1963). No other direct ongoing management effort exists at this time.

2.4 Relative Quality of Habitat Patches

Refer to the Connecticut and Androscoggin Headwaters (refer to the systems 5 and 7), the Western Hills (refer to the systems 3 and 9) and the Lakes Region (refer to the systems 10 and 14) habitat profiles.

Distinct habitat requirements of round whitefish are not well understood. Normandeau (1963) determined that spawning round whitefish in Newfound Lake used the same reef as spawning lake trout. Monitoring studies on the upper Connecticut River indicate adequate amounts of dissolved oxygen, low levels of embedded, fine particles or organic matter, and a variety of fish habitat (Francis and Mulligan

1997). Sedimentation and turbidity are identified as the 2 highest threats to the upper Connecticut River (Francis and Mulligan 1997). Silviculture practices have catalyzed bank erosion rates, introducing sediments and nutrients into the system. High water temperatures in the summer months, coupled with excessive nutrient levels can significantly lower dissolved oxygen rates. The Connecticut Lakes have rocky shorelines, which is the potential spawning substrate for round whitefish.

2.5 Habitat Patch Protection Status

Refer to the Connecticut and Androscoggin Headwaters (refer to the Systems 5 and 7), the Western Hills (refer to the systems 3 and 9) and the Lakes Region (refer to the systems 10 and 14) habitat profiles.

2.6 Habitat Management Status

Results of restoration and management of the habitat patches in relation to the round whitefish are unknown.

2.7 Sources of Information

Literature reviews were conducted to define key components required for habitats, as well as the historical abundances of populations. Internet sources were used to define current quality and management of specific habitat patches.

2.8 Extent and Quality of Data

Current available data regarding the species should only be used to indicate where a population once existed and may still be present today. Historically, 2 populations were defined as abundant and healthy (Bailey and Oliver 1939, Normandeau 1963), but the lack of current data makes it difficult to establish the heath and abundance of present populations.

2.9 Condition Assessment Research

Recent information of the species is very limited. Sampling presumed locations of the species should be a priority (The upper Connecticut River and Winnipesaukee, Newfound, First Connecticut, and Francis lakes). Length and weight data will be used to define condition indices, and age data and male/female ratios will help define growth rates and recruitment potential. Information obtained from sampling will determine the scope of action needed to protect the species.

Element 3

Not completed for this species

Element 4

Not completed for this species

Element 5: References

5.1 Literature

Bailey, J., and J. Oliver. 1939. The Fishes of the Connecticut Watershed. In: A Biological Survey of the Connecticut Watershed. New Hampshire Fish and Game Dept., Survey Report No. 4:150-189.

BiomonitoringProgram.<http://www.des.state.nh.us/wmb/biomonitoring/history.htm>. Accessed 2005.

Bouton, D., and E. Stegemann. 1993. Endangered and Threatened Fishes of New York. The Conservationist. New York State Department of Environmental Conservation. September p.14-21.

The Connecticut River. <http://www.des.state.nh.us/rivers/conn1.htm>. Accessed 2005.

Duda, M., and K. Young. 1996. New Hampshire Freshwater Angler Survey. New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

Francis, S., and A. Mulligan. 1997. Connecticut River Corridor Management Plan. <http://Francis and Mulligan 1997/corridor-plan/plan-TOC.html>. Accessed 2005 Jan.

New Hampshire Lakes Management and Protection Program. 1998. <http://www.des.state.nh.us/factsheets/r&l/rl-1.htm>. Accessed 2005.

Normandeau, D. 1963. The Life History of the Round Whitefish *Prosopium cylindraceum* Pallas, of Newfound Lake, N.H. 115p.

Scarola, J. 1987. Freshwater Fishes of New Hampshire. New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

Scott, W., and E. Crossman. 1973. Freshwater Fishes of Canada. Fisheries Research Board of Canada. 966p.

Shoreland Protection. 2004 Nov 1. < http://

www.des.state.nh.us/cspa/483B.htm#483b2 >. Accessed 2005.

Volunteer Lake Assessment Program. 2003 Mar 26. <http://www.des.state.nh.us/wmb/vlap/how.htm>. Accessed 2005.

5.2 Data Sources

UMMZ Fish Collection Search. http://141.211.243.52/UMMZ/. (Accessed: 2005 February 7).

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: January 24, 2005).

SPECIES PROFILE

Sea Lamprey

Petromyzon marinus

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S4
Author: Matthew A. Carpenter, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Sea lampreys spend their adult lives in the ocean as a parasite on other fish. After 20 to 30 months at sea they migrate into freshwater, following pheromones from larvae (ammocoetes) upstream (Vrieze and Sorenson 2001). Sea lampreys construct nests in gravel/cobble riffle sections of freshwater streams (Scarola 1987). Once hatched, the larvae float downstream to slow moving pools where they burrow into the substrate and filter feed on organic detritus drifting in the water column (Scarola 1987).

1.2 Justification

Sea lampreys are blocked from much of their spawning habitat by dams, and in New Hampshire depend on fishways to reach spawning habitat. Although Atlantic coastal populations are not currently endangered, there have been significant declines in lamprey populations throughout the northern hemisphere (Renaud 1997). A complex life cycle, which is dependent on multiple habitats in freshwater and marine ecosystems, makes the sea lamprey vulnerable to the effects of urbanization in coastal watersheds (Creel 2003).

1.3 Protection and Regulatory Status

A permit is required to collect lampreys for research.

1.4 Population and Habitat Distribution

The sea lamprey is native to rivers from Florida to Nova Scotia in the West Atlantic, and from Western Europe to northern Africa in the east Atlantic. In New Hampshire, sea lampreys are restricted to rivers with actively managed fish ladders. During the spring spawning runs of river herring and American shad, lampreys use the Connecticut River, Merrimack River, and coastal rivers (Scarola 1987).

1.5 Town Distribution Map

Not completed for this species

1.6 Habitat Map

Sea lampreys inhabit the lower section of the Merrimack River and the coastal watersheds of New Hampshire. See the Non-Tidal Coastal Watersheds (systems 11 and 12), Mainstem Watersheds (systems 1 and 2), and Tidal Coastal Watersheds (system 13) profiles.

1.7 Sources of Information

Sea lamprey numbers are recorded during the monitoring programs for other fish. (eels are catadromous)

1.8 Extent and Quality of Data

Data on sea lamprey returns are often incidental to data collected on the spawning runs of other fish.

1.9 Distribution Research

The actual locations of sea lamprey spawning habitat and ammocoete habitat within New Hampshire watersheds are unknown.

Element 2
Not completed for this species

Element 3
Not completed for this species

Element 4
Not completed for this species

Element 5: References

Creel, L. 2003. Ripple Effects: Population and Coastal Regions (Washington, D.C.: Population Reference Bureau)

Renaud, C.B. 1997. Conservation status of Northern Hemisphere lampreys (Petromyzontidae). Journal of Applied Ichthyology 13(3):143-148.

Scarola, J. 1987. Freshwater Fishes of New Hampshire (2nd Edition). New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

Vrieze, L.A., and P.W. Sorensen. 2001. Laboratory assessment of the role of a larval pheromone and natural stream odor in spawning stream localization by migratory sea lamprey. Canadian Journal of Fisheries and Aquatic Science 58:2374-2385.

SPECIES PROFILE

Shortnose Sturgeon

Acipenser brevirostrum

Federal Listing: Endangered
State Listing: Endangered
Affected Species: N/A
Global Rank: G3
State Rank: SH
Author: Benjamin, J. Nugent, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Shortnose sturgeons occupy freshwater rivers but occasionally enter saltwater. They prefer areas of a river with curves or bends and a sand or cobble substrate (Kynard et al. 2000). Adults return to specific parent streams to spawn (Scott and Crossman 1973). Spawning substrates consist of boulder, cobble, and gravel with water depths of 10 m or less. Water temperatures during spawning range from 9.0 to 18.0°C. Spawning runs were observed during late April in the Merrimack River, Massachusetts (Kieffer and Kynard 1996).

1.2 Justification

Shortnose sturgeon are federally listed as endangered and presumed extirpated in New Hampshire. They have not been observed in New Hampshire since 1971 (Doug Grout, NHFG, personal communication). Population declines due to the development of barriers (such as dams) in coastal rivers, alteration of spawning habitat, and commercial harvest have been documented (Friedland 2000). There is limited knowledge of the life stages or behavior of this species.

1.3 Protection and Regulatory Status

The possession of sturgeon is prohibited in New Hampshire.

1.4 Population and Habitat Distribution

Global distribution consists of populations along the eastern seaboard of North America (Scott and Crossman 1973). It is unclear whether populations within the Connecticut and Merrimack rivers once reached New Hampshire waters. It is believed that historic Connecticut River populations were obstructed at Turner Falls in Massachusetts (M. Kieffer, United States Geological Survey (USGS), personal communication). Historical populations within the Merrimack River were never distinguished from Atlantic sturgeon prior to dam construction (M. Kieffer, USGS, personal communication). A fish elevator at the Essex Dam (river km 46) on the Merrimack River in Massachusetts has never recorded sturgeon use. Given that shortnose sturgeon will migrate 200 km up rivers to spawn, it is likely that the species once inhabited the Merrimack River in New Hampshire (M. Kieffer, USGS, personal communication).

1.5 Town Distribution Map

Not completed for this species

1.6 Habitat Map

Shortnose sturgeon may once have inhabited the lower section of the Merrimack River and the coastal watershed of New Hampshire. See the Non-Tidal Coastal Watersheds (systems 11 and 12) and Tidal Coastal Watersheds (system 13) profiles.

1.7 Sources of Information

Published literature was used to define global range and characteristics of habitat used in freshwater. Historical distribution of the species was also obtained from published literature. Fisheries professionals provided information on current populations.

1.8 Extent and Quality of Data

Data are limited to 2 confirmed observations. Historical distribution information should be treated cautiously because there was often no distinction between Atlantic sturgeon and shortnose sturgeon (M. Kieffer, USGS, personal communication).

1.9 Distribution Research

Habitat assessments of the coastal rivers may reveal areas of potential spawning habitat. Results from these habitat assessments may identify barriers or other features that prevent the species from reaching desired spawning and foraging grounds.

Element 2

Not completed for this species

Element 3

Not completed for this species

Element 4

Not completed for this species

Element 5: References

Bigelow, H., and W. Schroeder. 1953. Fishes of the Gulf of Maine. Fishery Bulletin of the Fish and Wildlife Service. Number 74, Volume 53.

Friedland K. 2000. Atlantic and Shortnose Sturgeons. National Marine Fisheries Service. <http://www.nefsc.noaa.gov/sos/spsyn/af/sturgeon/#1>.

Kieffer, M., and B. Kynard. 1996. Spawning of the shortnose sturgeon in the Merrimack River, Massachusetts. Transactions of the American Fisheries Society 125:179-186.

Kynard, B., M. Horgan, M. Kieffer, and D. Seibel. 2000. Habitats used by shortnose sturgeon in two Massachusetts rivers, with notes on estuarine Atlantic sturgeon: a hierarchical approach. Transactions of the American Fisheries Society 129:487-503.

Scott, W., and E. Crossman. 1973. Freshwater Fishes of Canada. Fisheries Research Board of Canada. 966p.

SPECIES PROFILE

Slimy Sculpin

Cottus cognatus

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S4S5
Author: Benjamin, J. Nugent, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The slimy sculpin is found in cool streams and cold deep lakes with rock and gravel substrates. The species is commonly found under rocks in both rivers and lakes. Slimy sculpin often share stream habitat with eastern brook trout (*Salvelinus fontinalis*) (Scarola 1987). They spawn in the spring when temperatures reach from 40 to 50°F in lake and river environments (Scott and Crossman 1973). The undersides of logs and large rocks are used for egg placement during spawning (Kaeser and Sharpe 2001).

1.2 Justification

Slimy sculpin is one of 3 New Hampshire fish species that serve as hosts to the federally and state endangered dwarf wedgemussel (*Alasmidonta heterodon*) (Nedeau et al. 2000, B. Wicklow, Saint Anselm College, personal communication). Healthy populations of slimy sculpin in the Connecticut and Ashuelot Rivers likely contribute to the persistence of dwarf wedgemussel populations in New Hampshire. The tessellated darter (*Etheostoma olmstedi*) and Atlantic salmon (*Salmo salar*) are the only other New Hampshire fish species that are hosts for the dwarf wedgemussel (Nedeau et al. 2000), and the disappearance of a self-sustaining Atlantic salmon population from the Connecticut River watershed has increased the importance of slimy sculpin as a host species. Data on the distribution and health of slimy sculpin populations are needed to further protect the dwarf wedgemussel. The slimy sculpin is an indicator of the biological integrity of coldwater streams (Langdon 2001, Gray et al. 2004).

1.3 Protection and Regulatory Status

There is no specific protection of this species at the state, regional, or federal level.

1.4 Population and Habitat Distribution

The species is found throughout northern North America, and in New Hampshire is found in all major watersheds except the coastal watersheds (Scarola 1987). Slimy sculpin populations are more common in central and northern New Hampshire.

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

A map of pond, stream, and lake habitat in the Connecticut and Androscoggin Headwaters (systems 5 and 7), Connecticut River (systems 1 and 2), Western Hills (systems 3 and 9), White Mountains (systems 4, 6, and 8), Lakes Region (systems 10 and 14), and Merrimack River (systems 11 and 12) would facilitate future surveys.

1.7 Sources of Information

Published literature, New Hampshire Fish and Game (NHFG) unpublished data, New Hampshire Department of Environmental Services (NHDES) Biomonitoring data, and historic watershed surveys were used

to describe distribution and habitat.

1.8 Extent and Quality of Data

Slimy sculpin are inadvertently sampled during trout and salmon surveys. Most data are qualitative and insufficient to assess population trends. Surveys verify that the species is present in streams throughout central and northern New Hampshire and absent in the coastal watershed.

1.9 Distribution Research

Monitoring efforts should identify areas where slimy sculpin and dwarf wedgemussels co-occur. Because the slimy sculpin is an indicator of quality coldwater stream habitat, a map of the species' distribution would provide baseline information on the status of coldwater streams in New Hampshire. A better effort should be made to document slimy sculpin during surveys intended for other species. Records should be entered into a central database to monitor the distribution and status of New Hampshire fish species. Resurveying historic sample sites may show changes in slimy sculpin distribution and possibly identify streams in need of restoration.

Element 2

Not completed for this species

Element 3

Not completed for this species

Element 4

Not completed for this species

Element 5: References

5.1 Literature

Gray, M.A., R.A. Cunjak, and K.R. Munkittrick. 2004. Site fidelity of slimy sculpin (*Cottus cognatus*): insights from stable carbon and nitrogen analysis. Canadian Journal Fish and Aquatic Science 61:1717-1722.

Kaeser, A., and W. Sharpe. 2001. The influence of acid runoff episodes on slimy sculpin reproduction in Stone Run. Transactions of the American Fisheries Society 130:1106-1115.

Langdon, R.W. 2001. A preliminary index of biological integrity for fish assemblages of coldwater streams in Vermont. Northeastern Naturalist 8(2): 219-232.

Nedeau, E.J., M.A. McCollough, and B.I. Swartz. 2000. The Freshwater Mussels of Maine. Maine Department of Inland Fisheries and Wildlife, Augusta, Maine, USA.

Scarola, J. 1987. Freshwater Fishes of New Hampshire (2nd edition). New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

Scott, W., and E. Crossman. 1973. Freshwater Fishes of Canada. Fisheries Research Board of Canada. 966p.

5.2 Data Sources

Biomonitoring Program. 1995-2005. New Hampshire Department of Environmental Services, Watershed Management Bureau. < http://www.des.state.nh.us/wmb/biomonitoring/sites/index.html >. Accessed 2004 December 12

SPECIES PROFILE

Sunapee Trout
Salvelinus aureolus

Federal Listing: Not listed
State Listing: Endangered
Affected Species: N/A
Global Rank: G5
State Rank: SX
Author: Benjamin, J. Nugent, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Sunapee trout inhabited a limited number of oligotrophic, deep-water lakes in New Hampshire. They were restricted to deep, cool waters during warmer months (Balon 1980), and were found throughout the water column when temperatures were below 10°C. Spawning habitat consisted of off-shore reefs with rubble, boulder, and gravel substrates. Depths of spawning sites ranged from a few inches to 20 feet (Newell 1958). Eggs hatched in late winter with ice cover still present. Upon yolk sac absorption, fry moved to deeper water to feed on zooplankton (Balon 1980).

1.2 Justification

New Hampshire Fish and Game (NHFG) considers the Sunapee trout extirpated from the state because it has not been observed since the late 1970s (John Viar, NHFG, personal communication, NHFG unpublished data). Only 2 native populations occurred in New Hampshire (Scarola 1987), and attempts to introduce the species into other water bodies in New Hampshire were unsuccessful (Scarola 1987, John Viar, NHFG, personal communication). The species was vulnerable because it had a limited distribution and it was susceptible to predation and competition by other introduced fish species, especially lake trout (*S. namaycush*) and landlocked salmon (*Salmo salar*) (Newell 1958, Balon 1980, Scarola 1987).

1.3 Protection and Regulatory Status

This species is not specifically protected.

1.4 Population and Habitat Distribution

The phylogeny of Sunapee trout is unclear. It is likely that the Sunapee trout belonged to the Laurentian lineage of landlocked arctic char, which were trapped in northeastern lakes after the Wisconsin glaciation (Bernatchez et al. 2002). Isolated populations developed unique genetic characteristics as they adapted to local conditions (Bernatchez et al. 2002). One exception may be the now extinct silver trout, once found in Dublin Pond of New Hampshire, which may have been a subspecies of brook trout (*Salvelinus fontinalis*) or possibly even a separate species (Nelson et al. 2004). Unfortunately, due to the scarcity of preserved specimens, there may be no way to confirm the taxonomic classification of extirpated populations.

In New Hampshire, Sunapee trout existed in Sunapee Lake and Big Dan Hole Pond (Scarola 1987), though the source of these populations is not known. Attempts to introduce Sunapee trout into at least 5 other water bodies (Sawyer Pond, Penacook Lake, Third Connecticut Lake, Tewksbury Pond, and Connor Pond) were unsuccessful (Scarola 1987). No confirmed observations of the species have occurred in Sunapee Lake since the late 1960s. Unsuccessful introductions into Tewksbury Pond occurred until the mid 1970s (John Viar, NHFG, personal communication, NHFG unpublished data). The last reported stocking attempt occurred at Penacook Lake in 1977, and no samples of Sunapee trout were observed during a survey the following year (NHFG unpublished data). In 1925, 4 water bodies in Idaho

were stocked with Sunapee trout from Sunapee Lake (Kircheis et al. 1995, Fuller 2000). New York and Massachusetts also received populations of Sunapee trout in attempts to increase the range of the species (Fuller 2000).

The Laurentian lineage of arctic char is still present in 12 lakes in Maine (Bernatchez et al. 2002). A native, self-sustaining population from Floods Pond (Hancock County, Maine) was introduced to 7 other water bodies in Maine. Of the 7 introductions, at least 2 were successful in creating self-sustaining populations (Frost 2001).

1.5 Town Distribution Map

Maps of native and stocked populations are provided.

1.6 Habitat Map

Not completed for this species

1.7 Sources of Information

Peer-reviewed literature and gray literature were used to describe historic distribution and habitat. Gray literature consisted of unpublished reports, stocking cards, and papers completed by NHFG staff. Fisheries biologists from New Hampshire, Vermont, and Maine confirmed the status of the population (personal communication: John Viar, Kenneth Cox, and Dennis McNeish, respectively).

1.8 Extent and Quality of Data

Historic locations of the species are well documented. Documentation by several authors agree that the species is extirpated from New Hampshire.

1.9 Distribution Research

Because Sunapee trout are believed extinct in the state, no further research on the distribution of Sunapee trout is warranted. Fisheries management for bodies of water that once held populations of Sunapee trout includes monitoring for other fish species. No recent incidental captures of the Sunapee trout have been documented in these waters.

Element 2: Species/Habitat Condition

2.1 Scale

No conservation planning units for a possible reintroduction of the species have been identified. Part of the condition assessment research would be to identify any suitable water bodies available for reintroducing populations of Sunapee trout.

2.2 Relative Health of Populations

The Sunapee trout was once very prolific (Newell 1958). The species' reproductive success was compromised by hybridization, competition, and predation by lake trout and other salmonids (Balon 1980, Frost 2001). Forage food competition from landlocked salmon and lake trout was likely a major threat to Sunapee trout, and various other fish species have been observed to feed on Sunapee trout eggs after spawning (Newell 1958). An introduced population of Sunapee trout that was established in Third Connecticut Lake failed after the introduction of lake trout (Newell 1958).

2.3 Population Management Status

There are no ongoing population management efforts.

2.4 Relative Quality of Habitat Patches

Because it is believed that the species is extirpated, there are no current habitat patches.

2.5 Habitat Patch Protection Status

Because it is believed that the species is extirpated, there are no current habitat patches.

2.6 Habitat Management Status

There are no current habitat management or restoration efforts.

2.7 Sources of Information

Information regarding the condition of historical populations was found through literature review.

Status of populations was obtained through conversations with local fisheries professionals.

2.8 Extent and Quality of Data

The disappearance of Sunapee trout from state waters is well documented.

2.9 Condition Assessment Research

Restoration efforts will depend on a feasibility study to determine if any suitable habitat exists in New Hampshire. Restoring Sunapee would require identification of a population with similar genetic identity from another state, though the unique genetic characteristics of Sunapee trout in Sunapee Lake and Big Dan Hole Pond can never be replicated. Genetic research has already confirmed hybridization between populations of Sunapee trout and eastern brook trout (*Salvelinus fontinalis*) in Idaho, resulting in a species with a different genetic identity (Kircheis et al. 1995). Any attempt to reestablish the Sunapee trout in New Hampshire should be viewed as an effort to extend the range of a unique strain (Laurentian) of landlocked arctic char (Bernatchez et al. 2002). Sunapee trout in Floods Pond (Maine) may have the genetic characteristics most similar to former New Hampshire populations (Kircheis et al. 1995).

Element 3

Not completed for this species

Element 4

Not completed for this species

Element 5: References

5.1 Literature

Balon, E. Editor. 1980. Charrs Salmonid Fishes of the Genus *Salvelinus*. Dr. W. Junk Publishers. The Hague, Netherlands. 928p.

Bernatchez, L., J.G. Rhydderch, and F.W. Kircheis. 2002. Microsatellite gene diversity analysis in landlocked arctic char from Maine. Transactions of the American Fisheries Society 131:1106-1118.

Fuller, P. 2001. Salvelinus *aureolus oquassa* (Bean 1887) USGS. < http://nas.er.usgs.gov/queries/FactSheet.asp?SpeciesID=936> Accessed 2005 Jan 21.

Frost, F. 2001. Arctic Charr Assessment. Maine Department of Inland Fisheries and Wildlife Division of Fisheries and Hatcheries, Augusta, Maine, USA.

Kircheis, F., I. Kornfield, S. Seyoum. 1995. Genetic Identity of Transplanted Arctic Char: Implications for Restocking Programs. North American Journal of Fisheries Management 15:54-59

Nelson, J.S., E.J. Crossman, H. Espinosa-Pérez, L.T. Findley, C.R. Gilbert, R.N. Lea, and J.D. Williams. 2004. Common and scientific names of fishes from the United States, Canada, and Mexico. American Fisheries Society, Special Publication 29, Bethesda, Maryland. 386 p.

Newell, A. 1958.The Life History and Ecology of the Sunapee Trout, *Salvelinus aureolus* (Bean). New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

Scarola, J. 1987. Freshwater Fishes of New Hampshire (2nd edition). New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

SPECIES PROFILE

Swamp Darter

Etheostoma fusiforme

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S3
Author: Benjamin, J. Nugent, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The swamp darter inhabits lakes and ponds in shallow areas of soft muddy substrate, dense vegetation, and accumulated detritus. Stream habitats include both swift and slow moving water with patches of thick vegetation (Schmidt and Whitworth 1979, Scarola 1987). Research in Connecticut streams and ponds found swamp darters to be more abundant in ponds than in streams, and stream populations were usually found near known pond populations. Spawning activity was not observed in streams, indicating that stream populations may depend on recruitment from ponds (Schmidt and Whitworth 1979). Swamp darters are dependent on vegetation for spawning (Toth et al. 1998).

1.2 Justification

Swamp darter populations appear to be restricted to watersheds in the southeastern corner of the state. New Hampshire is near the northern extent of the swamp darters' global range. The short life span of the swamp darter (1 to 2 years), combined with aquatic habitat degradation caused by increasing development in southeastern New Hampshire, make the species vulnerable to extirpation from state waters (Schmidt 1983). There is little information available on the distribution, abundance, or health of swamp darter populations in New Hampshire.

1.3 Protection and Regulatory Status

This species is not protected.

1.4 Population and Habitat Distribution

The species inhabits watersheds in coastal plains of the eastern United States from Maine to North Carolina (Scarola 1987). Gordon (1937) and Bailey (1938) found populations of swamp darters in both lentic and lotic environments in the lower Merrimack and coastal watersheds. Populations in these areas were later observed in the mid 1980s (NHFG unpublished data).

1.5 Town Distribution Map

Within the last 20 years, swamp darters have been observed in Auburn, Barrington, Durham, Lee, Manchester, Merrimack, Milford, Salem, and Windham; before then, they were observed in Chester, Madbury, Nottingham, Raymond, and Strafford.

1.6 Habitat Map

More research is needed to determine the distribution and habitat requirements of this species in New Hampshire. A map of low gradient streams and pond habitat in the coastal watersheds (refer to the system 13) and the Merrimac watersheds (refer to system 11 and system 12) would help target future survey work.

1.7 Sources of Information

Published literature and Internet sources were used to define the species' global distribution and habitat requirements. Statewide distribution data for the swamp darter were obtained from NHFG survey sites

during the mid 1980s and from historical biological surveys of the Merrimack and Coastal watersheds. Historical distribution data were confirmed using samples contained in a museum database (UMMZ Fish Collection 2005).

1.8 Extent and Quality of Data

Information on the current distribution of the swamp darter within the state is limited, though statewide sampling data confirm that the species is restricted to southeastern New Hampshire. However, the range of the swamp darter population within this region is not well understood. The swamp darter can be confused with the tessellated darter.

1.9 Distribution Research

Of 19 known swamp darter records, 12 came from biological surveys by NHFGD in the 1930s. Resurveying historical sample sites should be the first step toward assessing the status of the swamp darter population. Habitat data collected from sites with known populations may be used to identify new survey sites. Data should be entered into a GIS database to help identify variables that may predict the presence of banded sunfish and to track the distribution of the species over time.

Element 2

Not completed for this species

Element 3

Not completed for this species

Element 4

Not completed for this species

Element 5: References

5.1 Literature

Bailey, R.M. 1938. The Fishes of the Merrimack Watershed. In: A Biological Survey of the Merrimack Watershed. New Hampshire Fish and Game Department, Survey Report No. 3:149-185.

Gordon, M. 1937. The Fishes of Eastern New Hampshire. In: A Biological Survey of the Androscoggin, Saco and Coastal Watersheds. New Hampshire Fish and Game Department, Survey Report No. 2:101-118.

Scarola, J. 1987. Freshwater Fishes of New Hampshire. New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

Schmidt, R., and W. Whitworth. 1979. Distribution and habitat of the swamp darter (*Etheostoma fusiforme*) in southern New England. American Midland Naturalist 102:408-413.

Schmidt, R. 1983. The Swamp Darter. American Currents: Publications of the North American Native Fishes Association. <http://www.nativefish.org/Articles/E_fusiforme.htm>. Accessed 2005 Jan.

Toth, L., S. Melvin, D. Arrington, and J. Chamberlain. 1998. Hydrologic Manipulations of the Channelized Kissimmee River. BioScience 48:757-764.

5.2 Data Sources

Biomonitoring Program. 1995-2005. New Hampshire Department of Environmental Services, Watershed Management Bureau. www.des.state.nh.us/wmb/biomonitoring/sites/index.html >. Accessed 2004 December 12

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. <http://www.natureserve.org/explorer> (Accessed: February 5, 2005).

University of Michigan Museum of Zoology (UMMZ). 2005. Fish Collection Search. <http://141.211.243.52/UMMZ/.> (Accessed: January 3, 2005).

SPECIES PROFILE

Tessellated Darter

Etheostoma olmstedi

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S4
Author: Benjamin, J. Nugent, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The tessellated darter inhabits pools of warm upland streams and shallow areas in large lakes and rivers (Scarola 1987). It is usually found over mud or sand substrates (Scarola 1987). Slow to moderate flow in rivers and streams are preferred, although larger individuals may be found in rocky riffles (Schmidt 1980). Spawning occurs in the spring under an overhanging rock or log in shallows (Schmidt 1980).

1.2 Justification

The tessellated darter is one of 3 New Hampshire fish species that serve as hosts to the federally and state endangered dwarf wedgemussel (*Alasmidonta heterodon*) (Nedeau et al. 2000), and healthy populations of tessellated darter in the Connecticut and Ashuelot Rivers likely contribute to the persistence of dwarf wedgemussel populations in New Hampshire. The slimy sculpin (*Cottus cognatus*) and Atlantic salmon (*Salmo salar*) are the only other New Hampshire fish species that act as hosts for the dwarf wedgemussel (Nedeau et al. 2000, B. Wicklow, Saint Anselm College, personal communication). The disappearance of a self-sustaining Atlantic salmon population from the Connecticut River watershed has increased the importance of tessellated darter as a host species. A Massachusetts study suggests that the ability of dwarf wedgemussels to colonize new areas may be limited by the movements of tessellated darters (McLain and Ross 2005). Monitoring of the distribution and health of tessellated darter populations is needed to help protect the dwarf wedgemussel.

1.3 Protection and Regulatory Status

There is no specific protection of this species at the state, regional, and federal levels.

1.4 Population and Habitat Distribution

Populations of tessellated darters are found in Atlantic drainages from the St. Lawrence River to Florida. In New Hampshire, the species had been reported to exist exclusively in the Connecticut River watershed, with no records in the extreme northern reaches (Scarola 1987). Bailey and Oliver (1939) found abundant populations of tessellated darters in the middle and lower portions of the Connecticut River and its tributaries. Tessellated darters have recently been documented in the Merrimack River watershed (NHDES Biomonitoring Program).

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

A map of pond, stream, and lake habitat in the Connecticut and Androscoggin Headwaters (refer to the systems 5 and 7), Connecticut River (refer to the systems 1 and 2), Western Hills (refer to the systems 3 and 9), and Merrimack River (refer to the systems 10, 11, and 12) would facilitate future surveys.

1.7 Sources of Information

NHFG unpublished data, NHDES Biomonitoring

data, and historic watershed surveys were used to define known and potential locations of tessellated darters within the state.

1.8 Extent and Quality of Data

Extensive survey work by NHFG and NHDES has documented the presence of tessellated darters in certain watersheds. Data suggest that the tessellated darter is not present in the coastal and Androscoggin watersheds. However, the possible presence of the species in these watersheds cannot be ruled out. Existing data are qualitative and are insufficient to identify population trends. Tessellated darters are often misidentified as swamp darters.

1.9 Distribution Research

Areas of potential coincidence of tessellated darters and dwarf wedgemussels should be a priority for distribution research. Reproduction of dwarf wedgemussel depends on populations of tessellated darters, therefore, there is a great need to obtain current distribution data. Resurveying sites with historical records may show changes in tessellated darter distribution patterns. Surveying additional locations in Connecticut and Merrimack River watersheds would provide better information on the statewide distribution of the species. Studies of the factors that limit the distribution and abundance of the species would aid in choosing survey sites. A better effort should be made to record observations of tessellated darter, as well as other nongame fish, during surveys of other species. Records of tessellated darter should be entered in a central database to track the distribution and status of all New Hampshire fish species.

Element 2

Not completed for this species

Element 3

Not completed for this species

Element 4

Not completed for this species

Element 5: References

5.1 Literature

Bailey J.R., and J.A. Oliver. 1939. The fishes of the Connecticut watershed. In: A biological survey of the Connecticut watershed. New Hampshire Fish and Game Dept., Survey Report No. 4:150-189

Bailey, R.M. 1938. The Fishes of the Merrimack Watershed. In: A Biological Survey of the Merrimack Watershed. New Hampshire Fish and Game Dept., Survey Report No. 3:149-185.

McLain, D.C., and M.R. Ross. 2005. Reproduction based on local patch size of *Alasmidonta heterodon* and dispersal by its darter host in the Mill River, Massachusetts, USA. Journal of the North American Benthological Society 24:139-147.

Nedeau, E.J., M.A. McCollough, and B.I. Swartz. 2000. The Freshwater Mussels of Maine. Maine Department of Inland Fisheries and Wildlife, Augusta, Maine, USA.

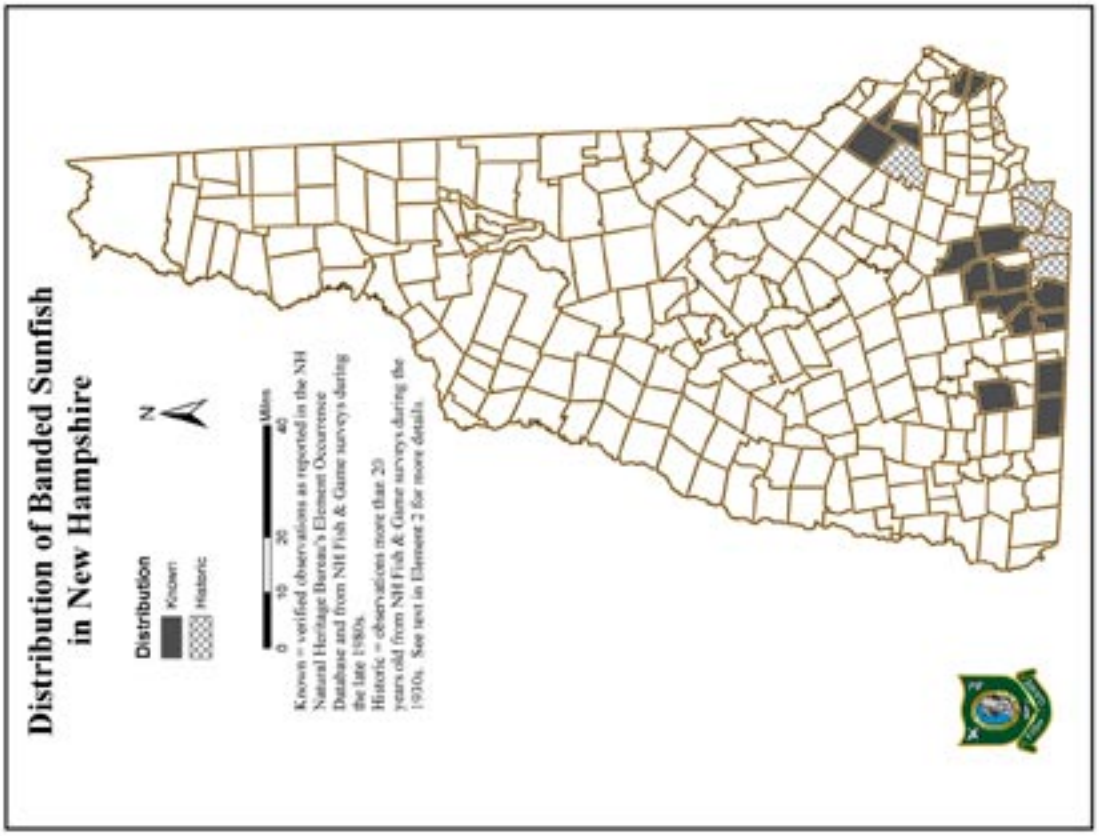
Scarola, J. 1987. Freshwater Fishes of New Hampshire (2nd edition). New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

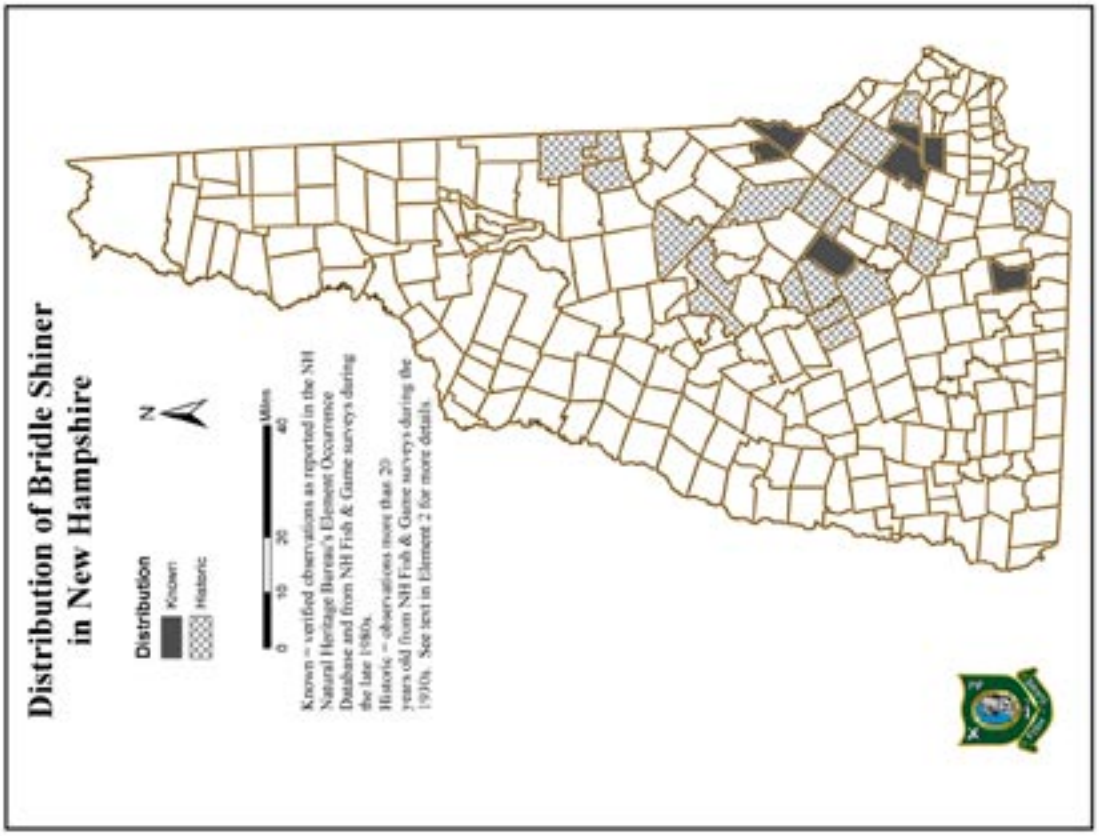
Schmidt R. 1980. The tessellated darter. North American Native Fish Association. <http://www.nativefish.org/Articles/E_olmstedi.htm>. Accessed 2005 Feb 4.

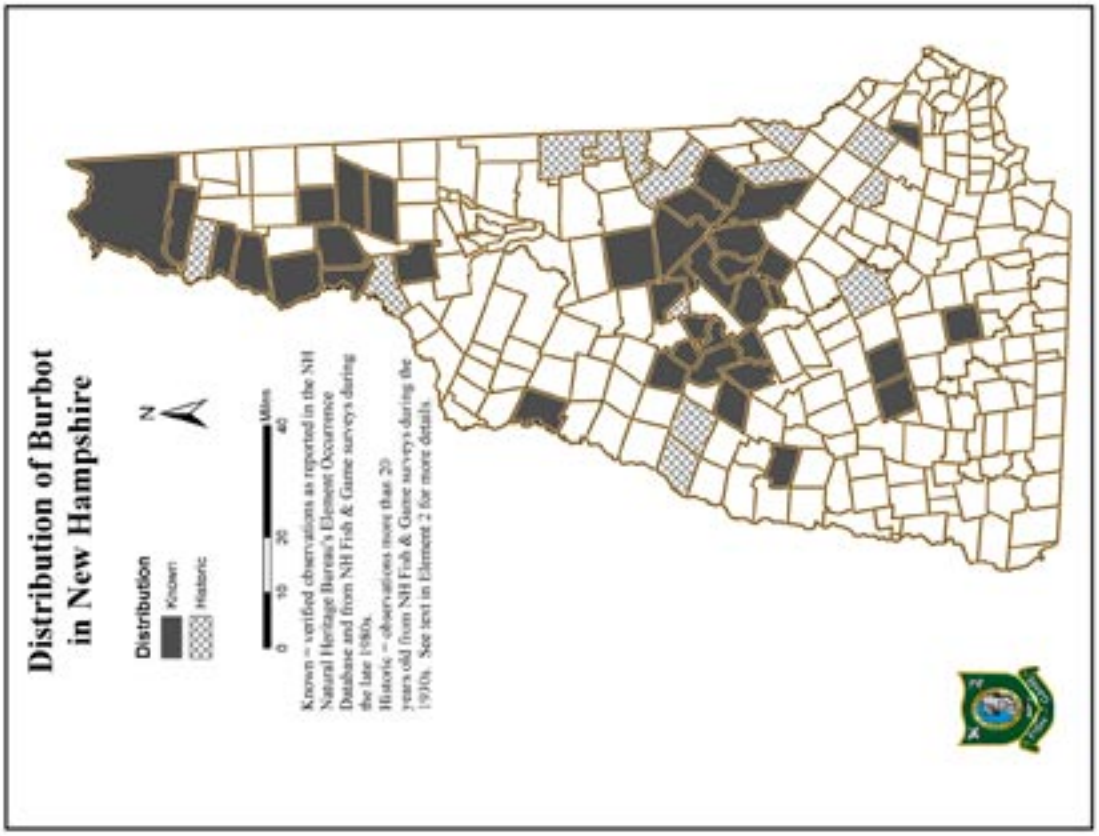
5.2 Data Sources

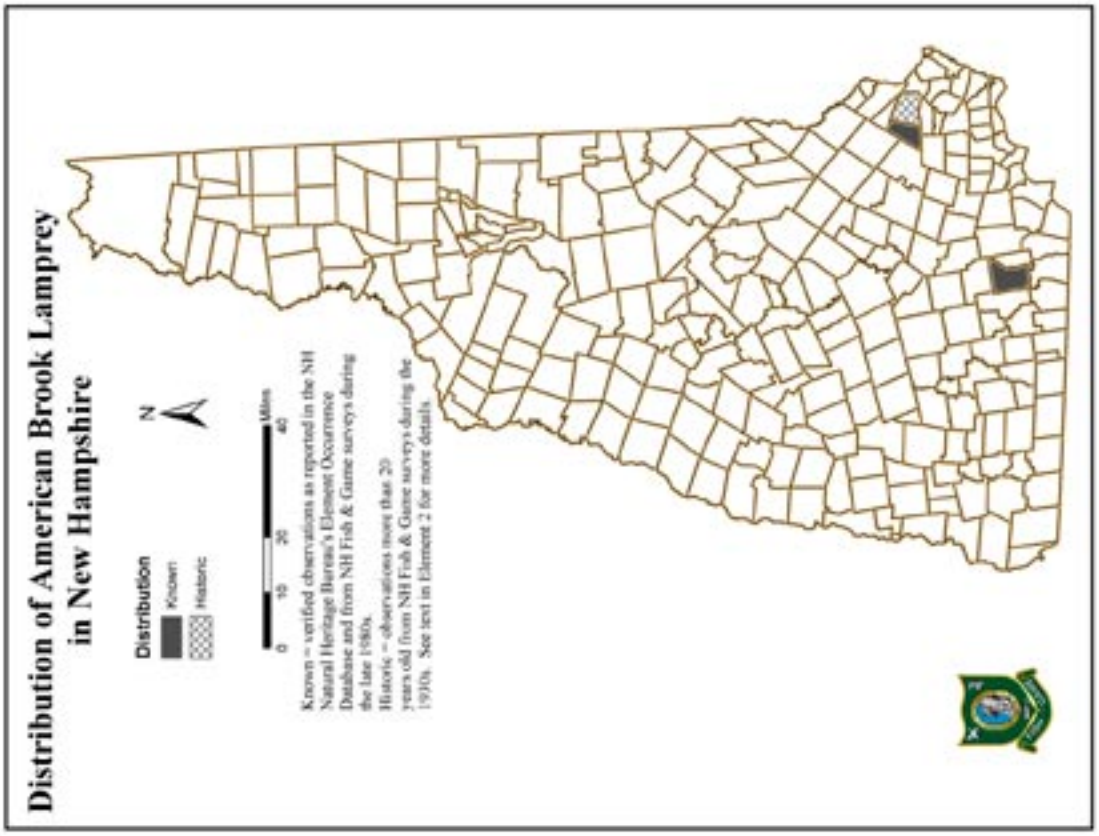
Biomonitoring Program. 1995-2005. New Hampshire Department of Environmental Services, Watershed Management Bureau. < http://www.des.state.nh.us/wmb/biomonitoring/sites/index.html >. Accessed 2004 December 12

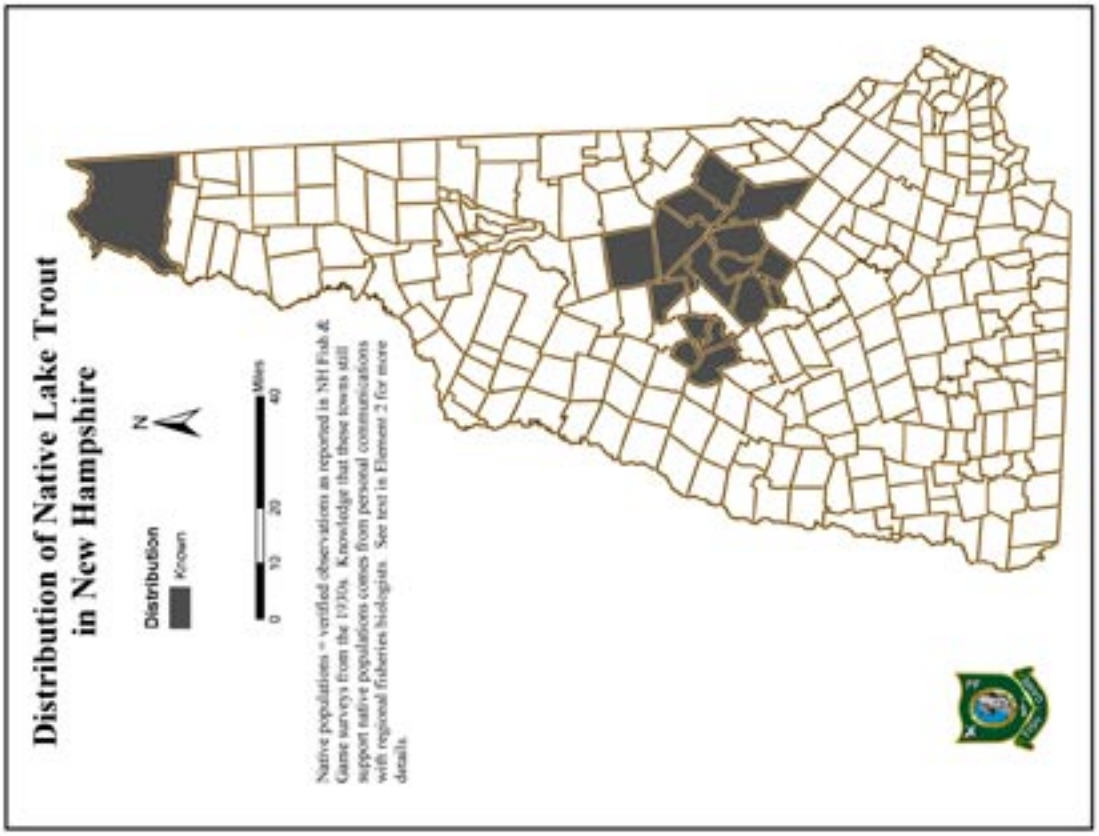
Fish Maps

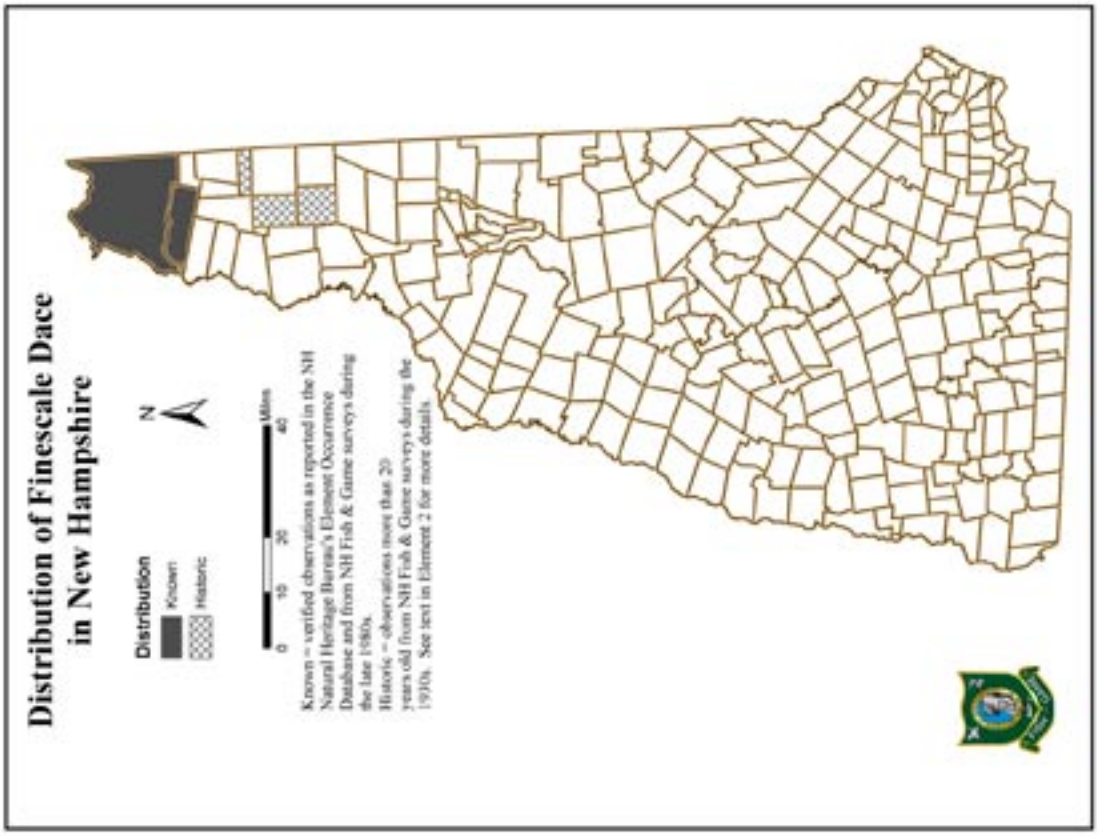

Distribution of Banded Sunfish
in New Hampshire
Distribution
Known
Historic
N
0
10
20
40
Miles
Known = verified observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and from NH Fish & Game surveys during the late 1980s.
Historic = observations more than 20 years old from NH Fish & Game surveys during the 1930s. See text in Element 2 for more details.

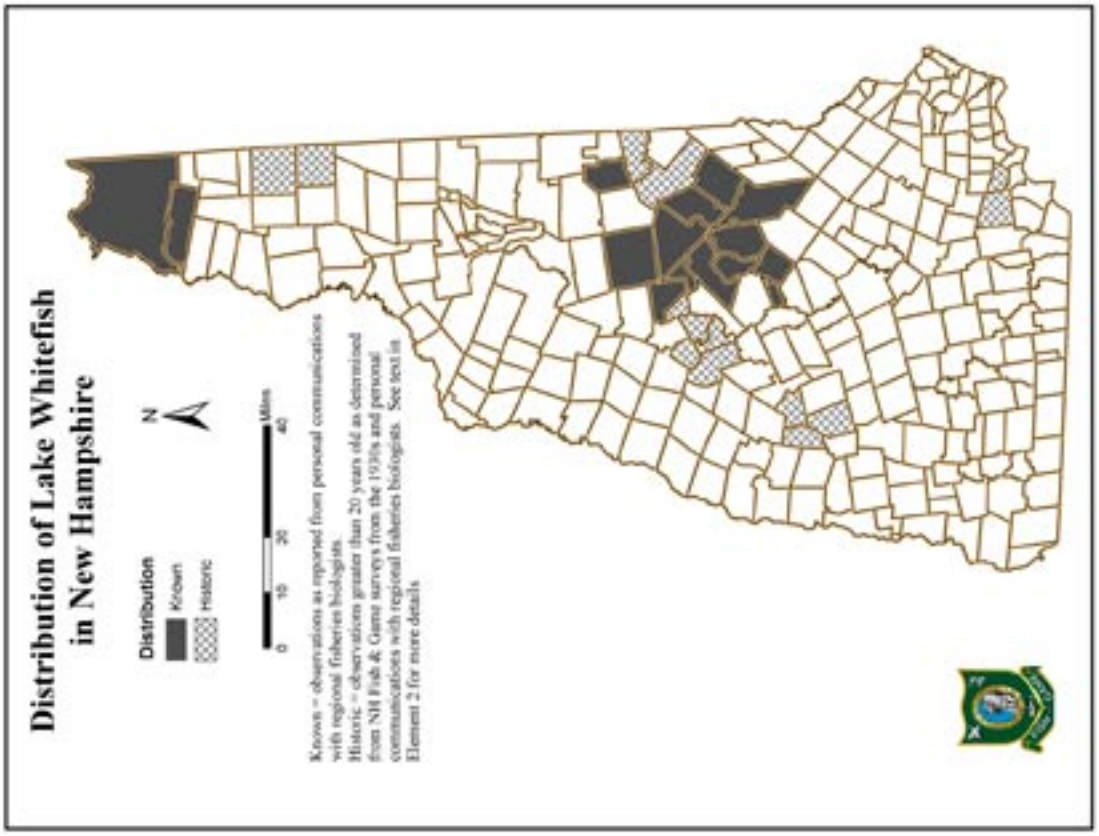

Distribution of Bridle Shiner
in New Hampshire
Distribution
Known
Historic
N
0
10
20
40
Miles
Known = verified observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and from NH Fish & Game surveys during the late 1980s.
Historic = observations more than 20 years old from NH Fish & Game surveys during the 1930s. See text in Element 2 for more details.

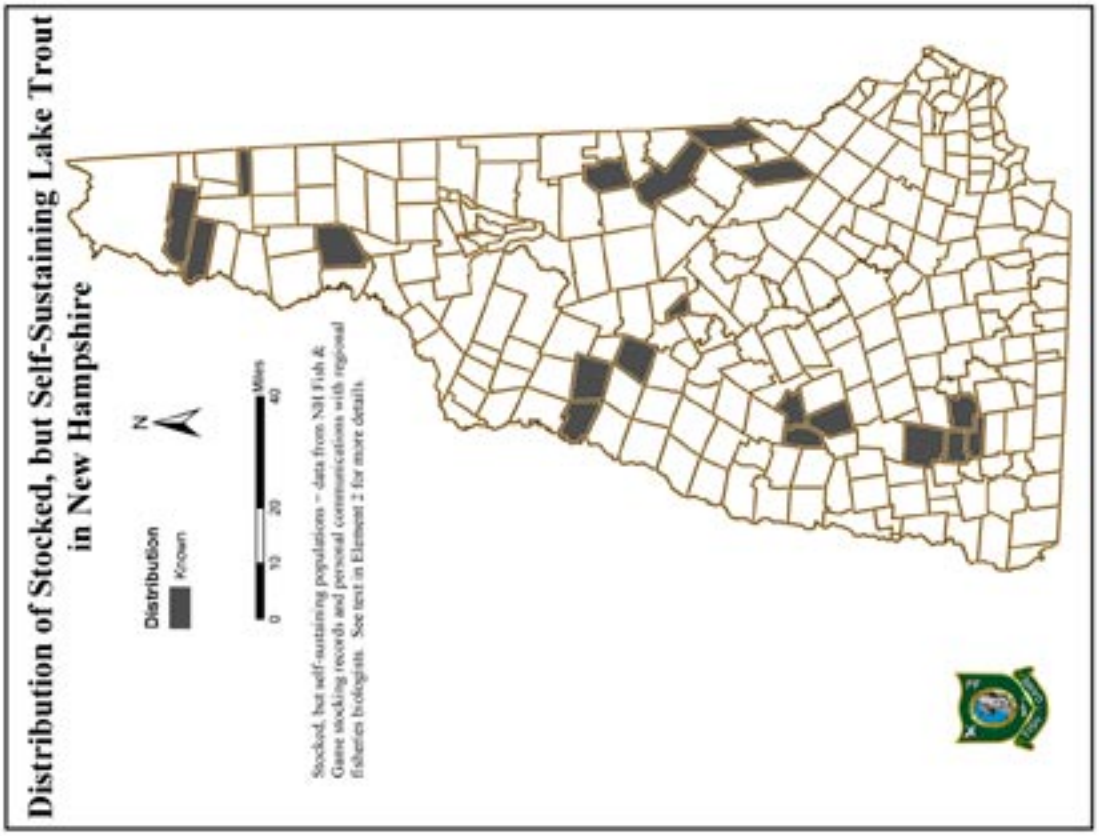

Distribution of Burbot
in New Hampshire
Distribution
Known
Historic
N
0 10 20 40
Miles
Known = verified observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and from NH Fish & Game surveys during the late 1980s.
Historic = observations more than 20 years old from NH Fish & Game surveys during the 1930s. See text in Element 2 for more details.


Distribution of American Brook Lamprey
in New Hampshire
Distribution
Known
Historic
N
0 10 20 40
Miles
Known = verified observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and from NH Fish & Game surveys during the late 1980s.
Historic = observations more than 20 years old from NH Fish & Game surveys during the 1930s. See text in Element 2 for more details.

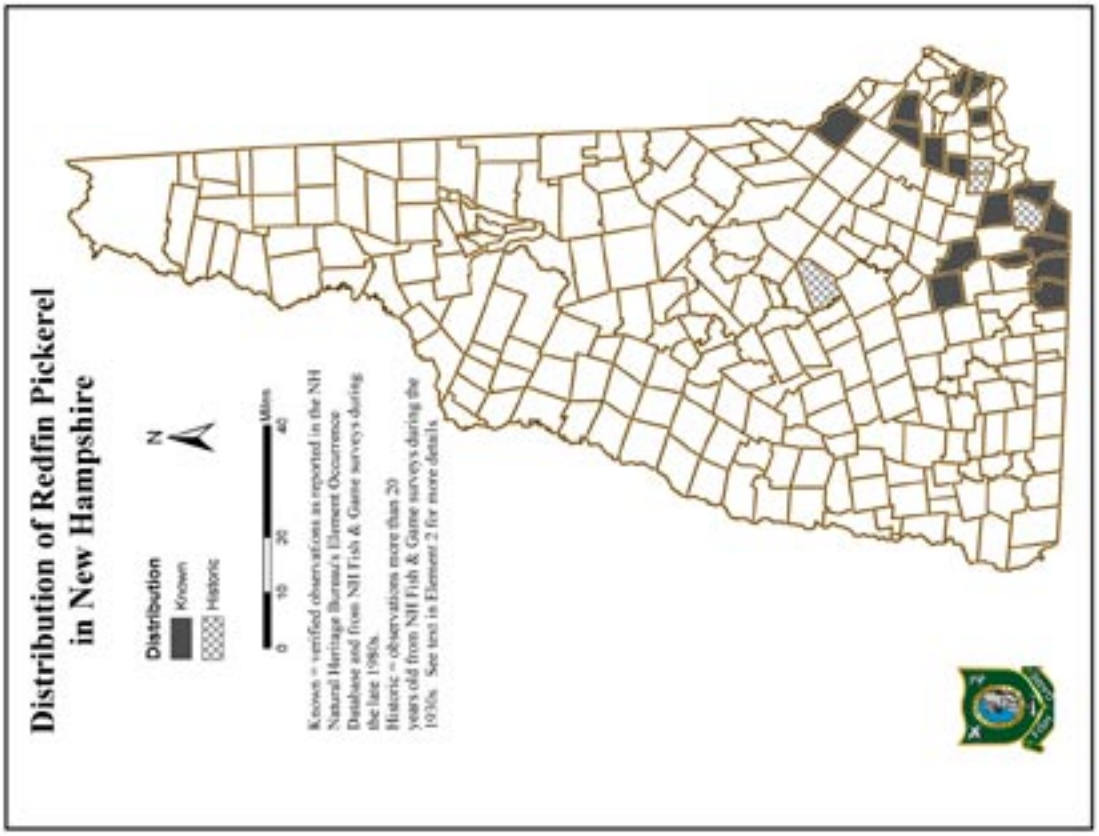

Distribution of Native Lake Trout in New Hampshire
Distribution
Known
N
0 10 20 40
Miles
Native populations = verified observations as reported in NH Fish & Game surveys from the 1930s. Knowledge that these towns still support native populations comes from personal communications with regional fisheries biologists. See text in Element 2 for more details.

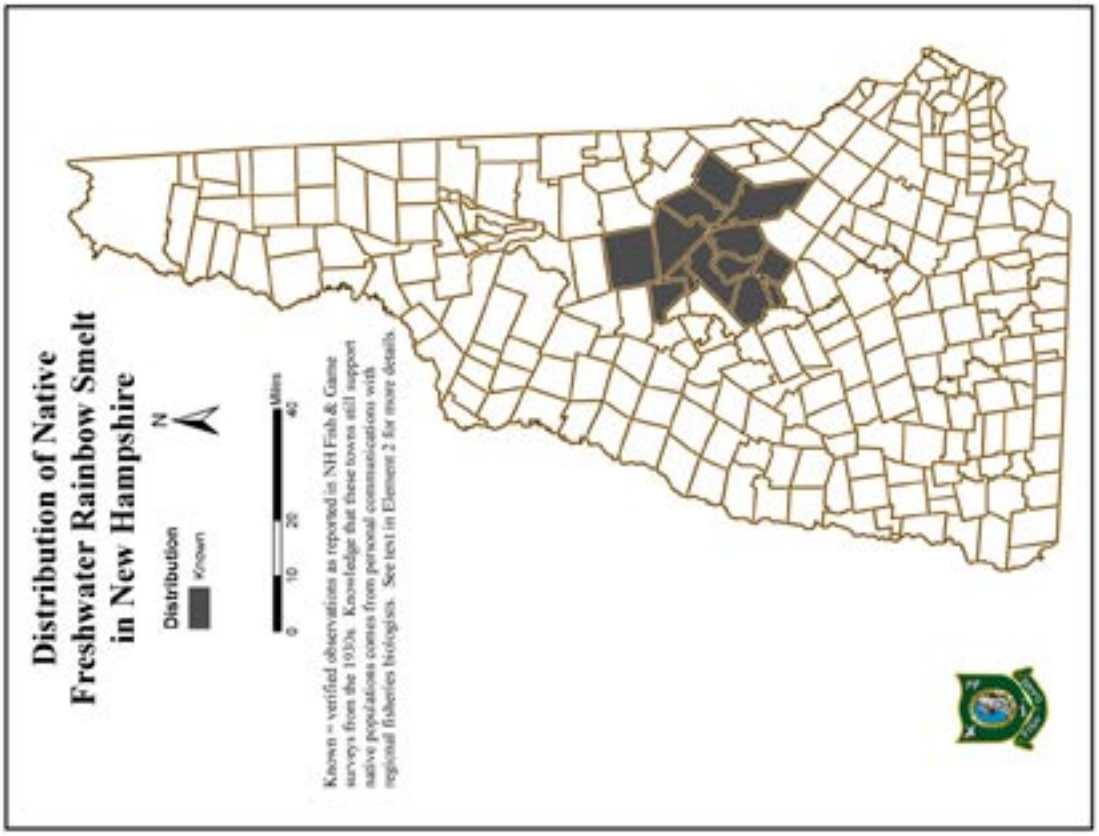

Distribution of Finescale Dace in New Hampshire
Distribution
Known
Historic
N
0 10 20 40
Miles
Known = verified observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and from NH Fish & Game surveys during the late 1980s.
Historic = observations more than 20 years old from NH Fish & Game surveys during the 1930s. See text in Element 2 for more details.


Distribution of Lake Whitefish in New Hampshire
Distribution
Known
Historic
N
0 10 20 40
Miles
Known = observations as reported from personal communications with regional fisheries biologists.
Historic = observations greater than 20 years old as determined from NH Fish & Game surveys from the 1930s and personal communications with regional fisheries biologists. See text in Element 2 for more details.

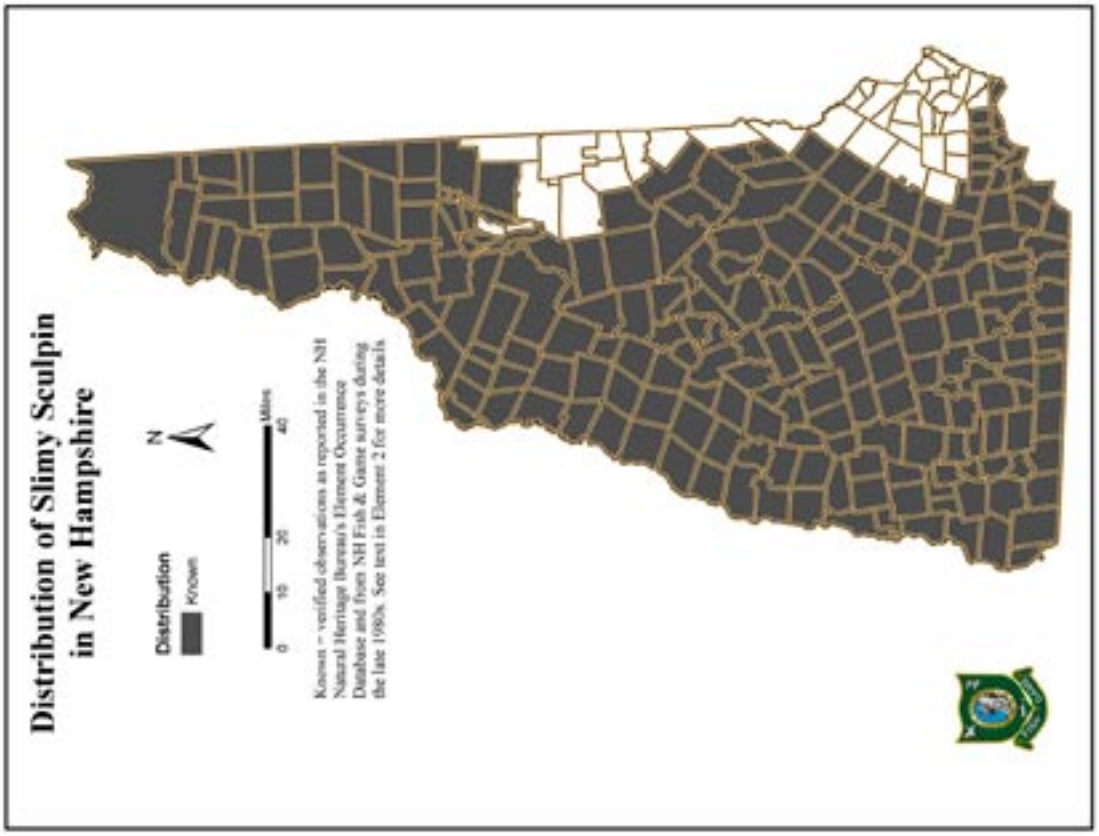

Distribution of Stocked, but Self-Sustaining Lake Trout in New Hampshire
Distribution
Known
N
0 10 20 40
Miles
Stocked, but self-sustaining populations = data from NH Fish & Game stocking records and personal communications with regional fisheries biologists. See text in Element 2 for more details.

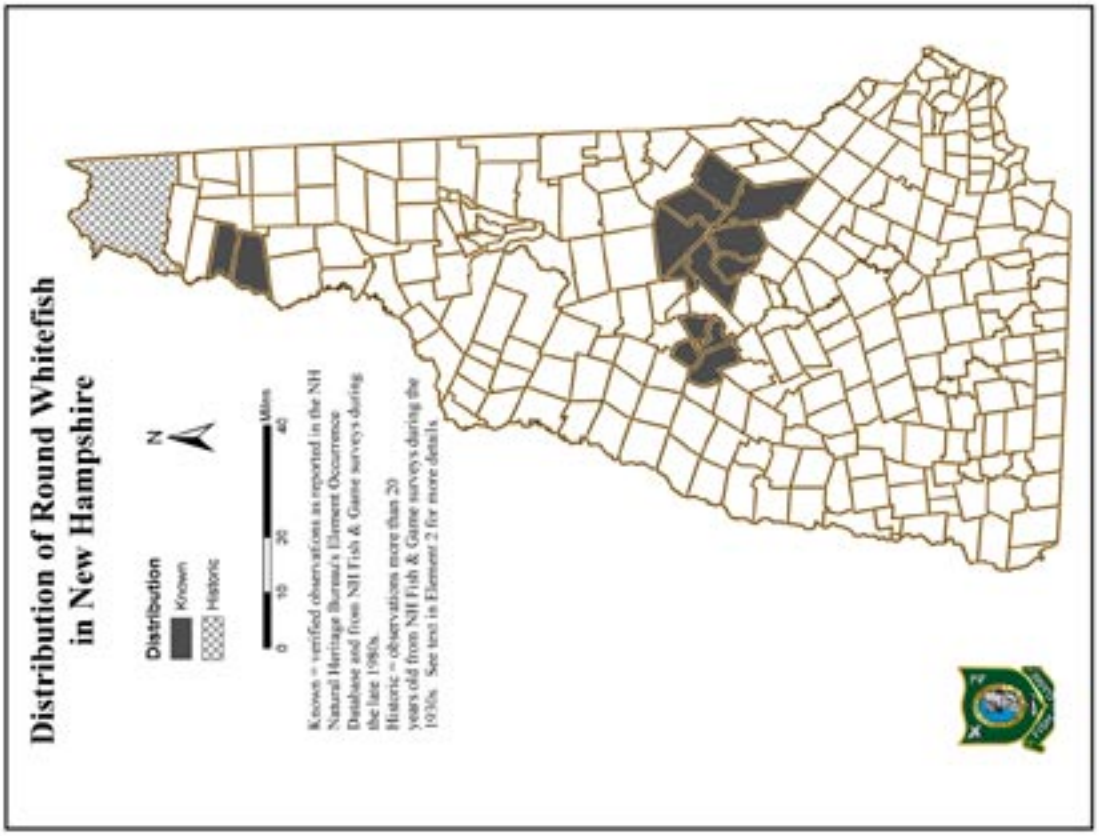
Distribution of Northern Redbelly Dace
in New Hampshire
Distribution
Known
Historic
N
0
10
20
40
Miles
Known = verified observations as reported in the NH
Natural Heritage Bureau's Element Occurrence
Database and from NH Fish & Game surveys during
the late 1980s.
Historic = observations more than 20
years old from NH Fish & Game surveys during the
1930s. See text in Element 2 for more details

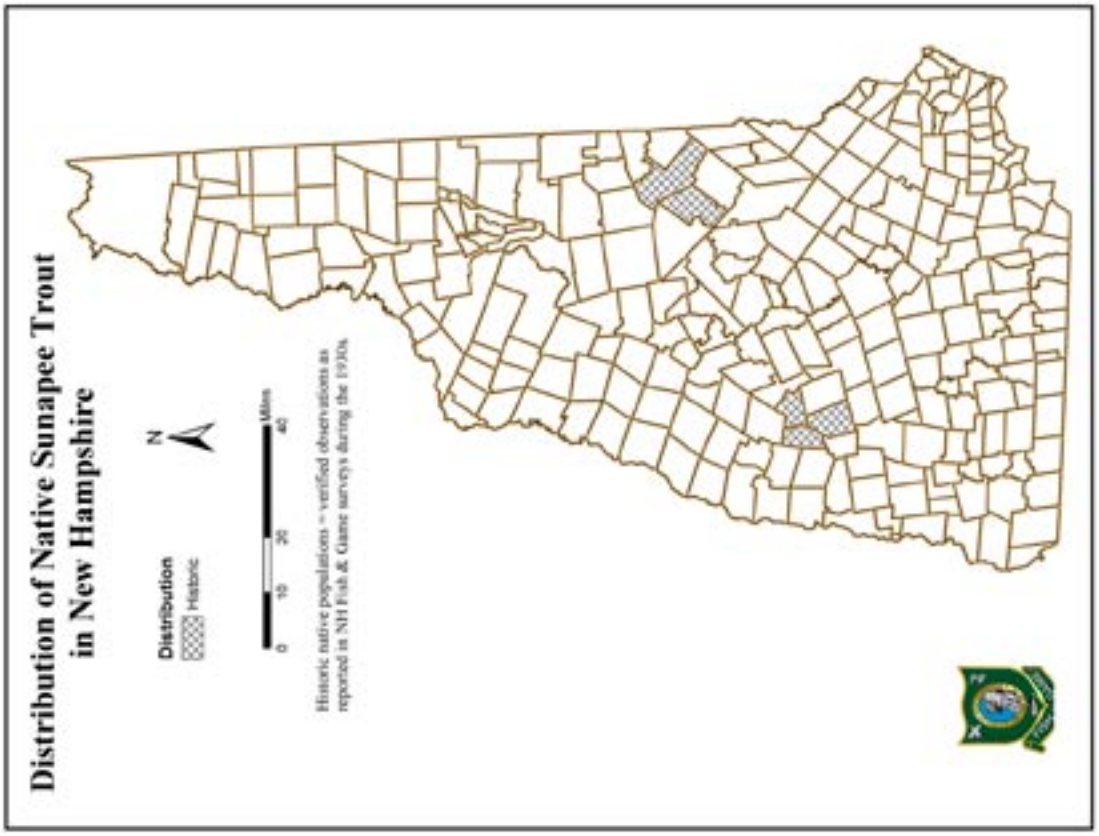

Distribution of Redfin Pickerel
in New Hampshire
Distribution
Known
Historic
N
0
10
20
40
Miles
Known = verified observations as reported in the NH
Natural Heritage Bureau's Element Occurrence
Database and from NH Fish & Game surveys during
the late 1980s.
Historic = observations more than 20
years old from NH Fish & Game surveys during the
1930s. See text in Element 2 for more details

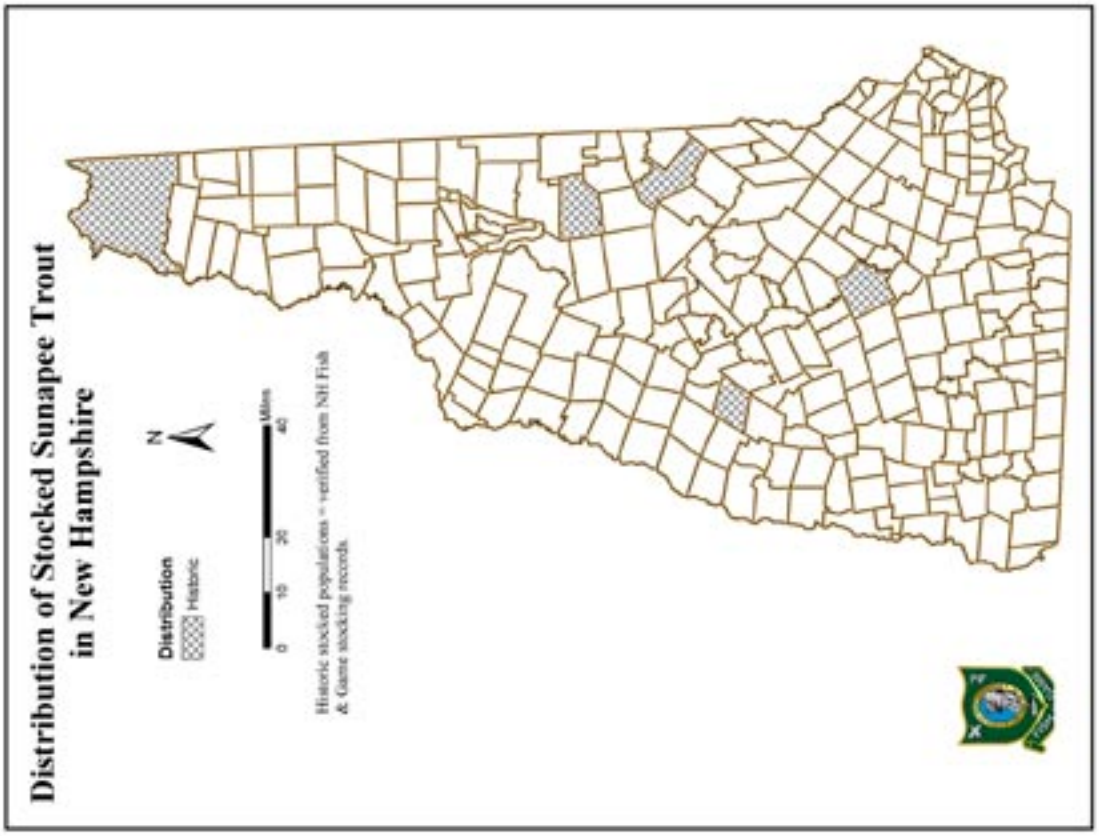

Distribution of Native
Freshwater Rainbow Smelt
in New Hampshire
Distribution
Known
N
0 10 20 40
Miles
Known = verified observations as reported in NH Fish & Game surveys from the 1930s. Knowledge that these towns still support native populations comes from personal communications with regional fisheries biologists. See text in Element 2 for more details.

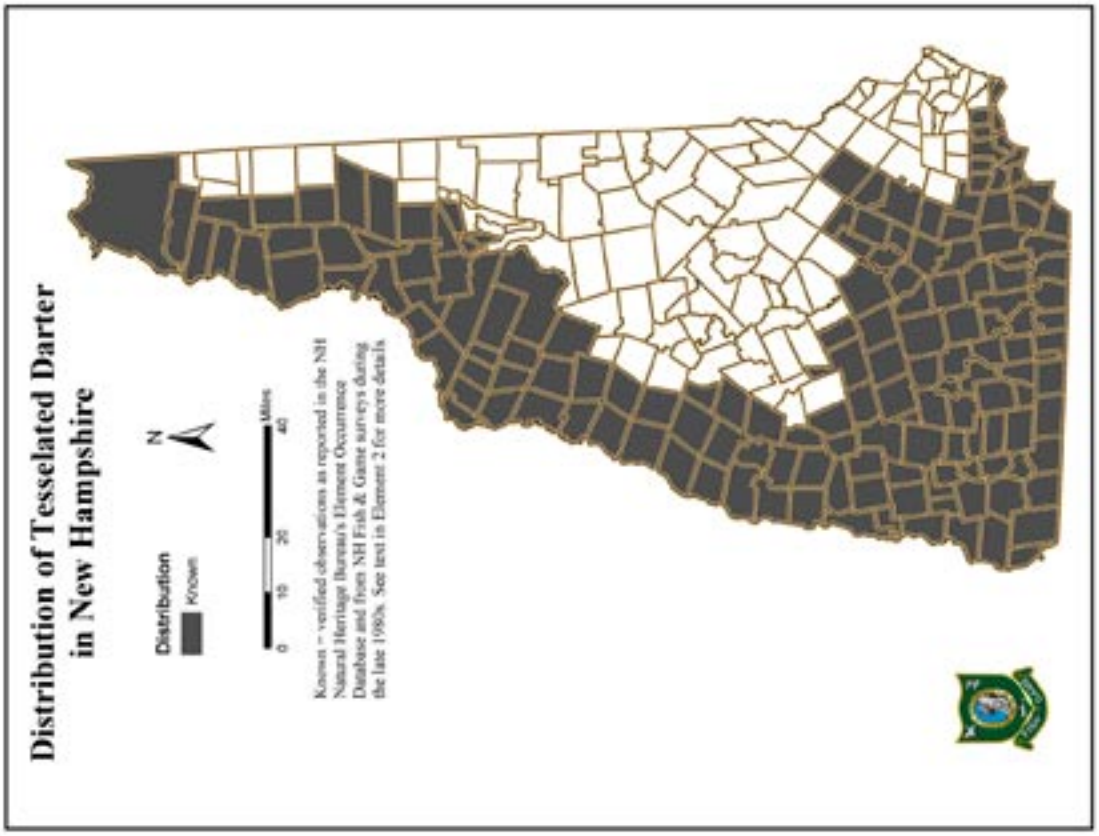
Distribution of Stocked, but Self Sustaining
Freshwater Rainbow Smelt
in New Hampshire
Distribution
Known
N
0 10 20 40
Miles
Stocked, but self-sustaining populations = data from NH Fish & Game stocking records and personal communications with regional fisheries biologists. See text in Element 2 for more details.

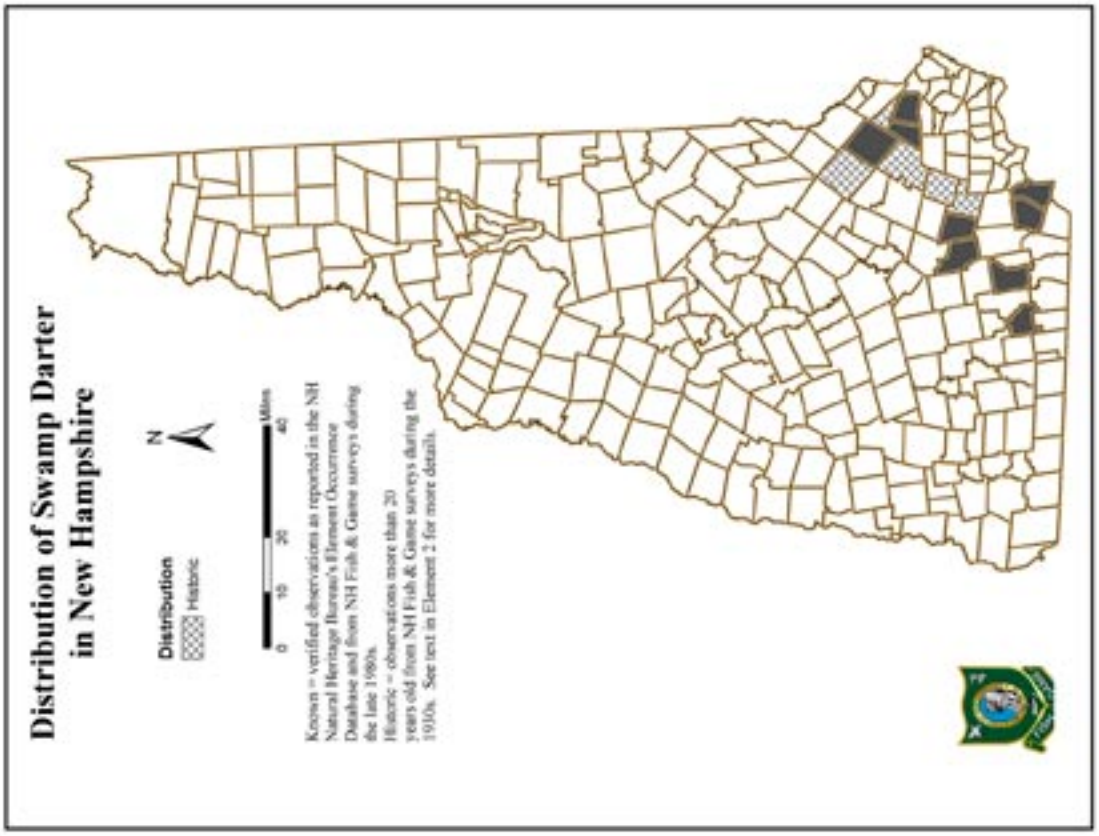

Distribution of Slimy Sculpin
in New Hampshire
Distribution
Known
N
0
10
20
40
Miles
Known = verified observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and from NH Fish & Game surveys during the late 1980s. See text in Element 2 for more details


Distribution of Round Whitefish
in New Hampshire
Distribution
Known
Historic
N
0
10
20
40
Miles
Known = verified observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and from NH Fish & Game surveys during the late 1980s.
Historic = observations more than 20 years old from NH Fish & Game surveys during the 1930s. See text in Element 2 for more details


Distribution of Native Sunapee Trout in New Hampshire
Distribution
Historic
N
0 10 20 40 Miles
Historic native populations = verified observations as reported in NH Fish & Game surveys during the 1930s.


Distribution of Stocked Sunapee Trout in New Hampshire
Distribution
Historic
N
0 10 20 40 Miles
Historic stocked populations = verified from NH Fish & Game stocking records.


Distribution of Tesselated Darter
in New Hampshire
Distribution
Known
N
0
10
20
40
Miles
Known = verified observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and from NH Fish & Game surveys during the late 1980s. See text in Element 2 for more details.


Distribution of Swamp Darter
in New Hampshire
Distribution
Historic
N
0
10
20
40
Miles
Known = verified observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and from NH Fish & Game surveys during the late 1980s.
Historic = observations more than 20 years old from NH Fish & Game surveys during the 1930s. See text in Element 2 for more details.

APPENDIX A

Species Profiles

Part One: Invertebrates

Barrens Itame (Lepidoptera).....A-3
Barrens Xylotype (Lepidoptera).....A-5
Brook Floater (Mollusca).....A-7
Broad-lined Catopyrrha (Lepidoptera).....A-15
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Cora Moth (Lepidoptera).....A-24
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SPECIES PROFILE

Barrens Itame

Itame sp. 1

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G3G4
State Rank: S1S2
Author: NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The Barrens itame occupies pine barrens (NatureServe 2005), particularly those areas that have been recently burned (Mello 1998). This species also occurs in Appalachian oak-pine woodlands composed of a dense scrub oak understory and greater canopy closure (NatureServe 2005). Larval host plants have not yet been documented, though captive specimens have been reared using scrub oak (Wagner et al. 2003), and various heath species (Ericaceae) are plausible food items (USAF 2002, Mello 1998). For a detailed habitat description refer to the pine barrens habitat profile.

1.2 Justification

The Barrens itame, along with other pine barren specialists, serves as an indicator of ecological condition. In the absence of disturbance or management, Barrens itame populations decline and become increasingly vulnerable to extirpation. Declines are likely a reflection of the loss of the vital compositional and structural elements of pine barrens (e.g., scrub oak understory) with increasing canopy closure.

1.3 Protection and Regulatory Status

NHNHB (2005) identified the Barrens itame as an important sprecies, but it is currently not protected.

1.4 Population and Habitat Distribution

The range of the Barrens itame extends from Maine to Virginia, and west to New York and Pennsylvania. Most occurrences are in high quality pine barrens of New Jersey. Barrens itame are believed to be more widespread in the Cape Cod and Islands region of Massachusetts, and probably on Long Island, New York (NatureServe 2005). In New Hampshire, specimens were collected in 1985 and 1995 at the West Branch Pine Barrens Reserve in Tamworth. For details regarding habitat distribution, see pine barrens habitat profile.

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

See pine barrens habitat profile

1.7 Sources of Information

Technical field reports, agency data, scientific journal articles, and element occurrence databases were used to determine habitat and distribution of the Barrens itame.

1.8 Extent and Quality of Data

The quality and extent of the data for the Barrens itame in New Hampshire are limited to the recorded sightings in Tamworth. Other areas where pine barrens occur in New Hampshire have not been surveyed for the Barrens itame.

1.9 Distribution Research

Additional surveys should be conducted to determine distribution, habitat requirements, and life

history traits of the Barrens itame. Current populations should be monitored for trends, while new sites containing key habitat elements should be surveyed for new occurrence data.

Elements 2-4

See the Karner blue butterfly profile and pine barrens profile

Element 5: References

5.1 Literature

United States Air Force (USAF). 2002. Threatened and Endangered Species and Fire Management at the Cape Cod Airforce Station, Massachusetts.

Wagner, D.L., M.W. Nelson, D.F. Schweitzer. 2003. Shrubland Lepidoptera of southern New England and southeastern New York: ecology, conservation, and management. Forest Ecology and Management 185:95-112.

5.2 Data Sources

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. Accessed 2005 March 30.

New Hampshire Natural Heritage Bureau. 2005. Database of rare species and exemplary natural community occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

SPECIES PROFILE

Barrens Xylotype

Xylotype capax

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G4
State Rank: S2
Author: NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The barrens xylotype in New Hampshire occupies pitch pine-scrub oak woodland (NatureServe 2005), an early-successional community dominated by pitch pine (*Pinus rigida*) and scrub oak (*Quercus ilicifolia*) (Sperduto and Nichols 2004). Larval host plants of the barrens xylotype include blueberry (*Vaccinium sp*.), cherry (*Prunus sp*.), crabapple (*Malus sp*.) and red oak (*Quercus rubra*) (Covell 1984). The flight period is August though November, with a peak in October. For a detailed habitat description, refer to the pine barrens habitat profile.

1.2 Justification

The barrens xylotype, along with other pitch pine-scrub oak woodland specialists, serves as an indicator of ecological condition. In the absence of disturbance or management, barrens xylotype populations decline and become increasingly vulnerable to extirpation. Declines likely reflect the loss of the vital compositional and structural elements (e.g., heath and stratum *Prunus* spp.) in pitch pine scrub-oak woodlands with increasing canopy closure.

1.3 Protection and Regulatory Status

NHNHB (2005) identified the barrens xylotype as an important species, but it is currently not protected.

1.4 Population and Habitat Distribution:

The barrens xylotype range includes southern Maine to Maryland, west to Manitoba and southeastern Kentucky (Colvell 1984). Distribution is spotty in the north and greater in the south (McCabe 1995). It is uncommon to rare inland and in the Northeast (Wagner 2000). In New Hampshire, the barrens xylotype has been recorded at 4 sites, including the Concord Pine Barrens in Concord (1991, 2000), the West Branch of the Ossipee Pine Barrens in Madison (1985), the Hookset Riverbluff Barrens (1985), and in the town of Milford (1875) (VanLuven 1994, Chandler 2000).

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

See Karner blue butterfly species profile and the pine barrens habitat profile.

1.7 Sources of Information

Technical field reports, agency data, scientific journal articles, and element occurrence databases were used to determine the barrens xylotype habitat and distribution.

1.8 Extent and Quality of Data

Lepidopteron surveys conducted at the Concord Pine Barrens have recorded this species. Other areas where pitch pine-scrub oak woodlands habitat occurs in New Hampshire have not been surveyed for the barrens xylotype.

1.9 Distribution Research

Additional surveys should be conducted in known and potential sites to determine distribution, habitat requirements, and life history traits of the barrens xylotype. Current populations should be monitored for trends, and new sites containing key habitat elements should be surveyed.

Elements 2-4

See the Karner blue butterfly profile and the pine barrens profile

Element 5: References

5.1 Literature

Chandler, D.S. 2002. New Hampshire Army National Guard butterfly and moth survey, 2001 final report. University of New Hampshire. Durham, New Hampshire, USA.

Covell, C.V., Jr. 1984. Peterson Field Guides: Eastern Moths. Houghton Mifflin Company, New York, New York, USA.

McCabe, T.L. 1995. The changing insect fauna of Albany's pine barrens. In: Our living resources: a report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. E.T. LaRoe, G.S. Farris, C.E. Puckett, P.D. Doran, and M.J. Mac, editors. U.S. Department of the Interior, National Biological Service, Washington, D.C.

VanLuven, D.E. 1994. Site Conservation Plan for the Concord Pine Barrens, Concord, New Hampshire. The Nature Conservancy, Concord, New Hampshire, USA.

Wagner, D.L. 2000. The Macrolepidoptera Fauna of Mount Everett, Massachusetts. The Nature Conservancy, Boston, Massachusetts, USA.

5.2 Data Sources

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. Accessed 2005 March 30.

New Hampshire Natural Heritage Bureau. 2005. Database of rare species and exemplary natural community occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

SPECIES PROFILE

Brook Floater

Alasmidonta varicosa

Federal Listing: Not Listed
State Listing: Endangered
Global Rank: G3
State Rank: S1
Author: Barry J. Wicklow, Department of Biology, Saint Anselm College

Element 1: Distribution and habitat

1.1 Habitat Description

Brook floaters are strictly riverine species inhabiting small streams to large rivers with high to moderate flows. They are absent in scour-prone areas of high gradient streams and avoid high velocity flow channels. Although they show no consistent substrate preference (Strayer and Ralley 1993), brook floaters in New Hampshire are often found in gravel and in sand among larger cobble in riffles, along shaded banks, and, in higher gradient streams, in sandy flow refuges behind large boulders (S. von Oettingen, USFWS, personal communication, B. Wicklow, Saint Anselm College, personal observation). They are found most often in nutrient-poor streams with low calcium levels (Strayer 1993). Mussels are suspension feeders, subsisting on phytoplankton, bacteria, fine particulate matter, and dissolved organic matter (Strayer 2004).

As in other unionid mussels, brook floaters' life cycle is complex and parasitic. Spawning occurs in summer as sperm are released into the water column, where they are drawn into the inhalent aperture of the female and into the outermost demibranchs of the gills, which function as marsupia. There the eggs are fertilized and develop and mature into larvae called glochidia. Brook floaters are long-term brooders. In New Hampshire, glochidia are held through the winter until release, which begins in mid-April and continues through May (B. Wicklow, Saint Anselm College, unpublished data). Glochidia must attach to a host fish in order to complete development and disperse.

The brook floater is a host generalist. Glochidia are capable of transforming on a variety of host fish species: longnose dace, *Rhinicthys cataractae*, blacknose dace, *Rhinicthys atratulus*, golden shiner, *Notemigonas chrysoleucas*, pumpkinseed sunfish, *Lepomis gibbosus*, yellow perch, *Perca flavescens*, tessellated darter, *Etheostoma olmstedi*, mad tom, *Noturus insignis*, and sculpin, *Cottus cognatus* (Wicklow and Wicklow, Saint Anselm College, unpublished data). Gravid female brook floaters release glochidia in loose masses that drift downstream. Transformation of encysted glochidia takes 3 to 4 weeks at 15^0 C. Upon release, juveniles burrow immediately into the substrate (Wicklow and Wicklow, Saint Anselm College, unpublished data).

1.2 Justification

Freshwater mussels are the most imperiled fauna in North America, having suffered steep declines in diversity, abundance, and distribution within the last 200 years (Richter et al. 1997, Lydeard et al. 2004). In the genus *Alasmidonta* 9 of 13 species are threatened, endangered, or extinct (Williams et al. 1992). The brook floater was a federal candidate species for listing under the Endangered Species Act until the candidate category was removed by congress in 1995. An Atlantic slope species, the brook floater once ranged from Nova Scotia to South Carolina and was widespread throughout much of its range. Populations have since declined sharply and in many states are considered rare or are extirpated. Many populations are small, have low densities, and show little or no evidence of recruitment. Brook floaters have declined in much of the south and are critically

imperiled in New Hampshire, Connecticut, Massachusetts, Maryland, and Virginia and are presumed extirpated in Rhode Island and Delaware.

The range has contracted in New York, although a robust population still exists in the Neversink River (Strayer 1997, Strayer and Ralley 1991). It has disappeared from many other New York locations including the Housatonic and Passaic basin and has declined severely in the Susquehanna basin (Strayer 1997, Strayer and Fetterman 1999, O'Brien, New York Department of Environmental Conservation, personal communication). It occurs in fewer than 12 streams in Connecticut (Nedeau 2002). It is threatened in Vermont, where it is restricted to the West River (Fichtel and Smith 1995) and in Maine is a species of special concern, occurring in most rivers that historically supported Atlantic salmon (Nedeau et al. 2000). Human activity has jeopardized populations through riparian disturbance, pollution, sedimentation, dams, impoundments, and artificial flow regimes. Stream fragmentation disrupts mussel life cycles, prevents host fish migration, blocks gene flow, and prohibits re-colonization resulting in reduced recruitment rates, decreased population densities, and increased probability of local extinctions (Neves et al. 1997, Watters 1999, Strayer et al. 2004).

1.3 Protection and Regulatory Status

- Fill and Dredge in Wetlands; New Hampshire Department of Environmental Services (NHDES, RSA 482-A)- requires applicant to obtain a permit to fill or dredge jurisdictional wetland habitats, including the banks of rivers and streams.
- The Shoreland Protection Act (NHDES, RSA 483-B) limits the amount of tree removal and other activities within 250 ft of major rivers and requires a primary structure setback of at least 50 ft.
- New Hampshire Endangered Species Conservation Act (RSA 212-A)- state endangered.
- Rivers Management and Protection Program; NHDES (RSA 438) designates rivers in New Hampshire for protection of cultural or natural resources and stipulates the following: no channel alteration activities shall be allowed in rivers designated as "natural;" no dams will be built on rivers designated as natural, rural or rural community rivers; a protected instream flow level shall be established for each designated river; no motorized watercraft are allowed on designated natural rivers; within 15.24 m (50ft) of a stream, 50% of basal area of trees cannot be cut. For fourth order streams and higher this extends to within 45.72 m (150 ft).
- Local regulations and zoning varies considerably.

1.4 Population and habitat distribution

Brook floaters require clean well-oxygenated streams with moderate to high flows. In New Hampshire, brook floaters occur in the Connecticut and Merrimack Rivers and in coastal watersheds. Over 70 % of reported populations have less than 30 individuals. Stream fragmentation resulting from dams, causeways, impoundments, channelization, and inhospitable stream segments results in spatially and genetically disjunct populations. Many populations have densities that put them in jeopardy of extirpation from stochastic demographic, genetic, or environmental events. Brook floaters in New Hampshire have very small linear ranges making them especially vulnerable to human impacts.

Only one state population occurs within the Connecticut River Watershed: the North Branch of the Sugar River (Cutko 1993). Several populations are found within the Merrimack River Watershed: the Blackwater, Piscataquog, Suncook, Soucook Rivers and in Merrimack River main stem (Cutko 1993, Gabriel 1995, NHNHB 1996, Wicklow, Saint Anselm College, unpublished data). Brook floaters exist in very low numbers or have been extirpated from the Nissitissit River in Hollis, Golden Brook in Windham, and Beaver Brook in Pelham where a population was first reported by Athearn and Clarke in 1952 (Clarke 1981, Gabriel 1995). In the coastal drainage, brook floater populations are in danger of extirpation. They appear to be gone from the Exeter River and are scattered in very low numbers in the Lamprey River (Cutko 1993, Albright 1994, Gabriel 1996, Wicklow, Saint Anselm college, unpublished data).

1.5 Town Distribution Map

A map is provided

1.6 Habitat Map

Not completed for this species

1.7 Sources of Information

Information on the life history, habitat, and distribution of brook floaters was obtained from the scientific literature, unpublished reports, databases, expert consultation, and unpublished research results.

1.8 Extent and Quality of Data

Most information on brook floater populations is qualitative and was acquired in the mid-1990s or earlier. Early surveys efforts employed Catch Per Unit Effort (CPUE) methods, and while helpful in determining presence of absence, these methods are not statistically valid and therefore cannot be reliably used to determine population changes or trends. In 1996, Wicklow began a 10-year quantitative study of the brook floater population in the main stem of the Piscataquog River in Goffstown. The population was monitored in 1996, 1997, 1999, 2004, and will be monitored again in 2005 and 2006 (Wicklow, Saint Anselm College, unpublished).

1.9 Distribution Research

Locations last visited in 1993 or 1995 need to be resurveyed to determine if brook floaters still exist. Sites in each of the three watersheds should be monitored. Priority sites for quantitative monitoring include: 1) the Lamprey River in Lee from Wadleigh Falls to Wiswall Dam, 2) the Blackwater River in Webster at the Webster Elementary School and Snyders Mills sites, 3) the Piscataquog River in Goffstown at the Henry Bridge site, 4) the Soucook river in Loudon, 5) the Suncook River in Epson, 6) the Merrimack River at Sewalls Falls, and 7) the North Branch of the Sugar River in Croyden. Surveys are needed in the Connecticut River Watershed, where the North Branch population is the only known occurrence.

All sites should be resurveyed for presence. Quantitative, statistically valid monitoring of the largest populations is needed.

Element 2: Species/ habitat condition

2.1 Scale

Brook floaters are present in three major river basins. Dams and inhospitable river reaches – current or historic – have fragmented larger populations, which now exist in small patches that are spatially and genetically isolated. Flood stage shear stress and substrate stability may limit he distribution of brook floaters within the scale of the river reach, less than1 kilometer (Layzer and Madison 1995, Strayer 1999, Hastie et al. 2001). Other potential influences are water depth and temperatures during low water periods.

2.2 Relative health of populations

Based on evidence of recruitment and abundance observed during CPUE surveys in 1993 and 1995, the Blackwater, Suncook, Soucook, and the North Branch Sugar River populations appear the most robust. Nevertheless the North Branch Sugar River population is small and insular and therefore at risk of harm from pollution and habitat degradation. Mussel populations end abruptly at the North Branch and Sugar River confluence where water quality is low (von Oettingen, USFWS, personal communication). Long-term monitoring of the Piscataquog River Henry Bridge population shows a decline in mussel density from 0.4 per meter squared in 1996 to 0.02 in 1999 (Wicklow, Saint Anselm College, unpublished data). A mussel bed on the South Branch of the Piscataquog River, monitored periodically since 1993, has been nearly extirpated. The coastal watershed populations are at high risk of extirpation.

2.3 Population management status

Mussel relocation during bank stabilization and bridge replacement projects requires wetland permits. A river restoration project upstream of a brook floater subpopulation is in progress on the Piscataquog River.

2.4 Habitat patch protection status

Very little habitat information exists. Most brook floater populations have not been assessed in over 10 years and ecological attributes have not been measured. Although brook floaters are capable of using a wide range of host fish, research on glochidial infestation of fish in natural populations has not been conducted. Research is needed to determine population size, density, and recruitment, and to assess water quality.

2.5 Habitat patch protection status

Little habitat protection exists for brook floater populations, though local and state organizations are beginning to address conservation.

2.6 Habitat management status

There is little management of brook floater habitat. However, the Lamprey River, designed as a Wild and Scenic River, was surveyed for brook floaters in 1993, 1994, and 1996 (Cutko 1993, Hibright 1994, Gabriel 1996).

2.7 Sources of information

Distribution data were obtained from the New Hampshire Natural Heritage Bureau Element Occurrence Database, unpublished reports, scientific literature, and consultation with experts.

2.8 Extent and quality of data

Nearly all the information on the condition of brook floater populations and habitat is qualitative and is based on CPUE methods. Needed are quantitative studies to assess habitat attributes such as sediment type and hydraulics, particularly shear, and water quality. Also needed are data on brook floater population structure, age class distribution, sex ratio, recruitment, growth rates, and dispersal, as well as distribution and abundance data on host fish. Studies that examine the effects of predation and competition are also important.

2.9 Condition ranking

To be provided by NHFG

2.10 Condition Assessment Research

Research is needed to determine the effects of extreme fluctuating artificial flow regimes displacement of juveniles and glochidia, interference of spawning success, glochidial release patterns, and glochidia-host fish attachment success. Also important are DNA studies to determine the genetic consequences of stream fragmentation on dwarf wedgemussel (King 1999). Mark-recapture techniques should be used to estimate survival, recruitment, and population growth of brook floaters (Villella et al. 2004). In addition, the possibility of relocating mussels to rehabilitated habitats should be investigated.

Element 3: threat assessment

3.1.1 Altered Natural Hydrology

(A) Exposure pathway

The conversion of free-flowing rivers to highly regulated rivers has seriously affected freshwater mussels (Locke et al. 2003, Watters 1996, Watters 1999). Barriers cause direct mortality, prevent dispersal, block gene flow, prohibit re-colonization of rehabilitated habitat, and prevent host fish migration (Layzer et al. 1993, Parmalee and Hughes 1993, Vaughn and Taylor 1999, Watters 1996).

Cycles of extreme episodic flooding and dewatering use cause direct adult mortality by scouring. Extreme fluctuations in flow disrupt mussels by exposing glochidia and juveniles to flood-induced damage, mortality, or displacement to unfavorable habitat downstream (Layzer et al. 1993, Layzer and Madison 1995, Hardison and Layzer 2000). Dewatering exposes mussels to heat, desiccation, and opportunistic predators. Predator foraging efficiency increases with decreasing depth.

(B) Evidence

Dams have separated brook floater populations in every river system they inhabit. Barriers decrease the size of linear ranges. Isolated mussel populations are more susceptible to pollution and habitat degradation (Strayer et al. 1996).

In 1999, Wicklow showed a correlation between presence of glochidia and high flow releases from the Surry Mountain Dam on the Ashuelot River (Wicklow, Saint Anselm College, unpublished data). During a period of low water in 1997, 163 brook floaters in a population downstream from the Gregg Falls Hydroelectric Dam on the Piscataquog River were lost to predation (Wicklow, Saint Anselm College, unpublished data).

In addition, over 100 dwarf wedgemussel valves were collected from muskrat middens in a 15-meter segment of the Ashuelot River during a period of extremely low water (von Oettingen, USFWS and Wicklow, Saint Anselm College, unpublished).

3.1.2 Non-point Source Pollution

(A) Exposure pathway
Runoff from municipalities, industrial waste, sewage outfalls, golf courses, and poorly managed agricultural and silvicultural land contributes to water quality degradation, increasing sedimentation and organic pollution. As development increases, impervious surfaces increase the volume and velocity of runoff, causing erosion, sedimentation, and high levels of toxins in rivers and streams. Riparian vegetation is critical in retarding these effects.

Mussels are sensitive to heavy metals introduced through runoff and atmospheric deposition, as well as to toxins, such as chlorine and ammonia (Naimo 1995, Augsburger et al. 2003). Glochidia and juveniles are most sensitive to pollutants. Because juveniles and adults burrow into and feed within the sediments, oxygen-poor and toxin-rich sediment may be a major pathway for contamination (Newton et al. 2003, Poole and Downing 2004).

(B) Evidence
The effect of acute pollution on freshwater mussels is well documented (Neves et al. 1997). The most widely reported sources of pollution are poor land use practices (Neves et al. 1997, Poole and Downing 2004)). For example, hundreds of mussel species were killed, including federal and state listed species, by waste runoff from a small farm in the Connecticut River Watershed (USFWS 2002). Chemical and agricultural waste spills also cause direct mussel mortality, though the effect of sediment toxicity is not well understood. However, recent toxicity tests for total residual chlorine showed that juvenile mussels are more sensitive to toxins than glochidia (Cherry et al. 2005).

3.2 Sources of Information

Information was gathered from the scientific literature, reports, consultation with experts and personal research.

3.3 Extent and quality of data

Threats to freshwater mussels and their habitats are well documented. The synergistic and long-term effect of chronic stresses on freshwater mussels is not known.

3.4 Threat assessment research

New surveys of brook floater populations are needed in order to assess and monitor threats. The North Branch of the Sugar River population is small and isolated and therefore may be strongly divergent compared with other New Hampshire populations. Funds for sequencing microsatellite DNA to determine the phylogenetic relationships of New Hampshire brook floater populations should be pursued. Mitochondrial DNA of brook floaters from the Piscataquog River has already been sequenced (King, USGS, unpublished data). Further research is needed to elucidate the life history of brook floaters, to determine the effects of hydraulics on glochidia and juveniles, and to assess glochidial infestation of host fish. Current USFWS toxicity testing of glochidia and juvenile mussels should continue (Cherry et al. 2005). Additional long-term monitoring sites should be established in each of the three watersheds where brook floaters occur and should include geomorphic, hydrologic, and water quality assessments. Relocation strategies need to be investigated.

Element 4: Conservation Actions

4.1.1 Restoration and management

(A) Stream fragmentation, altered flow regimes, pollution, riparian disturbance

(B) Justification
1. Stream fragmentation, and attendant gene flow restrictions, will be reduced by removing barriers such as nonfunctional dams, where feasible, by operating dams at "run of the river" flow regimes, and by rehabilitating degraded river reaches. These measures will increase dispersal and re-colonization of brook floaters into rehabilitated river reaches. Pollution may render stream reaches uninhabitable. Destruction and transformation of riparian corridors accelerates erosion, bank sloughing, and runoff leading to increased levels of stream toxins, sediment, and higher stream temperatures.
2. Dispersal increases the potential for persistence of species in patchy, unstable habitats such as rivers and streams. As mussels are established in new habitat, linear range, re-colonization, and population size increase. Protection of riparian corridors

through fee simple land acquisition, conservation easements, and private landowner cooperation will reduce pollution runoff and sedimentation.
3. Initially, action will focus within the river reach, less than 1 kilometer, and later expand to include the entire river.
4. Brook floater populations and habitats must be assessed prior to implementation. Mussels found below a dam removal site or rehabilitated river reach may appear within 3 to 5 years, but 10 to 20 years or more may be necessary to establish a viable population. Riparian protection and restoration will be a long-term effort.
5. As additional water quality and habitat assessment information is collected, efforts can be redirected or expanded.

(C) Conservation Performance Objective
The performance indicator is the presence of brook floaters downstream of former barriers. The number of reproducing subpopulations of brook floaters will indicate the success of the program. The performance indicator for protected or restored riparian corridors will be determined after population and habitat assessment.

(D) Performance Monitoring
Surveys of brook floater populations are needed. Surveys in subsequent years are intended to first detect mussels. Then, as populations enlarge, mussel sites should be monitored using quantitative, statistically valid methods. Water quality monitoring stations upstream of brook floater populations must be established.

(E) Ecological response objective
The habitat restoration response objective is to increase size and density of brook floater subpopulations. Decades may be needed to achieve the desired ecological response. Monitoring should indicate water quality improvement within 5 to 10 years. Additional survey and monitoring data are needed before response objectives can be quantified.

(F) Response monitoring
The initial response will be monitored with qualitative surveying. As mussel populations increase in size, quantitative methods will be used (Strayer and Smith 2003).

(G) Implementation
Surveys are needed to choose long-term, quantitative monitoring sites in the Blackwater, Lamprey, Suncook, Soucook, Merrimack Rivers, and the North Branch of the Sugar River. Long-term monitoring should continue in the Piscataquog River. A cooperative effort involving the NHFG and local conservation organizations is needed in order to develop site-specific conservation plans.

(H) Feasibility
Conservation partnerships have successfully restored river reaches and have protected open space that provides wildlife habitat and enhances water quality. Funding limits the success of these initiatives.

4.2 Conservation action research

Additional surveys, monitoring, and research are necessary in order to assess the efficacy of conservation action research.

Element 5: References

Albright, J. 1994. De novo inventory and baseline monitoring for Alasmidonta varicosa, Lamprey River, Epping and Lee Townships, New Hampshire. Unpublished report to the New Hampshire Heritage Program and New Hampshire Department of Fish and Game.

Augspurger, T., A.E. Keller, M.C. Black, W.G. Cope, and W.G. Cope. 2003. Water quality guidance for protection of freshwater mussels (Unionidae) from Ammonia exposure. Environmental Toxicology and Chemistry. 22:2569-2575.

Cherry, D. S., T. W. Valenti, R. J. Currie, R. J. Never, J. W. Jones, R. A. Mair, and C. M. Kane. 2005. Chlorine toxicity to early life stages of freshwater mussels. Report submitted to U. S. Fish and Wildlife Service, Virginia Field Office, Gloucester, Virginia.

Clarke, A.H. 1981. The Tribe Alasmidontini (Unionidae: Anodontinae), Part 1: *Pegias*, *Alasmidonta*, and *Arcidens*. Smithsonian Institution Press, Washington.

Cutko, A. 1993. Inventory and monitoring of the brook floater (Alasmidonta varicosa) in New Hampshire. Unpublished report from New Hampshire Heritage Program and the Nature Conservancy to

United Fish and Wildlife Service. 8 pp.

Downing, J.A. Y. Rochon, M. Perusse, H. Harvey. 1993. Spatial aggregation, body size, and reproductive success in the fresh-water mussel *Elliptio complanta*. Journal of the North American Benthological Society. 12:148-156.

Fichtel, C. and D.G. Smith . 1995. The freshwater mussels of Vermont. Vermont Fish and Wildlife Department Technical Report 18. Leahy Press, Montpelier, VT. 54 p.

Gabriel, M. 1995. Freshwater mussel distribution in the rivers and streams of Cheshire, Hillsborough, Merrimack and Rockingham counties, New Hampshire. Unpublished report to New Hampshire Department of Fish and Game.

Gabriel, M. 1996. 1996 Inventory and monitoring for the Brook Floater (*Alasmidonta varicosa*) in the Lamprey River, New Hampshire. New Hampshire Natural Heritage Program, Concord, New Hampshire.

Hardison, B.S., J.B. Layzer. 2000. Relations between complex hydraulics and the localized distribution of mussels in three regulated hydraulics and the localized distribution of mussels in three regulated rivers. Regulated Rivers: Research and Management.

Hastie, L.C., P.J. Boon, M.R. Young, S. Way. 2001. The effects of a major food on an endangered freshwater mussel population. Biological Conservation. 98:107-115.

King, T.L., M.S. Eackles, B. Gjetvaj, W.R. Hoeh. 1999. Intraspecific phylogeography of *Lasmigona subviridis* (Bivalvia: Unionidae): Conservation implications of range discontinuity. Molecular Ecology. 8 (suppl.1): S65-S78.

Layzer, J.B., M.E. Gordon, and R.M. Anderson. 1993. Mussels: The forgotten fauna of regulated rivers. A case study of the Caney Fork River. Regulated Rivers: Research and Management. 8:63-71.

Layzer, J.B., L.M. Madison. 1995. Microhabitat use by freshwater mussels and recommendations for determining their instream flow needs. Regulated Rivers: Research and Management. 10:329-345.

Locke A., J.M. Hanson, G.J. Klassen, S.M. Richardson, C.I. Aube. 2003. The damming of the Petitcodiac River: Species, populations, and habitats lost. Northeastern Naturalist. 10:39-54.

Lydeard C., R.H. Cowie, W.F. Ponder, A.E. Bogan, P.Boucet, S.A. Clark, K.S. Cummings, T.J. Frest, O.Gargominy, C.G. Herbert, R. Hershler, K. E. Perez., B. Roth, M. Seddon, E.E. Strong, and F.G. Thompson. The global decline of nonmarine mollusks. 2004. Bioscience. 54:321-330.

Naimo, T.J. 1995. A review of the effects of heavy metals on freshwater mussels. Ecotoxicology. 4: 341-362.

Nedeau, E.J., M.A. McCollough, and B.I. Swartz. 2000. The freshwater mussels of Maine. Maine Department of Inland Fisheries and Wildlife, Augusta, Maine.

Nedeau, E. and J. Victoria. 2002. A field guide to the freshwater mussels of Connecticut. Connecticut Bureau of Natural Resources, Hartford, Connecticut.

Neves, R.J., A.E. Bogan, J.D. Williams, S.A. Ahlstedt, P.W. Hartfield. 1997. Status of aquatic mollusks in the southeastern United States: A downward spiral of diversity Pages 43-85 in Bens G.W., D.E. Collins, eds. Aquatic Fauna in Peril: The Southeastern Perspective. Decatur (GA): Lenz Design and Communications.

New Hampshire Natural Heritage Program. 1996. A Natural Features Survey of the Blackwater Dam Property. Review Draft. New Hampshire Natural Heritage Program. Concord, NH.

Newton, TJ., JW. Allran, J.A. O'Donnell, M.R. Bartsch, and W.B. Richardson. 2003. Effects of ammonia on juvenile unionid mussels (*Lampsilis cardium*) in laboratory sediment toxicity tests. Environmental Toxicology and Chemistry. 22:2554-2560.

Parmalee, P.W., M.H. Hughes. 1993. Freshwater mussels (Mollusca; Pelecypoda: Unionidae) of Tellico Lake: twelve years after impoundment of the Little Tennessee River. Annals of the Carnegie Museum. 62:81-93.

Poole, K.E., J.A. Downing. 2004. Relationship of declining mussel biodiversity to stream-reach and watershed characteristics in an agricultural landscape. Journal of the North American

Benthological Society. 23:114-125.

Richter, B.D., D.P. Braun, J.A. Mendelson, L.L. Master. 1997. Threats to imperiled freshwater fauna. Conservation Biology. 11:1081-1093.

Strayer, D.L. 1999. Use of flow refuges by unionid mussels in rivers. Journal of the North American Benthological Society. 18:468-476.

Strayer, D.L., J. Ralley. 1993. Microhabitat use by

an assemblage of stream-dwelling unionaceans (Bivalvia), including two rare species of *Alasmidona*. Journal of the North American Benthological Society. 12:247-258

Strayer, D.L., S.J. Sprague, S. Claypool. 1996. A range-wide assessment of populations of *Alasmidonta heterodon*, an endangered freshwater mussel (Bivalvia: Unionidae). Journal of the North American Benthological Society. 15:308-317.

Strayer, D.L and K.J. Jirka. 1997. The Pearly Mussels of New York State. The New York State Education Department. Albany, New York.

Strayer, D.L. and A.R. Fetterman. 1999. Changes in the distribution of freshwater mussels (Unionidae) in the Upper Susquehanna River Basin, 1955-1965 to 1996-1997. American Midland Naturlist. 142: 328-339.

Strayer, D. L., D. R. Smith. 2003. A guide to sampling freshwater mussel populations. American Fisheries Society. Monograph 8, Bethesda, Maryland.

Strayer, D.L., J.A. Downing, W.R. Haag, T.L. King, J.B. Layzer, T.J. Newton, S.J. Nichols. 2004. Changing Perspectives on Pearly Mussels, North America's Most Imperiled Animals. BioScience. 54: 429-439.

Vaughn, C., C.M. Taylor. 1999. Impoundments and the decline of freshwater mussels: a case study of an extinction gradient. Conservation Biology. 13: 912-920.

Villella, R.F., D.R. Smith, D.P. Lemaire. 2004. Estimating survival and recruitment in a freshwater mussel population using mark-recapture techniques. American Midland Naturalist. 151: 114-133.

Watters G.T. 1996. Small dams as barriers to freshwater mussels (Bivalvia, Unionoida) and their hosts. Biological Conservation. 75:79-85.

Watters, T. 1999. Freshwater mussels and water quality: A review of the effects of hydrologic and instream habitat alterations. Proceedings of the First Freshwater Mollusk Conservation Society Symposium, 1999. Ohio Biological Survey, Columbus Ohio. Page 261-274.

Wicklow, B.J. 2000. The correlation of physical factors on larval release patterns of the endangered dwarf wedgemussel, *Alasmidonta heterodon* (Unionidae, Bivalvia) in the Ashuelot River, New Hampshire. Report submitted the Silvio O. Conte National Fish and Wildlife Refuge, Turners Falls, MA., 16pp.

Williams, J.D., M.L. Warren, Jr., K.S. Cummings, J.H. Harris, R.J. Neves. 1992. Conservation Status of Freshwater Mussels of the United States and Canada. American Fisheries Society. 18:6-22.

SPECIES PROFILE

Broad-lined Catopyrrha

Erastria coloraria

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G4
State Rank: S1
Author: NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Broad-lined catopyrrha in New Hampshire occupies pitch pine-scrub oak woodlands (NatureServe 2005), which are early-successional communities dominated by pitch pine (*Pinus rigida*) and scrub oak (*Quercus ilicifolia*) (Sperduto and Nichols 2004). The primary larval host plant of *E. coloraria* is New Jersey tea (*Ceanothus americanus*), which is necessary for the presence of this species, but other possible food sources include clover (*Trifolium* sp.) and brambles (*Rubus* sp.) (Covell 1984). *E. coloraria* has two broods during the spring and summer, with flight periods occurring from late May to mid-June and mid-July to early August (VanLuven 1994). For a detailed habitat description refer to the pitch pine-scrub oak woodland community profile.

1.2 Justification

E. coloraria, along with other pitch pine-scrub oak woodland specialists, serves as an indicator of ecological condition. In the absence of disturbance or management, *E. coloraria* populations decline and become increasingly vulnerable to extirpation. Declines are likely a reflection of the loss of the vital compositional and structural elements (e.g., heath stratum and nitrogen-fixing plants) that are lost in pitch pine scrub-oak woodlands with increasing canopy closure.

1.3 Protection and Regulatory Status

NHNHB (2005) has identified the *E. coloraria* as a species of very high importance, but it is currently not protected.

1.4 Population and Habitat Distribution

The range for *E. coloraria* extends from Connecticut in the north to Florida in the south, and west to Minnesota and Texas (Colvell 1984). In New Hampshire, a single occurrence of *E. coloraria* has been documented in Concord (1976), although, this species is presently considered extirpated from the state (Schweitzer 1983).

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

See Karner blue butterfly and Pine Barrens profiles

1.7 Sources of Information

Technical field reports, agency data, scientific journal articles, and element occurrence databases were used to determine *E. coloraria* habitat and distribution.

1.8 Extent and Quality of Data

Lepidoptera surveys conducted at the Concord Pine Barrens have not generated any *E. coloraria* specimens. Other areas where pitch pine-scrub oak woodland habitat occurs have not been surveyed for *E. coloraria*.

1.9 Distribution Research

Additional surveys should be conducted in known and potential sites to determine distribution, habitat requirements, and life history traits of *E. coloraria*. Current populations should be monitored for trends, and new sites containing key habitat elements should be surveyed for new occurrence data.

Elements 2-4

See the Karner Blue Butterfly and Pine Barrens profiles

Element 5: References

5.1 Literature

Covell, C.V. Jr. 1984. Peterson Field Guides: Eastern Moths. Houghton Mifflin Company, New York, New York, USA.

Helmbolt, K., and M. Amaral. 1994. Status of the Karner blue butterfly in New Hampshire. Pages 123-128 in D.A. Andow, R.J. Baker, and C.P. Lane, eds. Karner blue butterfly: a symbol of a vanishing landscape. Minnesota Agricultural Experiment Station. St. Paul, Minnesota, USA.

Schweitzer, D.F. 1983. Rare Lepidoptera of the Concord, N.H. pine barrens with suggestions for a potential preserve. The Nature Conservancy, Boston, Massachusetts, USA.

VanLuven, D.E. 1994. Site Conservation Plan for the Concord Pine Barrens, Concord, New Hampshire. The Nature Conservancy, Concord, New Hampshire, USA.

5.2 Data Sources:

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. Accessed 2005 March 30.

New Hampshire Natural Heritage Bureau. 2005. Database of rare species and exemplary natural community occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

SPECIES PROFILE

Cobblestone Tiger Beetle

Cicindela marginipennis

Federal Listing: Category 2
State Listing: Threatened
Global Rank: G2
State Rank: S1
Author: Alina, J. Pyzikiewicz, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Cobblestone tiger beetles inhabit sandy cobble beaches on the upstream sides of islands and along the banks of free-flowing rivers (Dunn 1981, Nothnagle 1993, Leonard and Bell 1999). The upstream sides of islands are typically covered with pebbles and cobble-sized stones, while downstream ends are sandy (Leonard and Bell 1999). Vegetation is sparse at the upstream end with a moderate diversity of grasses, herbs, and forbs, and few shrubs and trees (Nothnagle 1993, Sperduto and Nichols 2004). Characteristic vegetation includes bladder campion (*Silene cucubalis*), sand cherry (*Prunus pumila*), dogbane (*Apocynum sibiricum*), blue-grasses (*Poa* spp.), bent grasses (*Agrostis* spp.), goldenrods (*Solidago* spp.), willows (*Salix* spp.), blackberries, and raspberries (*Rubus* spp.) (Nothnagle 1993, Sperduto and Nichols 2004). Riverine islands are subject to annual disturbance from frequent flooding and ice scouring in the spring, which maintains suitable habitat by eliminating encroaching vegetation from the cobbled shore (TNC 1995, Sperduto and Nichols 2004, NatureServe 2005).

Cobblestone tiger beetles concentrate in the middle of the cobbled shoreline, 20-50 m away from the water's edge (Nothnagle 1993, 1995; TNC 1995). This area is not heavily scoured or subject to heavy sedimentation and the vegetation is not dense (TNC 1995). The minimum required habitat size is approximately 0.08 ha (0.2 ac) with a sand and vegetation cover of 20-50% and cobble-sized stones ranging in diameter from 2.5-7.6 cm (1-3 in) (Nothnagle 1995). Cobblestone tiger beetles do not typically inhabit gravel or areas with large stones and boulders (Nothnagle 1995).

2.2 Justification

Because of their extremely restricted habitat, cobblestone tiger beetles are under constant threat from fluctuating water levels, dam and waterway construction, and human disturbance (TNC 1995). The 2-year larval period makes larvae particularly susceptible to long-term flooding. New Hampshire populations of cobblestone tiger beetles rarely exceed 100 individuals, which further increases the risk of local extirpation from a single event.

2.3 Protection and Regulatory Status

Cobblestone tiger beetles are protected under the New Hampshire Endangered Species Act RSA 212. The Connecticut River Protection Program states: "it is unlawful to kill or remove the beetle from its natural habitat", and the cobblestone tiger beetle is the town insect of Plainfield, New Hampshire (TNC 1995).

2.4 Population and Habitat Distribution

In 1995, there were roughly 25 populations of cobblestone tiger beetles rangewide (TNC 1995). Isolated populations occur throughout the eastern United States on the islands and banks of the Connecticut River in New Hampshire, Vermont, Connecticut, and Massachusetts, the White River in Vermont, the Cattaraugus and Upper Genesee Rivers in New York, the Delaware River in New Jersey, as well as other

large rivers in Indiana and Ohio (Dunn 1981, Nothngale 1995, TNC 1995, Leonard and Bell 1999). Cobblestone tiger beetles have been extirpated from the big rivers of Pennsylvania, West Virginia, Mississippi, and Alabama due to flooding of their habitat by dams (TNC 1995, NatureServe 2005).
In New Hampshire, populations of cobblestone tiger beetles only occur on islands in the upper valley of the Connecticut River (Dunn 1981, Dunn 1986, NHNHB 2005). These are high quality populations because of their size and minimal habitat disturbance (TNC 1995).

1.5 Town Distribution Map
A map is provided.

1.6 Habitat Map
Not completed for this species

1.7 Sources of Information

Sources of information include tiger beetle field guides, habitat and natural community guides, peer-reviewed journal articles, conservation plans, and the NatureServe database.

1.8 Extent and Quality of Data

Locations of cobblestone tiger beetles in New Hampshire have been well documented since their discovery in the 1960s (Dunn 1978, NHNHB, 2005). Habitat information is well covered in field guides and peer-reviewed journal articles, even thought these sources are 10-30 years old. Little is known about cobblestone tiger beetle movements and dispersal patterns. The larva of the cobblestone tiger beetle is not adequately described (Leonard and Bell 1999).

1.9 Distribution Research

- Resurvey known locations of cobblestone tiger beetles
- Conduct presence/absence surveys at other areas with similar habitat
- Initiate studies regarding movement, dispersal, and use of secondary habitats (e.g., sandy riverbanks)
- Monitor to detect long-term changes and patterns of abundance

Element 2: Species/Habitat Condition

2.1 Scale
Not applicable for this species

2.2 Relative Health of Populations

Cobblestone tiger beetles have been documented on Burnaps and Hart Islands in Plainfield, Chase Island in Cornish, Johnston Island in Lebanon, and Walpole Island in Walpole (TNC 1995, NHNHB 2005). They were first discovered in New Hampshire in the 1960s, but the exact location is unknown due to poor documentation (Dunn 1981). An attempt to locate this site was made in 1977 and several populations were found on islands near Plainfield, Walpole, and Cornish (Dunn 1981). Surveys in 1983 and 1993 indicate small but stable populations of cobblestone tiger beetles (Nothnagle 1993). Johnston and Burnaps Islands had the fewest cobblestone tiger beetles (10 and 7, respectively), whereas Walpole and Chase Island had the most (58 and 26, respectively) (Nothnagle 1993).

2.3 Population Management Status

Population management has not been documented and is not being conducted because of the uncertain distribution of cobblestone tiger beetles in New Hampshire and because of insufficient and dated information.

2.4 Relative Quality of Habitat Patches

Cobblestone tiger beetles are restricted to the open, cobbled, and sparsely vegetated areas of river islands. The upstream sections of Burnaps, Chase, Hart, Johnston, and Walpole Islands all provide suitable habitat for cobblestone tiger beetles. The lower sections of these islands support well-established floodplain forests, which do not provide adequate habitat due to heavy sedimentation and dense vegetation cover (TNC 1995). Appropriate habitats for cobblestone tiger beetles south of Walpole Island in the Connecticut River in Massachusetts and Connecticut, as well as in feeder streams, have not been surveyed (Nothnagle 1993).

2.5 Habitat Patch Protection Status

All islands that support cobblestone tiger beetles are protected under the state Endangered Species Act. The Connecticut River was designated as an American Heritage River in 1999. The Silvio O. Conte National Wildlife Refuge Act (1991) and the Rivers Management and Protection Act (RSA 483) protect the Connecticut River. Burnaps Island is owned by the town of Plainfield. Chase Island is a wildlife management area owned by NHFG where hunting and trapping of small game is permitted. Hart Island is privately owned and can be susceptible to timber removal and development. Johnston and Walpole Islands are owned by an unknown agency of the State of New Hampshire (TNC 1995).

2.6 Habitat Management Status

None of the islands that support cobblestone tiger beetles are actively managed because of the uncertain distribution of cobblestone tiger beetles in New Hampshire and because of insufficient and dated information.

2.7 Sources of Information

Sources of information include the NHNHB Element Occurrence Database, conservation plans, and field surveys and reports.

2.8 Extent and Quality of Data

Current population estimates of cobblestone tiger beetles do not exist. The last known survey was conducted in 1993 (Nothnagle 1993). Habitat quality has not been assessed since 1995 (TNC 1995).

2.9 Condition Assessment Research

Survey cobblestone tiger beetles to estimate current population sizes. Survey beach microhabitats, including substrate structure, composition, and physiology of known and potential sites to update habitat suitability. Identify factors limiting cobblestone tiger beetle populations. Evaluate feeder streams and unsurveyed islands and beaches.

Element 3: Species and Habitat Threat Assessment

3.1.1 Altered Hydrology (River Flow Management)

(A) Exposure Pathway
Dams pose a threat to cobblestone tiger beetles by fluctuating water levels to a greater extent than natural flooding during spring melts and after heavy summer rains (Nothnagle 1993, TNC 1995). Upstream from islands that support cobblestone tiger beetles, the Wilder Dam has the capacity to raise and lower the water levels of the Connecticut River over a meter in the course of a day during the summer. This fluctuation increases high water duration and inundates the soils, potentially affecting the survival of cobblestone tiger beetle larvae and adults (Nothnagle 1993).

In addition, the Connecticut River has the greatest number of riverine ice jams in New Hampshire (USACE, Cold Region Research and Engineering Laboratory Ice Jam Database 2005). Eliminating or reducing seasonal ice-scouring on the upstream portions of islands that support cobblestone tiger beetles would create unsuitable habitat by allowing late-stage successional plants to encroach on the sparsely vegetated cobble substrates (Nothnagle 1993, TNC 1995).

(B) Evidence
Populations of cobblestone tiger beetles have become extirpated in Mississippi, West Virginia, and Pennsylvania due to flooding by dams (TNC 1995, NatureServe 2005). Populations in New Hampshire were under threat when 2 hydroelectric projects were proposed in the mid 1980s (TNC 1995). The Department of the Interior did not approve these projects because the dams would interrupt Atlantic salmon (*Salmo salar*) migration, inundate one of the last free-flowing stretches the Connecticut River and 150 acres of farmland, and impact rare plants and animals that use this stretch of river, including cobblestone tiger beetles (TNC 1995).

The United States Army Corps of Engineers, Cold Region Research and Engineering Laboratory considered ways to prevent ice damage to the Cornish-Windsor covered bridge, a historical landmark (TNC 1995). Their conclusion was to break up the ice and move it slowly downstream by increasing the

flow rate of water from the upstream Wilder Dam from 19 to 840 m^3/sec (700 to 30,000 ft^3/sec) (TNC 1995). This project was discontinued because the dam could not accommodate the high flow rate and the water fluctuations in the reservoir would be well over the federal regulation of 5 feet (TNC 1995). By adopting this action, the flow regime would have degraded cobblestone beetle habitat by altering the structure and vegetation of the islands.

3.1.2 Recreation

(A) Exposure Pathway
Canoeists, campers, and off-highway recreational vehicle users can crush cobblestone tiger beetle larvae and burrows and destroy their habitat.

(B) Evidence
In studies of other rare tiger beetle species, populations were small to nonexistent in areas of heavy recreation and larger in areas where recreation was limited and vehicles were prohibited (USFWS 1990). All islands that support cobblestone tiger beetles are subject to stopovers by canoeists, but Hart Island is the only island that is accessible to off-highway recreational vehicles during periods of low water levels (TNC 1995). Although the impacts of these vehicles on cobblestone tiger beetles have not been studied, recreational vehicles have been observed on Hart Island and USFWS personnel from the Vermont Field Office have erected barriers around this island to discourage recreational vehicle use (USFWS field trip report, unpublished data).

3.1.3 Introduced Species

(A) Exposure Pathway
Non-native vegetation can displace native vegetation, including rare plant species, which degrade the habitat of cobblestone tiger beetles.

(B) Evidence
Several non-native plant species are found on the islands that support cobblestone tiger beetles, including Japanese knotweed (*Polygonum cuspidatum*), leafy spurge (*Euphorbia esula*), and purple loosestrife (*Lythrum salicaria*). These species have begun to displace native vegetation in the sparsely vegetated areas used by cobblestone tiger beetles (Nothnagle 1993, TNC 1995).

3.2 Sources of Information

Sources of information include conservation plans, technical reports, field surveys, and tiger beetle recovery plans.

3.3 Extent and Quality of Data

Since cobblestone tiger beetle populations are so small and restricted, accurate threat information is limited, although potential threats are well documented. The effects of an altered hydrologic regime in New England are poorly documented.

3.4 Threat Assessment Research

- Monitor recreation and its impacts on cobblestone tiger beetle populations, particularly during the summer.
- Monitor water level and flow rate fluctuations caused by the Wilder and Bellows Falls Dams and their effects on cobblestone tiger beetle habitats and populations.

Element 4: Conservation Actions

4.1.1 Promote Education and Knowledge of Cobblestone Tiger Beetle Distribution and Habitat, Education and Outreach

(A) Direct Threats Affected
Recreational Disturbance

(B) Justification
1) The idea of an endangered or threatened insect is unfamiliar to many people. Educating the public about the islands that support cobblestone tiger beetles will raise the awareness needed to maintain one of the best populations.
2) Educating the public to avoid certain areas in the Connecticut River will allow established populations of cobblestone tiger beetles to increase and potentially colonize other suitable habitats.
3) Educational programs and materials will be targeted toward conservation groups and recreational users.
4) Education and outreach materials do not exist for the cobblestone tiger beetle, except for life history fact sheets. It is imperative that materials

be developed now to prevent this species from becoming extirpated.

5) As new locations of cobblestone tiger beetles are discovered and data are collected, education and outreach materials will be updated and restricted access areas will be posted at canoe launches and campgrounds.

(C) Conservation Performance Objective
Increase awareness of cobblestone tiger beetles and their habitats. Reduce or prohibit recreational use of islands and other potential habitats. Assemble a volunteer base for monitoring recreation and cobblestone tiger beetles at these sites.

(D) Performance Monitoring
Observe recreation to show a decrease in activity or avoidance of islands and other potential cobblestone tiger beetle habitat.

(E) Ecological Response Objective
Increase populations of cobblestone tiger beetles on islands where there is recreational disturbance.

(F) Response Monitoring
Monitor known and potential cobblestone tiger beetle habitats for increases in population sizes and productivity due to access restrictions at those sites.

(G) Implementation
Develop and post interpretive signs about the presence of cobblestone tiger beetles and their ecology on islands and at campsites and canoe launches along the Connecticut River. Post signs at popular launches and campsites to restrict canoeists, campers, and recreational vehicles during critical periods of cobblestone tiger beetle development. Partner with the Vermont Fish and Wildlife Department to develop public presentations and materials about cobblestone tiger beetles. Work with conservation organizations and land trust groups (e.g., Upper Valley Land Trust, Connecticut River Watershed Council, Connecticut River Joint Commissions) to include information about cobblestone tiger beetles in their public events and newsletters. Engage the Upper Valley Land Trust Easement Volunteers to monitor cobblestone tiger beetle habitats. Update the wildlife and natural resources sections of management plans for the Connecticut River (e.g., Connecticut River Corridor Management Plan, Silvio O. Conte National Fish & Wildlife Refuge Action Plan and Environmental Impact Statement, Instream Flow Uses, Values and Policies in the Upper Connecticut River Watershed) by including information on cobblestone tiger beetles and their habitats.

(H) Feasibility
The NHFG is limited in the staff and funding needed to develop and implement a cobblestone tiger beetle education and outreach strategy. Contact with Connecticut River conservation groups and land trusts regarding assistance in cobblestone tiger beetle education and outreach has not been made.

4.1.2 Inclusion of the Cobblestone Tiger Beetle in Water Flow Policies, Regulation and Policy

(A) Direct Threats Affected
Flooding of Habitat, critical

(B) Justification

1) When developing recommendations for water flow policies, include considerations for cobblestone tiger beetles so that flow regimes will not cause inundation of islands for extensive periods.
2) Prevent extended flooding of cobblestone tiger beetle habitats so that larvae can complete their life cycle, thereby increasing populations.
3) Cobblestone tiger beetle habitats are downstream from two dams on the Connecticut River and are in the direct path of alterations to the hydrologic regime.
4) In New Hampshire, cobblestone tiger beetles coexist with hydropower and fluctuating water levels. Instream flow policies will not change until there are proposed changes in dam operations that could affect cobblestone tiger beetle habitats.
5) As dam operations change, new policies for water flow will be developed and implemented.

(C) Conservation Performance Objective
Enforce current regulations on flow rates from upstream dams to protect downstream cobblestone tiger beetle habitats from becoming inundated by high water levels.

(D) Performance Monitoring

Monitor water levels of the Connecticut River in areas near known and potential cobblestone tiger beetle habitats.

(E) Ecological Response Objective
Prevent known and potential tiger beetle habitats from becoming inundated by increased water levels as a result of increased water flows from upstream dams.

(F) Response Monitoring
Monitor cobblestone tiger beetle habitats for increases in population sizes and productivity and monitor potential habitats for colonizations that result from regulated flow rates from upstream dams.

(G) Implementation
Review current instream policies and determine how cobblestone tiger beetles are being affected. Develop guidelines for instream flow that would benefit cobblestone tiger beetles. If they pose no threat to cobblestone tiger beetles, support the recommendations of the Connecticut River Corridor Management Plan and the Connecticut River Joint Commissions for instream flow uses, values, and policies for the upper Connecticut River watershed. Coordinate with Vermont to develop flow management policies for the Connecticut River that will benefit cobblestone tiger beetles. Assist the New Hampshire Department of Environmental Services by incorporating considerations for cobblestone tiger beetles in their instream flow rule. Review potential projects on the Connecticut River that might alter the hydrologic regime and negatively affect cobblestone tiger beetles.

(H) Feasibility
The NHFG is limited in the amount of knowledge regarding flow rates to develop recommendations. Contacts that might provide assistance have not been identified.

4.2 Conservation Action Research

The effects of proposed actions are unclear because adequate population estimates of cobblestone tiger beetles are lacking. Surveys of cobblestone tiger beetles have not been conducted in New Hampshire since 1993. It is imperative that known and potential cobblestone tiger beetle habitats be resurveyed to assess the population status. Before creating sound strategies to address the threats to cobblestone tiger beetles, the severity of the threats must be understood.

Element 5: References

5.1 Literature

Dunn, G. A. 1978. Tiger beetles of New Hampshire (Coleoptera: Cicindelidae). Thesis, University of New Hampshire, Durham, New Hampshire, USA.

Dunn, G. A. 1981. The tiger beetles of New Hampshire. Cicindela. 13: 1-28.

Dunn, G. A. 1986. Tiger beetles of New England (Coleoptera: Cicindelidae). Entomological Society Quarterly. 3: 27-41.

Leonard, J. G. and R. T. Bell. 1999. Northeastern tiger beetles: a field guide to tiger beetles of New England and Eastern Canada. CRC Press, Boca Raton, Florida, USA.

The Nature Conservancy. 1995. Conservation plan for Burnaps, Chase, Hart, Johnston, and Walpole Islands, New Hampshire. The Nature Conservancy, Concord, New Hampshire, USA.

Nothnagle, P. 1993. Status survey of New Hampshire/Vermont populations of the cobblestone tiger beetle (*Cicindela marginipennis*). Report submitted to the U. S. Fish and Wildlife Service, Concord, New Hampshire, USA.

Nothnagle, P. 1995. Survey of the White River for the cobblestone tiger beetle (*Cicindela marginipennis*). Prepared for the Vermont Fish and Wildlife Department, Waterbury, Vermont, USA and the U. S. Fish and Wildlife Service, Hadley, Massachusetts, USA.

Sperduto, D. D., and W. F. Nichols. 2004. Natural communities of New Hampshire. New Hampshire Natural Heritage Bureau, Concord, New Hampshire, USA.

United States Fish and Wildlife Service. 1990. Endangered and threatened wildlife and plants; determination of threatened status for the Puritan tiger beetle and the northeastern beach tiger beetle. Federal Register 55: 32088-32094.

5.2 Data Sources

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. Accessed 2005 March 17.

New Hampshire Natural Heritage Bureau. 2005. Database of Rare Species and Exemplary Natural Community Occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

United States Army Corps of Engineers, Cold Region Research and Engineering Laboratory Ice Jam Database. 2005. Hanover, New Hampshire http://www.crrel.usace.army.mil/ierd/ijdb/. Accessed 2005 March 22.

SPECIES PROFILE

Cora Moth

Cerma cora

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G3G4
State Rank: S1S2
Author: New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

Cora moth occupies pitch pine-scrub oak woodlands in the north and bluff and ravine forests and riparian swamps in the south (NatureServe 2005). In New Hampshire, *C. cora* inhabits pine barrens (NatureServe 2005), an early-successional community dominated by pitch pine (*Pinus rigida*) and scrub oak (*Quercus ilicifolia*) (Sperduto and Nichols 2004). *C. cora* larvae feed on Pin cherry (*Prunus pensylvanica*), spend much of their lives as pupae within dead wood, and mature in early or mid-July. For a detailed habitat description refer to the pine barrens profile.

1.2 Justification

C. cora, along with other pine barrens specialists, serves as an indicator of ecological condition. As the habitat goes unmanaged and reverts to a closed canopy system, *C. cora* populations decline and become increasingly vulnerable to extirpation, a reflection of the loss of vital compositional and structural elements within the community.

1.3 Protection and Regulatory Status

C. cora is widely distributed throughout much of the United States and does not appear to need protection.

1.4 Population and Habitat Distribution

C. cora range extends from New Hampshire in the north to Wisconsin in the west and south to Florida and Louisiana (NatureServe 2005). Primarily a southern species, *C. cora* is spottily distributed throughout much of its range, with few to no occurrences in many of these states (VanLuven 1994). Other than Wisconsin, no other state has verified more than 5 occurrences (NatureServe 2005). In New Hampshire, this species has been documented in the Concord Pine Barrens (1983) as well as in the town of Webster (1898) (NHNHB 2005).

1.5 Town Distribution Map

Not completed for this species

1.6 Habitat Map

See Karner blue butterfly species profile and the pine barrens habitat profile.

1.7 Sources of Information

Technical field reports, agency data, scientific journal articles, and element occurrence databases were used to determine *C. cora* habitat and distribution.

1.8 Extent and Quality of Data

Lepidoptera surveys conducted at the Concord Pine Barrens have not resulted in any observation of the *C. cora* in recent years. Other areas where pine barrens habitat occurs have not been surveyed for *C. cora*.

1.9 Distribution Research

Additional surveys should be conducted in known and potential sites to determine distribution, habitat

requirements, and life history traits of *C. cora*. Current populations should be monitored for trends, and new sites containing key habitat elements should be surveyed for new occurrence data.

Elements 2-4: *See the Karner Blue Butterfly and the Pine Barrens profiles.*

Element 5: References

5.1 Literature:

VanLuven, D.E. 1994. Site Conservation Plan for the Concord Pine Barrens, Concord, New Hampshire. The Nature Conservancy, Concord, New Hampshire, USA.

Wagner, D.L. 2000. The Macrolepidoptera Fauna of Mount Everett, Massachusetts. The Nature Conservancy, Boston, Massachusetts, USA.

5.2 Data Sources

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. Accessed 2005 March 30.

New Hampshire Natural Heritage Bureau. 2005. Database of rare species and exemplary natural community occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

SPECIES PROFILE

Dwarf Wedgemussel

Alasmidonta heterodon

Federal Listing: Endangered
State Listing: Endangered
Global Rank: G1
State Rank: S1
Author: Barry J. Wicklow, Department of Biology, Saint Anselm College

Element 1: Distribution and habitat

1.1 Habitat Description

Dwarf wedgemussels, *Alasmidonta heterodon*, are Atlantic slope species inhabiting small streams to large rivers with moderate flow. They are found in hydrologically stable areas within a variety of substrates including gravel and coarse sands, fine sands, and clays in depths from a few centimeters to several meters. Mussels are suspension and deposit feeders, subsisting on phytoplankton, bacteria, fine particulate organic matter, and dissolved organic matter (Strayer et al. 2004).

The dwarf wedgemussel's life cycle is complex. Gametogenesis occurs from May through July (Michaelson and Neves 1995). Spawning occurs in summer when sperm are released into the water column and drawn into the inhalant aperture of the female. Eggs are fertilized, undergo development, and mature in the outermost demibranchs of each gill, which function as marsupia. Well-developed glochidia are present in the Connecticut River mussels as early as late August. Dwarf wedgemussels are long-term brooders, holding glochidia through the winter until release begins in early March and continues through mid-June (Wicklow unpublished data). Glochidia must attach to a host fish in order to complete development and to facilitate dispersal. Host fish include the tessellated darter *(Etheostoma olmstedii)*, johnny darter *(Etheostoma nigrum)*, mottled sculpin *(Cottus cognatus)*, (Michaelson and Neves 1995), slimy sculpin *(Cottus cognatus)*, and juveniles and parr of the Atlantic salmon *(Salmo salar)* (B. Wicklow, Saint Anselm College, unpublished data). Due to fish range limitations, the tessellated darter, slimy sculpin, and Atlantic salmon are the only host fish available for dwarf wedgemussel glochidia in New Hampshire. The dwarf wedgemussel is the only species of *Alasmidonta* that uses a behavioral display to attract host fish (B. Wicklow, Saint Anselm College, unpublished data).

1.2 Justification

Freshwater mussels have declined dramatically in diversity, abundance, and distribution within the last 200 years and are considered the most imperiled fauna in North America (Richter et al. 1997, Lydeard et al. 2004). In the genus *Alasmidonta* 9 of 13 species are threatened, endangered, or extinct (Williams et al. 1992). Historically, the dwarf wedgemussels was found from the Petitcodiac River in New Brunswick, Canada to the Neuse River in North Carolina, and was found in 15 major Atlantic slope river systems (United States Fish and Wildlife Service (USFWS) 1993). It is now extinct in Canada, extirpated in the Neuse River, and present in low densities throughout much of its former range (USFWS, 2002 Range Wide Assessment Meeting).

Only 54 populations remain; 41 of these are estimated to contain fewer than 50 individuals and of these, 32 have fewer than 10 individuals or are possibly extirpated; 8 or 9 are estimated at between 50 and 1,000 individuals; 4 are estimated at between 10,000 and 100,000 individuals. Human impacts including riparian disturbance, pollution, sedimentation, impoundments, artificial flow regimes, and stream fragmentation disrupt mussel life cycles, prevent host fish migration, block gene flow, and prohibit recolonization, resulting in reduced recruitment rates,

decreased population densities and increased probability of local extinctions (Neves et al. 1997, Watters 1999, Strayer et al. 2004).

1.3 Protection and Regulatory Status

- Listed as endangered on Federal Endangered Species Act (listed on March 14, 1990)
- Clean Water Act-Section 404; administered by the Army Corp of Engineers and Environmental Protection Agency -- regulates discharge of dredge or fill material into "waters of the United States," including wetlands.
- Fill and Dredge in Wetlands; New Hampshire Department of Environmental Services (NHDES, RSA 482-A)- requires applicant to obtain a permit to fill or dredge jurisdictional wetland habitats, including the banks of rivers and streams.
- The Shoreland Protection Act (NHDES, RSA 483-B) limits the amount of tree removal and other activities within 250 ft of major rivers and requires a primary structure setback of at least 50 ft.
- New Hampshire Endangered Species Conservation Act (RSA 212-A)- state endangered.
- Rivers Management and Protection Program; NHDES (RSA 438) designates rivers in New Hampshire for protection of cultural or natural resources and stipulates the following: no channel alteration activities shall be allowed in rivers designated as "natural"; no dams will be built on rivers designated as natural, rural or rural community rivers; a protected instream flow level shall be established for each designated river; no motorized watercraft are allowed on designated natural rivers; ithin 15.24 m (50ft) of a stream, 50% of basal area of trees cannot be cut; for fourth order streams and higher this extends to within 45.72 m (150 ft).
- Local regulations and zoning varies considerably.

1.4 Population and habitat distribution

Since the extirpation in Canada, the Connecticut River drainage in New Hampshire has held the largest remaining dwarf wedgemussel populations and represents the northern limit of the distribution (USFWS, 2002 Range Wide Assessment Meeting). Nevertheless, these populations are extremely patchy, clustered in scattered mussel beds.

Dwarf wedgemussels require unpolluted streams or rivers with high dissolved oxygen, moderate current, and stable substrata within refugia (Strayer 1993b, Strayer and Ralley 1993). Stream fragmentation from dams, causeways, impoundments, channelization, and inhospitable stream segments results in spatially and genetically disjunct populations. Perhaps 50% or more of populations have densities that put them in jeopardy of extinction from catastrophes or stochastic demographic, genetic, or environmental events. Though populations range from 100 to 10,000 individuals, densities are low enough (mean = 0.01 to 0.05 per square meter, Strayer et al. 1996) to cause concern. Because mussels are broadcast spawners, populations with low densities may suffer reduced fertilization success (Downing et al. 1993, McLain and Ross 2005), which may strongly limit recruitment. Dwarf wedgemussels occupy small, linear ranges, putting populations at higher risk from impacts of pollution, habitat degradation, and disease (Strayer et al. 1996).

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

Known occupied stretches of river are mapped in the Natural Heritage Bureau database. Future mapping efforts should identify suitable habitat that has not been surveyed.

1.7 Sources of Information

Information on the life history, habitat requirements, and distribution of dwarf wedgemussels was obtained form the scientific literature, unpublished reports, databases, expert consultation, unpublished research results, and mussel recovery meetings.

1.8 Extent and Quality of Data

Dwarf wedgemussels in the Connecticut River main stem have been surveyed and intermittently monitored since 1988. Early surveys were conducted by canoe and snorkeling in shallow water, usually within 15 meters of the bank. Later SCUBA surveys found a significant number of dwarf wedgemussels in depths greater than 1.5 meters. Most of the early monitoring efforts employed Catch Per Unit Effort (CPUE)

methods. While helpful in determining presence or absence, CPUE methods are not statistically valid and therefore cannot be reliably used to determine population changes or trends.

Dwarf wedgemussels in the Connecticut River main stem have been surveyed and intermittently monitored since 1988. Dams and reservoirs divide mussels into 3 spatially and genetically disjunct populations.

1. The northern population occurs within 29-kilometer river section from Northumberland to Dalton. It was surveyed in 1996. One location in this section between Lancaster New Hampshire and Lunenburg, Vermont has been monitored regularly since 1997 when 536 dwarf wedgemussels including 87 tagged specimens were relocated 100 meters upriver as part of a bank stabilization project. Over 4,000 dwarf wedgemussels were found within the study area in 2000 (Gloria and Wicklow 2001). The Moore and Comerford dams and reservoirs separate this population from populations downstream.
2. A second population may occur in the section of river from the Comerford Dam and McIndoe Falls to the Wilder Dam impoundment. Dwarf wedgemussels were historically present and may still be extant in this section. This section is a priority for SCUBA survey.
3. The third population occurs in scattered beds within a 27-kilometer river segment between Plainfield and Charlestown. Biologists surveyed and monitored this section periodically since 1988. Strayer surveyed this section in 1994, estimating a population size of between 20,000 and 100,000 individuals (Strayer et al. 1996). Since 1991, several site-specific surveys have been conducted (Gabriel 1996, O'Brien 2001, Nedeau 2002). Between 1991 and 1995 five sites were monitored, three of the five annually (Gabriel and Strayer 1995). These three sites were monitored again in 2001 (O'Brien 2001). A 400 x 10 m area at the Charlestown Fort at Number 4 site was surveyed in 2002 (Nedeau 2003).

The Ashuelot River population downstream of the Surry Mountain flood control dam has been periodically monitored since 1991 (Gabriel and Strayer 1995). In 2004, Nedeau conducted a quantitative survey of dwarf wedgemussels in the Ashuelot River downstream of the Surry Mountain dam. The method, described in Strayer and Smith 2003, is recommended for estimating population size, density, and spatial distribution (Nedeau 2004).

1.9 Distribution research

Quantitative, statistically valid monitoring methods in known Connecticut main stem populations are needed. Using SCUBA, additional segments of the Connecticut River main stem need to be surveyed. Of particular priority is the stretch of river from below McIndoe Falls to Lyme, New Hampshire (von Oettingen, USFWS, personal communication). Other areas include the river south of Charlestown and the northern section from Pittsburg to Colebrook.

Nedeau and Werle surveyed the Ashuelot River from Keene to Hinsdale, finding 13 individuals just upstream of Sawyer Crossing (Nedeau and Werle 2003). Dwarf wedgemussels were sparse or absent in other river segments. Although present water quality and habitat appear suitable for dwarf wedgemussel, a long history of pollution and habitat degradation decimated dwarf wedgemussels in the Ashuelot below Keene. The scattered groups of mussel found recently may have persisted in refugia or may represent a re-colonization from the source population downstream of the Surry Mountain Dam (Nedeau and Werle 2003). Dispersal distance of encysted glochidia on tessellated darters and sculpin is less than 100 meters, thus re-colonization of areas of local extinction would be slow (McLain and Ross 2005).

Element 2: Species/ habitat condition

2.1 Scale

Dams and reservoirs divide the Connecticut River main stem into 3 major segments, each containing spatially and genetically disjunct populations: 1) the northern section, upstream of the Moore and Comerford Dams, that includes the Dalton-Lancaster population, 2) a middle section downstream of the Moore and Comerford Dams that includes high potential habitat from Monroe to Lyme, and 3) a southern section downstream of the Wilder Dam that include the Plainfield-Charlestown population. Within these linear units, subpopulation exists in scattered patches

that may function together as a metapopulation. Likewise, the Ashuelot River population downstream of Surry Mountain Dam is separated from the main stem by inhospitable reaches and dams. Distribution of mussels at the scale of the river reach, less than 1 kilometer, may be determined by flood stage shear stress and sediment stability (Strayer 1999b, Layzer and Madison 1995, Hastie et al. 2001).

2.2 Relative health of populations

Based on the presence of young individuals, the north and south populations on the Connecticut River main stem and the Ashuelot population appear viable. The north Connecticut River population appears to be most robust.

2.3 Populations management status

Population management has been limited to relocation initiatives stemming from bank stabilization projects, such as along Route 2 in Lunenburg, Vermont and at the Fort at Number 4 site in Charlestown, New Hampshire.

2.4 Relative quality of habitat patches

Both north and south populations in the Connecticut River main stem are estimated at between 10,000 and 100,000 individuals. These populations have been surveyed qualitatively and are in need of quantitative, statistically valid monitoring. Nevertheless, the Lancaster, New Hampshire, and Lunenburg, Vermont sites have patches of high mussel density, with all age classes present, and a high density of tessellated darter host fish (Gloria and Wicklow 2000, Nedeau 2004). This section of river is free flowing from the Murphy Dam at Lake Francis in Pittsburg to the Moore Dam Reservoir in Littleton and hosts the most vigorous, viable population known. The Ashuelot River Population, also considered among the largest populations, extends from the Surry Mountain Dam to Swanzey and is estimated at 10,000 individuals. Two sites downstream of Surry Mountain Dam were monitored quantitatively. The site closest to the dam showed an age distribution skewed toward older individuals, with little evidence of recruitment, whereas the downstream site showed a wider age distribution, with evidence of recruitment (Nedeau 2004).

2.4 Habitat patch protection status

Very little habitat protection exists. The Army Corps of Engineers operates the Surry Mountain Flood control dam and holds land downstream to the East Surry Road Bridge.

2.6 Habitat management status

Currently there are no management or restoration efforts targeting dwarf wedgemussel habitat in the state. However, the Nature Conservancy, the Monadnock Conservancy, the Society for the Protection of New Hampshire Forests, and the Southwestern Regional Planning Commission have developed a conservation plan for the Ashuelot River Watershed (Zankel 2004). The Connecticut River Joint Commission is currently updating a Connecticut River Management Plan for the main stem (S. Francis, Executive Director, Connecticut River Joint Commission, personal communication). A recent USFWS initiative in riparian restoration in the Lancaster, New Hampshire to Lunenburg, Vermont reach of the Connecticut River failed due to lack of landowner cooperation (von Oettingen, USFWS, personal communication).

2.7 Sources of information

Distribution data were obtained from the New Hampshire Natural Heritage Bureau Element Occurrence Database, unpublished reports, scientific literature, and consultation with experts.

2.8 Extent and quality of data

Much of the information on the condition of dwarf wedgemussel populations and habitat is qualitative. Needed are quantitative studies to assess the physical habitat, including sediment type and hydrology, particularly shear, and water quality. Also needed are data on dwarf wedgemussel population structure, age class distribution, sex ratio, recruitment, growth rates, and migration, as well as distribution and abundance data on host fish. Studies that examine the effects of predation and competition would be helpful.

2.9 Condition ranking

To be provided by NHFG.

2.10 Condition assessment research

Research is needed to determine the biological response of dwarf wedgemussel to artificial flow regimes. Response variables include displacement of juveniles and glochidia, interference of spawning success, glochidial release patterns, and host fish attachment success. Also important are studies using micro satellite DNA markers to determine the genetic consequences of stream fragmentation on dwarf wedgemussel (King 1999). Villella et al. used mark-recapture techniques to estimate survival, recruitment, and population growth of freshwater mussels (Villella et al. 2004), and this technique could provide valuable demographic information for dwarf wedgemussel populations. Mussels were marked during a relocation project at the Lunenburg, Vermont bank stabilization site in 1997, and additional mussels were marked in 2003. A much larger sample size is needed to complete this study (Wicklow, Saint Anselm College, unpublished).

Element 3: Species and habitat threat assessment

3.1.1 Altered Hydrology

(A) Exposure pathway
The conversion of free-flowing rivers to highly regulated rivers has seriously affected freshwater mussels. Dams, causeways, reservoirs, gravel mining, dredging, channelization, poor land use, and municipal and industrial pollution have resulted in scattered populations. Barriers cause direct mortality, prevent dispersal, block gene flow, prohibit re-colonization of unoccupied but rehabilitated habitat, and prevent host fish migration (Layzer et al. 1993, Parmalee and Hughes 1993, Vaughn and Taylor 1999, Watters 1996).

(B) Evidence
On the Connecticut River main stem the Moore, Comerford, and Wilder Dams have divided dwarf wedgemussels into 3 populations. Dams on the Ashuelot River are also barriers to dispersal; in a survey in the Ashuelot River dwarf wedgemussels were absent below the Swanzey Dam (Nedeau and Werle 2003), and historic water and habitat degradation was apparent (Nedeau and Werle 2003). Notably, the 1968 construction of a causeway across the Petitcodiac River in New Brunswick Canada transformed a macro-tidal estuary into a shallow freshwater impoundment thereby eliminating diadromous fish including the Atlantic salmon (Locke et al. 2003), a host fish of the dwarf wedgemussel (Wicklow, unpublished data). By the 1980s, the dwarf wedgemussel had disappeared from the Petitcodiac River and in 1999 the Committee on the Status of Endangered Wildlife in Canada declared the dwarf wedgemussel officially extinct (Hanson and Locke 2000).

3.1.2 Altered Hydrology

(A) Exposure pathway
Cycles of extreme episodic flooding and dewatering use cause direct adult mortality by scouring. Extreme fluctuations in flow disrupt mussel life cycles by exposing glochidia and juveniles to flood-induced damage, mortality, or displacement to potentially unfavorable habitat downstream (Layzer et al. 1993, Richter et al. 1997). Dewatering exposes mussels to heat, desiccation, and opportunistic predators. Predator foraging efficiency increases with decreasing depth.

(B) Evidence
In 1999, Wicklow showed a correlation between presence of glochidia in stream drift samples and high flow releases from the Surry Mountain Dam on the Ashuelot River (Wicklow, Saint Anselm College, unpublished data). In addition, over 100 dwarf wedgemussel valves were collected from muskrat middens in a 15 m segment of the Ashuelot River during a period of extremely low water (von Oettingen, USFWS and Wicklow, Saint Anselm College, unpublished).

3.1.3 Non-Point Source Pollution

(A) Exposure pathway
As development increases and riparian vegetation buffers decrease, the effects of pollution on the biota in the Connecticut River and tributaries will increase. Runoff from municipalities, industrial waste, sewage outfalls, golf courses, poor agricultural and silviculture land contributes to sedimentation, organic pollution, and general water quality degradation (Poole and Downing 2004). Mussels are sensitive to toxins, such as chlorine and ammonia, and to heavy metals introduced through runoff and atmospheric deposi-

tion (Naimo 1995, Augsburger et al. 2003). Glochidia and juveniles are the most sensitive to pollutants, juveniles because they burrow into and feed within the sediments. Thus sediment, particularly when low in pore-water oxygen and high in toxins, may be a major contamination pathway for infaunal juveniles, as well as for adults, who may also deposit feed (Newton et al. 2003, Poole and Downing 2004).

(B) Evidence
The effect of acute pollution on freshwater mussels is well documented (Neves et al. 1997). Chemical and agricultural waste spills cause direct mussel mortality. The most widely reported sources of pollution are poor agriculture practices (Neves et al. 1997, Poole and Downing 2004)); 20 dwarf wedgemussels and hundreds of other mussel species were killed by waste runoff from a small farm in the Connecticut River Watershed (USFWS 2002). The effect of sediment toxicity is not well understood. However, recent toxicity tests for total residual chlorine showed that juvenile mussels are much more sensitive to toxins than are glochidia (Cherry et al. 2005).

3.1.4 Introduced Species

Adult zebra mussels are transported from basin to basin while attached to boats, and larvae may be transported in bilge and bait bucket water. Zebra mussels compete with native freshwater mussels for food and may reduce food concentration to levels that cannot support native species (Caraco et al. 1997, Strayer 1999). Larvae of zebra mussels require calcium levels between 8 and 20 ppm in order to complete development, well within the levels in the Connecticut River (Michelle Babione, Wildlife Biologist, Silvio O. Conte National Wildlife Refuge, personal communication). Because zebra mussels tend to infest rivers greater than 30 meters wide, the Ashuelot River is at lower risk of invasion.
After their initial discovery in Lake Saint Clare in 1988, zebra mussels quickly spread throughout many regions of the United States and parts of Canada. Their effect on the decline of freshwater mussels in the Hudson River is well documented (Caraco et al. 1997, Strayer 1999). Zebra mussels are present in Lake Champlain in Vermont. Recently a zebra mussel was detected on a boat in a boatyard at Lake Winnipesaukee. This underscores our need to intensify boat ramp surveys, particularly at high-use boating areas and priority biological sites, such as dwarf wedgemussel habitat. High boat use lakes, such as Sunapee Lake, that connect to biologically sensitive areas and have the potential for further zebra mussel spreading should be targeted (Michelle Babione, Wildlife Biologist, Silvio O. Conte National Wildlife Refuge, personal communication).

3.2 Sources of Information

Information was gathered from the scientific literature, reports, consultation with experts, and personal research.

3.3 Extent and quality of data

Whereas not all threats have been documented specifically for dwarf wedgemussels and their habitat, there is documentation for threat effects on other unionid mussels. The synergistic and long-term effect of the multiple kinds of chronic stresses on freshwater mussels is not known.

3.4 Threat assessment research

Expand research to determine phylogeographic relationships of New Hampshire populations of dwarf wedgemussels, using micro satellite DNA sequences (King et al., unpublished data). Further elucidate the life history of the dwarf wedgemussel. Determine the effect of hydrology on the life history of dwarf wedgemussels. Compare patterns of glochidial release observed in the mussels in the Ashuelot River prior to and after the change to “run of the river” flow management at the Surry Mountain Dam. Continue USFWS toxicity testing of glochidia and juvenile mussels (Cherry et al. 2005). Establish long-term monitoring sites on the Connecticut River that include geomorphologic, hydrological, and water quality assessments. Identify the physical characteristics of dwarf wedge mussel habitat and survey potential habitats for the presence of dwarf wedgemussel. Investigate the potential for relocation strategies.

Element 4 - Conservation actions

4.1.1 Restoration and management

(A) Stream fragmentation, altered flow regimes, pollution, riparian disturbance, invasive species

(B) Justification
Reducing stream fragmentation by removing barriers such as nonfunctional dams and by rehabilitating degraded river reaches will increase dispersal and re-colonization of dwarf wedgemussels. As barriers to dispersal are removed, gene flow is enhanced and heterozygosity increases.

Pollution may render stream reaches uninhabitable. Destruction and transformation of riparian corridors accelerates erosion, bank sloughing, and runoff, leading to higher temperatures, toxin levels, and sediment levels. Dam impoundments and reservoirs have a higher probability of zebra mussel colonization than do free-flowing river segments. Greater attention should be paid to areas of high risk. More intense boat ramp surveys, particularly at high-use boating areas and priority biological sites are warranted.

Dispersal increases the potential for persistence of species in patchy, unstable habitats such as rivers and streams. As mussels are established in new suitable habitat patches, linear range, population size, and likelihood of re-colonization increase. Protection of riparian corridors through fee simple land acquisition, conservation easements, and private landowner cooperation will reduce pollution runoff and sedimentation in the Connecticut River main stem and the Ashuelot River.

Removal of a small dam on the Ashuelot River will open kilometers of new habitat. Ultimately the Ashuelot River may be free of barriers through to the Connecticut River main stem. Riparian protection and restoration will improve downstream water quality and habitat.

Mussels found below a dam removal site or in rehabilitated river reach may appear within 3 to 5 years, but 10 to 20 years or more may be necessary to establish a viable population. Riparian protection and restoration will be a long-term effort.

As additional water quality and habitat assessment information is collected, efforts can be redirected or expanded.

(C) Conservation performance objective: The performance objective is to restore the Ashuelot River to a free flowing condition free of physical barriers and inhospitable degraded river segments within 5 to 10 years. The performance indicator is the presence of dwarf wedgemussels downstream of former barriers. The number of reproducing subpopulations of dwarf wedgemussel will indicate the success of the program. The performance indicator for protected or restored riparian corridors is 25 to 35% additional riparian protection along the Ashuelot River in 10 years and 15 to 20% additional riparian protection along the Connecticut River main stem in 10 to 20 years.

(D) Performance monitoring: The Ashuelot River was surveyed from Keene to Hinsdale between 2001 and 2003 (Nedeau and Werle 2003). Surveys in subsequent years are intended first to detect mussels. Then, as populations enlarge, mussel sites should be surveyed using quantitative, statistically valid methods. Water quality monitoring stations upstream of dwarf wedgemussel populations must be established.

(E) Ecological response objective: The habitat restoration response objective is to increase size and density of dwarf wedgemussel subpopulations downstream from Keene to Hinsdale and the mouth of the Connecticut River main stem. Decades may be needed to achieve the desired ecological response. Monitoring should indicate water quality improvement within 5 to 10 years. Additional survey and monitoring data is needed for the Connecticut River main stem before response objectives can be quantified.

(F) Response monitoring: The initial response will be monitored with qualitative surveying. As mussel populations increase in size, quantitative methods will be used (Strayer and Smith 2003).

(G) Implementation: In 2000 the NHDES helped establish the New Hampshire River Restoration Task Force with the objective, in part, of exploring possible dam removal in order to restore rivers. The Task Force includes state and federal agencies, conservation organizations, towns, and other interest groups. The Task Force facilitated the removal of two dams on the Ashuelot River: the McGoldrick Dam in Hinsdale in 2001 and the Winchester Dam in 2002. Two dams remain: the Homestead Woolen Mill Dam in West

Swanzey and the Fiske Mill Dam in Hinsdale. The Homestead Woolen Mill Dam is under consideration for removal; however, the Fiske Mill Dam was under consideration for removal but was purchased recently for hydroelectric power use (Loiselle, River Restoration Coordinator, NHDES). In addition, The Nature Conservancy has begun implementing a land conservation plan for the Ashuelot River (Zankel, 2004).

(H) Feasibility: Dam removal projects are feasible. However, the Town of Swanzey has not yet decided to remove the Homestead Dam. In 1998 the owner of Homestead Woolen Mills applied to breach the dam, though he is now willing to convey ownership to the town. Issues that may favor the town taking ownership of the dam include the historic covered bridge just upstream of the dam that may suffer scour damage without the dam and the influence of decreased water levels on fire department access. The selectmen are soliciting comment prior to an August 2005 meeting to reach a consensus. A final decision may require a warrant article for town meeting, March 2006 (Sara Carbonneau, Swanzey Town Planner, personal communication).

The Nature Conservancy's land protection initiative will begin in 2006 (Aldridge, The Nature Conservancy, personal communication). In addition, The Nature Conservancy's Connecticut River Program, in partnership with the United States Geological Survey, the University of Massachusetts, and Dartmouth College and the Army Corps of Engineers will hire a postdoctoral student to assess and implement trial flow regimes and determine their ecological responses in the Ashuelot River (Lutz, Director, The Connecticut River Program, The Nature Conservancy, personal communication).

4.2 Conservation action research:

In addition to removal of McGoldrick and Winchester Dams on the Ashuelot River, the Cuddebackville Dam on the Neversink River, New York, was successfully removed without apparent impairment of the downstream dwarf wedgemussel population (Strayer, Institute for Ecosystem Studies, Millbrook, New York, personal communication).

Element 5: References

5.1 Literature

Augspurger, T., A.E. Keller, M.C. Black, W.G. Cope, and W.G. Cope. 2003. Water quality guidance for protection of freshwater mussels (Unionidae) from Ammonia exposure. Environmental Toxicology and Chemistry. 22:2569-2575.

Caraco, N.F., J.J. Coe, P.A. Raymond, D.L. Strayer, M.L. Pace, S.A.G. Findlay, D.T. Fischer. 1997. Zebra mussel invasion in a large, turbid river: Phytoplankton response to increased grazing. Ecology. 78:588-602.

Cherry, D. S., T. W. Valenti, R. J. Currie, R. J. Never, J. W. Jones, R. A. Mair, and C. M. Kane. 2005. Chlorine toxicity to early life stages of freshwater mussels. Report submitted to U. S. Fish and Wildlife Service, Virginia Field Office, Gloucester, Virginia.

Downing, J.A. Y. Rochon, M. Perusse, H. Harvey. 1993. Spatial aggregation, body size, and reproductive success in the fresh-water mussel *Elliptio complanta*. Journal of the North American Benthological Society. 12:148-156.

Gabriel, M. and D. Strayer. 1995. Preliminary monitoring plan for the dwarf wedgemussel (*Alasmidonta heterodon*) in the Connecticut River in New Hampshire and Vermont: A discussion of methods. Unpublished report for the Nongame & Natural Heritage Program, Vermont Fish and Wildlife Department and the United States Fish and Wildlife Service. 20 pp.

Gabriel, M. 1996. 1996 Monitoring of the dwarf wedgemussel (*Alasmidonta heterodon*) in the Ashuelot and Connecticut Rivers, New Hampshire. Report submitted to The Nature Conservancy, Eastern Regional Office, Boston, Massachusetts. 27 pp.

Gloria, T. and B. Wicklow. 2001. Unpublished report. A third investigation of the survival of dwarf wedgemussels for the relocation project on the Connecticut River, Route 2 stabilization project, Lunenburg, Vermont. Report to the Vermont Agency of Transportation. Montpelier, Vermont. 24 pp.

Hanson, J.M., A. Locke. 2000. The status of the Dwarf Wedgemussel, *Alasmidonta heterodon*, in Canada. Canadian Field-Naturalist. 114:271-

278.

Hardison, B.S., J.B. Layzer. 2000. Relations between complex hydraulics and the localized distribution of mussels in three regulated hydraulics and the localized distribution of mussels in three regulated rivers. Regulated Rivers: Research and Management.

Hastie, L.C., P.J. Boon, M.R. Young, S. Way. 2001. The effects of a major food on an endangered freshwater mussel population. Biological Conservation. 98:107-115.

King, T.L., M.S. Eackles, B. Gjetvaj, W.R. Hoeh. 1999. Intraspecific phylogeography of *Lasmigona subviridis* (Bivalvia: Unionidae): Conservation implications of range discontinuity. Molecular Ecology. 8 (suppl.1): S65-S78.

Layzer, J.B., M.E. Gordon, and R.M. Anderson. 1993. Mussels: The forgotten fauna of regulated rivers. A case study of the Caney Fork River. Regulated Rivers: Research and Management. 8:63-71.

Layzer, J.B., L.M. Madison. 1995. Microhabitat use by freshwater mussels and recommendations for determining their instream flow needs. Regulated Rivers: Research and Management. 10:329-345.

Locke A., J.M. Hanson, G.J. Klassen, S.M. Richardson, C.I. Aube. 2003. The damming of the Petitcodiac River: Species, populations, and habitats lost. Northeastern Naturalist. 10:39-54.

Lydeard C., R.H. Cowie, W.F. Ponder, A.E. Bogan, P.Boucet, S.A. Clark, K.S. Cummings, T.J. Frest, O.Gargominy, C.G. Herbert, R. Hershler, K. E. Perez., B. Roth, M. Seddon, E.E. Strong, and F.G. Thompson. The global decline of nonmarine mollusks. 2004. Bioscience. 54:321-330.

McLain D.C., M.R. Ross. 2004. Reproduction based on local patch size of Alasmidonta heterodon and dispersal by its darter host in the Mill River, Massachusetts. Journal of North American Benthological Society. 24(1):139-147.

Michaelson, D.L., R.J. Neves. 1995. Life history and habitat of the endangered dwarf wedgemussel *Alasmidonta heterodon* (Bivalvia:Unionidae). Journal of the North American Benthological Society. 14:324-340.

Naimo, T.J. 1995. A review of the effects of heavy metals on freshwater mussels. Ecotoxicology. 4: 341-362.

Nedeau, E. 2002. Unpublished report. Dwarf wedgemussel (*Alasmidonta heterodon*) survey near the Fort at no. 4 on the Connecticut River Charlestown, New Hampshire. Unpublished report prepared for the Connecticut River Joint Commission. 12pp.

Nedeau, E., and S. Werle. 2003. Freshwater Mussels of the Ashuelot River. Report submitted to United States Fish and Wildlife Service, Concord, New Hampshire.

Nedeau, E., 2004a. A fourth investigation of the survival of dwarf wedgemussels *(Alasmidonta heterodon)* for the relocation project on the Connecticut River, Route 2 stabilization project, Lunenburg, Vermont.

Nedeau, E., 2004b. Quantitative survey of dwarf wedgemussel (*Alasmidonta heterodon*) populations downstream of the Surry Mountain Flood Control Dam on the Ashuelot River. Report submitted to United States Fish and Wildlife Service, Concord, New Hampshire.

Neves, R.J., A.E. Bogan, J.D. Williams, S.A. Ahlstedt, P.W. Hartfield. 1997. Status of aquatic mollusks in the southeastern United States: A downward spiral of diversity Pages 43-85 in Bens G.W., D.E. Collins, eds. Aquatic Fauna in Peril: The Southeastern Perspective. Decatur (GA): Lenz Design and Communications.

Newton, TJ., JW. Allran, J.A. O'Donnell, M.R. Bartsch, and W.B. Richardson. 2003. Effects of ammonia on juvenile unionid mussels (*Lampsilis cardium*) in laboratory sediment toxicity tests. Environmental Toxicology and Chemistry. 22:2554-2560.

O'Brien, C. 2001. Unpublished report. Inventory and monitoring of the dwarf wedgemussel (*Alasmidonta heterodon*) in the Connecticut River in New Hampshire and Vermont. Report submitted to the Nongame & Natural Heritage Program, Vermont Fish and Wildlife Department, 103 South Main St., Waterbury, VT. 16 pp.

Parmalee, P.W., M.H. Hughes. 1993. Freshwater mussels (Mollusca; Pelecypoda: Unionidae) of Tellico Lake: twelve years after impoundment of the Little Tennessee River. Annals of the Carnegie Museum. 62:81-93.

Poole, K.E., J.A. Downing. 2004. Relationship of declining mussel biodiversity to stream-reach and watershed characteristics in an agricultural landscape. Journal of the North American
Benthological Society. 23:114-125.

Richter, B.D., D.P. Braun, J.A. Mendelson, L.L. Master. 1997. Threats to imperiled freshwater fauna. Conservation Biology. 11:1081-1093.

Strayer, D.L. 1999*a*. Effects of alien species on freshwater mollusks in North America. Journal of the North American Benthological Society. 18:74-98.

Strayer, D.L. 1999*b*. Use of flow refuges by unionid mussels in rivers. Journal of the North American Benthological Society. 18:468-476.

Strayer, D.L., J. Ralley. 1993. Microhabitat use by an assemblage of stream-dwelling unionaceans (Bivalvia), including two rare species of *Alasmidona*. Journal of the North American Benthological Society. 12:247-258

Strayer, D.L., S.J. Sprague, S. Claypool. 1996. A range-wide assessment of populations of *Alasmidonta heterodon*, an endangered freshwater mussel (Bivalvia: Unionidae). Journal of the North American Benthological Society. 15:308-317.

Strayer, D. L., D. R. Smith. 2003. A guide to sampling freshwater mussel populations. American Fisheries Society. Monograph 8, Bethesda, Maryland.

Strayer, D.L., J.A. Downing, W.R. Haag, T.L. King, J.B. Layzer, T.J. Newton, S.J. Nichols. 2004. Changing Perspectives on Pearly Mussels, North America's Most Imperiled Animals. BioScience. 54: 429-439.

United States Fish and Wildlife Service. 1993. Dwarf Wedgemussel *Alasmidonta heterodon* Recovery Plan. Hadley, Massachusetts.

United States Fish and Wildlife Service. 2003. Biological opinion on the bank stabilization project at the Fort at Number 4 site, Charlestown, NH. Report. Concord Field Office.

Vaughn, C., C.M. Taylor. 1999. Impoundments and the decline of freshwater mussels: a case study of an extinction gradient. Conservation Biology. 13: 912-920.

Villella, R.F., D.R. Smith, D.P. Lemaire. 2004. Estimating survival and recruitment in a freshwater mussel population using mark-recapture techniques. American Midland Naturalist. 151: 114-133.

Watters G.T. 1996. Small dams as barriers to freshwater mussels (Bivalvia, Unionoida) and their hosts. Biological Conservation. 75:79-85.

Watters, T. 1999. Freshwater mussels and water quality: A review of the effects of hydrologic and instream habitat alterations. Proceedings of the First Freshwater Mollusk Conservation Society Symposium, 1999. Ohio Biological Survey, Columbus Ohio. Page 261-274.

Wicklow, B.J. 2000. The correlation of physical factors on larval release patterns of the endangered dwarf wedgemussel, *Alasmidonta heterodon* (Unionidae, Bivalvia) in the Ashuelot River, New Hampshire. Report submitted the Silvio O. Conte National Fish and Wildlife Refuge, Turners Falls, MA., 16pp.

Williams, J.D., M.L. Warren, Jr., K.S. Cummings, J.H. Harris, R.J. Neves. 1992. Conservation Status of Freshwater Mussels of the United States and Canada. American Fisheries Society. 18:6-22.

Zankel, M. 2004. A land conservation plan for the Ashuelot River Watershed. The Nature Conservancy, Concord, New Hampshire.

SPECIES PROFILE

Eastern Pondmussel

Ligumia nasuta

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G4
State Rank: S1
Author: Barry J. Wicklow, Department of Biology, Saint Anselm College

Element 1: Distribution and habitat

1.1 Habitat Description

Eastern pondmussels inhabit ponds, lakes, and the low velocity segments of streams and rivers. They are often found in fine sands and other soft sediments (Strayer and Jirka 1997). Mussels are suspension feeders, subsisting on phytoplankton, bacteria, fine particulate matter, and dissolved organic matter (Strayer 2004).

Unionid mussels have complex life cycles. Larvae called glochidia must attach and encyst on a host species – usually a fish – to complete development disperse. Little is known about the reproductive biology of the Eastern pondmussel, and host fish species for glochidia have not been determined. They are long-term brooders, spawning in summer, then releasing glochidia the following spring or summer.

Mantle displays in eastern pondmussel function to attract hosts; papillae line the mantle edge, rhythmic movements of which elicit attacks by potential host fish (Corey 2003). Glochidia are discharged during the attack.

1.2 Justification

Freshwater mussels are the most imperiled fauna in North America, having suffered steep declines in diversity, abundance, and distribution within the last 200 years (Richter et al. 1997, Master et al. 2000, Lydeard et al. 2004). The Eastern pondmussel is distributed from Ontario, Canada, along the Atlantic coast to Virginia and west into Pennsylvania and New York. It is stable and abundant in many locations and is expanding its range into the Allegheny basin in New York (Strayer and Jirka 1997). Nevertheless, the Freshwater Mussel Subcommittee of the American Fisheries Society's Endangered Species Committee listed it as a species of special concern (Williams et al. 1992), and the Northeast Endangered Species and Wildlife Diversity Technical Committee listed it as a species of regional conservation concern (Therres 1999). It is listed as threatened in New Jersey and endangered in Delaware. In Maine, Massachusetts, and Connecticut it is listed as Special Concern (Nedeau et al. 2000, Nedeau and Victoria 2002). The Eastern pondmussel was ranked as a priority candidate for status under the Committee on the Status of Endangered Wildlife in Canada, COSEWIC (Metcalfe-Smith 1998).

In New Hampshire, Eastern pondmussels are found in only 4 ponds in the southeast part of the state. Zebra mussel, *Dreissena polymorpha*, introduction is a critical threat to the Eastern pondmussel. Zebra mussels have decimated unionid mussels in ponds, lakes, and rivers.

1.3 Protection and Regulatory Status

- Fill and Dredge in Wetlands; New Hampshire Department of Environmental Services (NHDES, RSA 482-A)- requires applicant to obtain a permit to fill or dredge jurisdictional wetland habitats, including the banks of rivers, streams, and lakes.
- The Shoreland Protection Act (NHDES, RSA 483-B) limits the amount of tree removal and other activities within 250 ft of major rivers and requires a primary structure setback of at least 50 ft.
- Local regulations and zoning vary considerably.

1.4 Population and habitat distribution

The only extant populations of Eastern pondmussels occur in 4 locations in the coastal watershed: Golden Brook near the outflow of Simpson Pond in Windham, Wash Pond in Hampstead, Great Pond in Kingston, and Powwow Pond in East Kingston (Clench and Russell 1938, Master 1990, Cutko and Johnson 1992). There is 1 historic record for Keene in the Connecticut River watershed (Clench and Turner 1938). Eastern pondmussels were not found during surveys of the Ashuelot River from Keene to Hinsdale between 2001 and 2004 (Nedeau and Werle 2003). However, it is found in the Connecticut River watershed in Massachusetts and Connecticut, and recently in a Connecticut River tributary as far north as Whately, Massachusetts (von Oettingen, USFWS, personal communication).

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

Known occupied lakes and rivers are mapped in the Natural Heritage Bureau database. Future mapping efforts should identify suitable habitat that has not been surveyed.

1.7 Sources of Information

Information on the life history, habitat requirements, and distribution of Eastern pondmussel was obtained from the scientific literature, unpublished reports, databases, and expert consultation.

1.8 Extent and Quality of Data

Information of the Eastern pondmussel in New Hampshire is sparse, and data are limited to occurrence locations: Wash pond Hampstead, 9 living individuals, 1992; Golden Brook near the outflow of Simpson Pond, Windham, 1 individual, 1990; Powwow Pond, East Kingston, 1 individual, 2004; Great pond, Kingston, 1 live individual in 2 hours of searching on the southwestern shore, 1992. In 2000, on the eastern shore of Great Pond several dozen individuals were observed embedded in fine sand (von Oettingen, USFWS, personal observations).

1.9 Distributional research

All current occurrence locations need to be resurveyed. Larger populations should be monitored using quantitative, statistically valid methods.

Element 2: Species/Habitat Condition

2.1 Scale

Each pond with an existing population of Eastern pondmussel should be treated as a conservation management unit.

2.2 Relative health of populations

Information that is needed to assess relative abundance, size, density, or recruitment of Eastern pondmussel populations does not exist. Based on incomplete surveys and observations, it appears that Great Pond in Kingston supports a viable population. It is possible that Eastern pondmussel will be found in other coastal watershed ponds and streams as well as in the Connecticut River watershed.

2.3 Population management status

There is no population management of the Eastern pondmussel. Additionally survey information is needed in order to identify potential conservation opportunities.

2.4 Habitat patch protection status

Very little habitat information exists. Most Eastern pondmussel populations or site occurrences have not been assessed in over 10 years. Ecological attributes have not been measured, and research is needed to determine population size, density, and recruitment and to assess habitat.

2.5 Habitat patch protection status

Information needed to assess the quality of habitats is sparse. The Department of Environmental Service Limnology Bureau monitors water quality at all occurrence locations.

2.6 Habitat management status

There are no habitat management efforts for Eastern pondmussel populations.

2.7 Sources of information

Information was obtained from reports, database, and consultation with experts.

2.8 Extent and quality of data

Data on the condition of Eastern pondmussel populations do not exist. Department of Environmental Service water quality data meet United States Environmental Protection Agency standards.

2.9 Condition assessment research

Ponds with Eastern pondmussel occurrences need to be resurveyed to include all areas of potential habitat. In addition to resurveys of occurrence sites, surveys of pond outflow streams as well as nearby ponds and lakes are needed. Powwow River, which drains both Great Pond and Powwow Pond, is a priority stream. Other priority sites are Country pond, Kingston; Long Pond, Danville; Island Pond, Hampstead/Derry; and Philips and Angle Ponds, Sandown. Populations of Eastern pondmussel need to be monitored using techniques that indicate density, recruitment, and population trends (Strayer and Smith 2003, Villella et al. 2004). Research to determine life history traits and host fish species is essential.

Element 3: Species and habitat threat assessment

3.1.1 Introduced Species

(A) Exposure Pathway
Adult zebra mussels are transported from basin to basin while attached to boats, and larvae may be transported in bilge and bait bucket water. Zebra mussels compete with native freshwater mussels for food and may reduce food concentration to levels that cannot support native species. Larvae of zebra mussels require calcium levels between 8 20 ppm in order to complete development, well within the range of calcium levels found, for example, in the Connecticut River.

(B) Evidence
After their initial discovery in Lake Saint Clare in 1988, zebra mussels quickly spread throughout many regions of the United States and parts of Canada. Their effect on the decline of freshwater mussels in the Hudson River is well documented (Caraco et al. 1997, Strayer 1999), and zebra mussels have severely affected mussels in Lake Champlain in Vermont. Recently a zebra mussel was detected on a boat in a boatyard at Lake Winnipesaukee, underscoring the need to intensify boat ramp surveys, particularly at high-use boating areas at all Eastern pondmussel locations and neighboring ponds.

3.1.2 Development (Habitat Loss and Conversion)

(A) Exposure pathway
Riparian corridors and adjacent lands are being rapidly developed in New Hampshire. Lakeshores are highly valued for the recreation potential they offer, and lakeside development, docks, and motorized boat traffic degrade habitat, lower water quality, and increase pollution.

(B) Evidence
Habitat destruction, pollution, and water degradation are considered the most likely causes for the decline of freshwater mussels (Neves 1997, Strayer et al. 2004). The east and south shores of Great Pond are developed, and development continues on the southwest shore of Powwow Pond an around most of Wash Pond. Additional on-site threat evidence needs to be gathered.

3.1.3 Non-Point Source Pollution

(A) Exposure Pathway
Runoff from municipalities, industrial waste, sewage outfalls, golf courses, and poorly managed agricultural and silvicultural lands degrades water and leads to sedimentation and organic pollution. As rapid development increases, impervious surfaces increase the volume and velocity of runoff, causing erosion, sedimentation, and toxic pollution in streams and rivers. Riparian vegetation is critical in retarding these effects.

Mussels are sensitive to chronic and acute exposure to heavy metals introduced through runoff and

atmospheric deposition as well as to toxins, such as chlorine and ammonia (Naimo 1995, Augsburger et al. 2003). Glochidia and juveniles are considered the life stages most sensitive to pollutants. Juveniles burrow into and feed within the sediments; adult mussels may also deposit feed. Low sediment pore-water oxygen and high sediment levels of toxins put infaunal juveniles at risk. Hence, sediments may represent a major contamination pathway for mussels (Newton et al. 2003, Poole and Downing 2004).

(B) Evidence
The effect of acute pollution on freshwater mussels is well-documented (Neves et al. 1997), and chemical and agricultural waste spills cause direct mussel mortality. For instance, hundreds of mussels, some state and federally listed, were killed by waste runoff from a small farm in the Connecticut River watershed (USFWS 2002). The most widely reported sources of pollution are poor land use practices (Neves et al. 1997, Poole and Downing 2004). The effect of sediment toxicity is not well understood. However, recent toxicity tests for total residual chlorine showed that juvenile mussels are much more sensitive to toxins than glochidia (Cherry et al. 2005).

3.2 Sources of Information

Information was gathered from the scientific literature, reports, and consultation with experts

3.3 Extent and quality of data

Threats have not been documented specifically for Eastern pondmussels and their habitat, though the threats to other unionid mussels are well documented. The synergistic and long-term effect of the multiple kinds of chronic stresses on freshwater mussels is unknown.

3.4 Threat assessment research

Mussel surveys and additional land use data are needed in order to assess the potential for future development at Eastern pondmussel occurrence locations.

Element 4: Conservation Actions

4.1.1 Restoration and management

It is difficult to define specific conservation actions without information about distribution and abundance, reproduction, and life history of Eastern pondmussels. In general however, efforts are needed to protect riparian buffers, monitor pollution runoff from agricultural, residential, and commercial sources, intensify zebra mussel boat surveys, and further educate resident boat owners of the impacts of zebra mussel introduction.

Element 5: References

5.1 Literature:

Augspurger, T., A.E. Keller, M.C. Black, W.G. Cope, and W.G. Cope. 2003. Water quality guidance for protection of freshwater mussels (Unionidae) from Ammonia exposure. Environmental Toxicology and Chemistry. 22:2569-2575.

Cherry, D. S., T. W. Valenti, R. J. Currie, R. J. Never, J. W. Jones, R. A. Mair, and C. M. Kane. 2005. Chlorine toxicity to early life stages of freshwater mussels. Report submitted to U. S. Fish and Wildlife Service, Virginia Field Office, Gloucester, Virginia.

Clench, W.J. and H.D. Russell. 1938, Fresh Water Shells of New Hampshire. Biological Survey of the Connecticut River Watershed, Report Number 4, Museum of Comparative Zoology, Harvard University.

Corey, C. 2003. Freshwater Mussel Behavior: Displays by members of the genus *Ligumia* and habitat selection by juveniles of two species. Thesis presented to the faculty of the University at Albany, State University of New York.

Downing, J.A., Y. Rochon, M. Perusse, H. Harvey. 1993. Spatial aggregation, body size, and reproductive success in the fresh-water mussel *Elliptio complanta*. Journal of the North American Benthological Society. 12:148-156.

Hastie, L.C., P.J. Boon, M.R. Young, S. Way. 2001. The effects of a major food on an endangered freshwater mussel population. Biological Conservation. 98:107-115.

Lydeard C., R.H. Cowie, W.F. Ponder, A.E. Bogan,

P.Boucet, S.A. Clark, K.S. Cummings, T.J. Frest, O.Gargominy, C.G. Herbert, R. Hershler, K. E. Perez., B. Roth, M. Seddon, E.E. Strong, and F.G. Thompson. The global decline of nonmarine mollusks. 2004. Bioscience. 54:321-330.

Master, L.L., B.A. Stein, L.S. Hunter, G.A. Hammerson. 2000. Vanishing assets: Conservation status of U.S. species. In Stein, B.A., L.S. Kutner, and J.S. Adams, eds. Precious heritage: The status of biodiversity in the United States. Oxford University Press.

Metcalfe-Smith, J.L., S.K. Staton, G.L. Mackie, and N.M. Lane. 1998. Changes in the biodiversity of freshwater mussels in the Canadian waters of the lower Great Lakes drainage basin over the last 140 years. Journal of Great Lakes Research 24: 845-858.

Naimo, T.J. 1995. A review of the effects of heavy metals on freshwater mussels. Ecotoxicology. 4: 341-362.

Nedeau, E.J., M.A. McCollough, and B.I. Swartz. 2000. The freshwater mussels of Maine. Maine Department of Inland Fisheries and Wildlife, Augusta, Maine.

Nedeau, E. and J. Victoria. 2002. A field guide to the freshwater mussels of Connecticut. Connecticut Bureau of Natural Resources, Hartford, Connecticut.

Neves, R.J., A.E. Bogan, J.D. Williams, S.A. Ahlstedt, P.W. Hartfield. 1997. Status of aquatic mollusks in the southeastern United States: A downward spiral of diversity Pages 43-85 in Bens G.W., D.E. Collins, eds. Aquatic Fauna in Peril: The Southeastern Perspective. Decatur (GA): Lenz Design and Communications.

Newton, TJ., JW. Allran, J.A. O'Donnell, M.R. Bartsch, and W.B. Richardson. 2003. Effects of ammonia on juvenile unionid mussels (*Lampsilis cardium*) in laboratory sediment toxicity tests. Environmental Toxicology and Chemistry. 22:2554-2560.

Poole, K.E., J.A. Downing. 2004. Relationship of declining mussel biodiversity to stream-reach and watershed characteristics in an agricultural landscape. Journal of the North American Benthological Society. 23:114-125.

Richter, B.D., D.P. Braun, J.A. Mendelson, L.L. Master. 1997. Threats to imperiled freshwater fauna. Conservation Biology. 11:1081-1093.

Strayer, D.L and K.J. Jirka. 1997. The Pearly Mussels of New York State. The New York State Education Department. Albany, New York..

Strayer, D. L., D. R. Smith. 2003. A guide to sampling freshwater mussel populations. American Fisheries Society. Monograph 8, Bethesda, Maryland.

Strayer, D.L., J.A. Downing, W.R. Haag, T.L. King, J.B. Layzer, T.J. Newton, S.J. Nichols. 2004. Changing Perspectives on Pearly Mussels, North America's Most Imperiled Animals. BioScience. 54: 429-439.

Therres, G. D., Chairman of the Northeast Endangered Species and Wildlife Diversity Technical Committee. 1999. Wildlife species of regional conservation concern in the northeastern United States. Northeast Wildlife 54:93-100.

Villella, R.F., D.R. Smith, D.P. Lemaire. 2004. Estimating survival and recruitment in a freshwater mussel population using mark-recapture techniques. American Midland Naturalist. 151: 114-133.

Williams, J.D., M.L. Warren, Jr., K.S. Cummings, J.H. Harris, R.J. Neves. 1992. Conservation Status of Freshwater Mussels of the United States and Canada. American Fisheries Society. 18:6-22.

SPECIES PROFILE

Frosted Elfin

Callophrys (Incisalia) irus

Federal Listing: Not listed
State Listing: Endangered
Global Rank: G3
State Rank: S1
Author: NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The habitat of the frosted elfin in New Hampshire is identical to that of the federally endangered Karner blue butterfly (*Lycaeides melissa samuelis*): pine barrens with ample patches of blue lupine (*Lupinus perennis*), the only larval host plant (Schweitzer 1992, Swengel 1996). Whereas Karner blue butterfly larvae consume the leaves, frosted elfin larvae typically consume flowers and seedpods of the blue lupine (Swengel 1996). Flight period of the frosted elfin is from May to June, coinciding with the first flight of the Karner blue butterfly. Frosted elfin eggs are laid among the flower stalks and buds of the blue lupine (Swengel 1996). Larvae pupate underground and remain there until the following spring (Schwitzer 1992, Swengel 1996). For a detailed habitat description, see the Karner blue butterfly and pine barrens profiles.

1.2 Justification

The frosted elfin, along with the Karner blue butterfly, is an indicator of the health of the pine barrens habitat. As habitat goes unmanaged and reverts to a closed canopy system, the frosted elfin will die out. Frosted elfins are highly susceptible to population declines, which are a product of host plant specificity, environmental change, low dispersal rates, and small subpopulation size (Cushman and Murphy 1993), as well as cannibalism among larva. These factors are magnified by a severe loss of habitat. Nearly 90% of historic pine barrens communities along the Merrimack River have been lost, leaving a mere 560 fragmented acres, primarily in Concord (Helmbolt and Amaral 1994). Because frosted elfin eggs are laid among the flowers of the blue lupine, they are vulnerable to early summer mowing and incidental ingestion by herbivorous species.

1.3 Protection and Regulatory Status

The frosted elfin is listed as Endangered under the New Hampshire State Endangered Species Act. Blue lupine is listed as threatened in New Hampshire under the Native Plant Protection Act (RSA 217-A).

1.4 Population and Habitat Distribution

The range of the frosted elfin extends from northern New England across to New York, Ohio, Indiana, Michigan, and Wisconsin, and along the eastern seaboard with pockets in southern New Jersey, eastern Maryland, West Virginia, South Carolina, and northern Florida (Swengel 1986, Schwitzer 1992, NatureServe 2005). The frosted elfin is believed to have been extirpated in Ontario, Maine, and Illinois (NatureServe 2005).

In New Hampshire, populations of the frosted elfin currently occur only in the Concord Pine Barrens, but there are records from the towns of Webster and Durham from the early 1900s (NHNHB 2005). Numbers at the Concord Pine Barrens are low. Between 10 and 30 frosted elfin are observed each year during lepidopteran surveys conducted at the Concord Pine Barrens (Chandler 2002, NHFG). For details regarding habitat distribution, see Karner blue butterfly species profile and pine barrens habitat profile.

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

See Karner blue butterfly species profile and pine barrens habitat profile.

1.7 Sources of Information

Sources of information include field reports, agency data, scientific journal articles, and element occurrence databases.

1.8 Extent and Quality of Data

Lepidoptera surveys are conducted annually at the Concord Pine Barrens, and frosted elfin have been seen every year. Other areas where pine barrens habitat occurs have not been surveyed for frosted elfin.

1.9 Distribution Research

Survey other remnant pine barrens sites along the Merrimack River in Manchester and Bedford for frosted elfin. Historic frosted elfin observations in Webster and Durham warrant further investigation.

Elements 2-4: *See Karner Blue Butterfly and Pine Barrens profiles.*

Element 5: References

5.1 Literature:

Chandler, D.S. 2002. New Hampshire Army National Guard butterfly and moth survey, 2001 final report. University of New Hampshire. Durham, New Hampshire, USA.

Cushman, J.H. and D.D. Murphy. 1993. Susceptibility of Lycaenid butterflies to endangerment. Wings 17:16-21.

Helmbolt, K., and M. Amaral. 1994. Status of the Karner blue butterfly in New Hampshire. Pages 123-128 *in* Karner blue butterfly: a symbol of a vanishing landscape, D.A. Andow, R.J. Baker, and C.P. Lane, editors. Minnesota Agricultural Experiment Station. St. Paul, Minnesota, USA.

Schweitzer, D.F. 1992. *Incisalia irus* revisited: a response to Reverend Ronald Gatrelle. News of the Lepidopterists Society 4:69-70.

Swengel, A.B. 1996. Observations of *Incisalia irus* (Lepidoptera: Lycaenidae) in Central Wisconsin 1988-95. The Great Lakes Entomologist 29: 47-62.

5.2 Data Sources

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. Accessed 2005 March 30.

New Hampshire Natural Heritage Bureau. 2005. Database of rare species and exemplary natural community occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

SPECIES PROFILE

Indigo Duskywing
Erynnis baptisiae

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S1
Author: Alina, J. Pyzikiewicz, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The wild indigo duskywing (*Erynnis baptisiae*) is an associate of the federally endangered Karner blue butterfly (*Lycaeides melissa samuelis*) and lives in the grassy openings of pine barrens, under powerlines, and along roadsides where crown vetch (*Coronilla varia*) grows (Schweitzer 1992, Glassberg 1993, Mello 1998). Wild indigo (*Baptisia tinctoria*) and blue lupine (*Lupinus perennis*) were historically the predominant larval host plants, but as these plants have declined in number, wild indigo duskywing began to feed on crown vetch (Schweitzer 1992, Glassberg 1993, Mello 1998). Adult wild indigo duskywings fly from late April to early June and again in July and August (Scott 1986). Eggs are laid singly on the host plant, and the second brood larvae overwinter (Scott 1986). For a detailed habitat description, see Karner blue butterfly species profile and the Pine Barrens habitat profile.

1.2 Justification

The wild indigo duskywing, along with the Karner blue butterfly, frosted elfin (*Callophrys* [*Incisalia*] *irus*), and Persius duskywing (*Erynnis persius persius*), is an indicator of the health of the pine barrens habitat. It is in severe decline in the eastern part of range due to habitat loss and fire suppression (Schweitzer 1992); nearly 90% of historic pitch pine-scrub oak barren communities along the Merrimack River have been lost, leaving a mere 560 fragmented acres, primarily in Concord (Helmbolt and Amaral 1994).

With the decline of wild indigo and blue lupine, the wild indigo duskywing became uncommon in the eastern part of its range. It has since adapted to utilize crown vetch as its larval host plant, and is rapidly colonizing areas where crown vetch is planted (along roadways and airports). Wild indigo duskywing is extremely difficult to identify in the field due to its similarity to other members of the *Erynnis* genus, and therefore there is some uncertainty about larval food plants and specific habitat requirements (Schweitzer 1992).

1.3 Protection and Regulatory Status

Although the wild indigo duskywing is not state or federally listed, it is protected as an associate of blue lupine, which is listed as threatened in New Hampshire and protected under the Native Plant Protection Act (RSA 217-A).

1.4 Population and Habitat Distribution:

The wild indigo duskywing was uncommon until larvae became adapted to crown vetch. It is now widespread and is expanding its range from New England and extreme southern Ontario southward to the Gulf Coast states excluding Florida, and westward to Minnesota, central Nebraska, and south central Texas (Opler and Malikul 1992, Glassberg 1993).

In New Hampshire, the wild indigo duskywing was observed in 1986 under the power lines along Merrill Hill in Hudson (New Hampshire Natural Heritage Bureau 2005). Wild indigo duskywings have also been positively identified in the Concord pine barrens during lepidopteran surveys conducted there in 1998 and 2001 (Mello 1998, Chandler 2001).

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

N/A

1.7 Sources of Information

Sources of information include field reports, field guides, and element occurrence databases.

1.8 Extent and Quality of Data

There are only two documented occurrences of the wild indigo duskywing in New Hampshire (Mello 1998, Chandler 2001, NHNHB 2005). Since this species is very similar to other members of the *Erynnis* genus, proper identification in the field is challenging.

1.9 Distribution Research

Before initiating surveys for this species, voucher specimens are needed and distinguishing characteristics should be noted.

Elements 2-4: *See the Karner Blue Butterfly and the Pine Barrens profiles.*

Element 5: References

5.1 Literature

Chandler, D.S. 2001. New Hampshire Army National Guard butterfly and moth survey, Concord, New Hampshire. University of New Hampshire, Durham, New Hampshire, USA.

Glassberg, J. 1993. Butterflies through binoculars: a field guide to butterflies in the Boston- New York –Washington region. Oxford University Press. New York, New York, USA.

Helmbolt, K., and M. Amaral. 1994. Status of the Karner blue butterfly in New Hampshire. Pages 123-128 *in* Karner blue butterfly: a symbol of a vanishing landscape, D.A. Andow, R.J. Baker, and C.P. Lane, editors. Minnesota Agricultural Experiment Station. St. Paul, Minnesota, USA.

Mello, M. 1998. Survey of state-listed and other rare Lepidoptera at proposed Army National Guard, Army Aviation Support Facility lease property, Regional Drive, at Concord Municipal Airport and at other sites within Concord New Hampshire's pine barrens. Lloyd Center for Environmental Studies, South Dartmouth, Massachusetts, USA.

Opler, P.A., and V. Malikul. 1992. Peterson field guides: eastern butterflies. Houghton Mifflin. New York, New York, USA.

Schweitzer, D. 1992. *Erynnis persius persius* and *Incisalia irus*. The Nature Conservancy, Memorandum of March 3, 1992.

Scott, J.A. 1986. The butterflies of North America: a natural history and field guide. Stanford University Press. Stanford, California, USA.

5.2 Data Sources

New Hampshire Natural Heritage Bureau. 2005. Database of rare species and exemplary natural community occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

SPECIES PROFILE

Karner Blue Butterfly

Lycaeides melissa samuelis

Federal Listing: Endangered
State Listing: Endangered
Global Rank: G5T2
State Rank: S1
Author: NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Karner blue butterflies inhabit pine barrens, an early-successional community composed of 4 distinct vegetative strata: herbaceous, heath, scrub, and canopy. Within the scrub and canopy strata, shade-providing pitch pine (*Pinus rigida*) and scrub oak (*Quercus ilicifolia*) dominate. The lower strata include grasses, vascular plants, and heath. Throughout these layers little bluestem (*Schizachyrium scoparium*) and big bluestem (*Andropogon gerardii*) are the principle grass species, affording roost sites and predator protection by attendant ants. New Jersey tea (*Ceanothus americanus*), spreading dogbane (*Apocynum androsaemifolium*), lowbush blueberry (*Vaccinium angustifolium*), and huckleberry (*Gaylussacia bacata*), as well as state threatened blue lupine (*Lupinus perennis*), blunt-leaved milkweed (*Asclepias amplexicaulis*), and golden heather (*Hudsonia ericoides*) comprise the majority of the herbaceous and heath layer and provide a critical source of nectar (United States Fish and Wildlife Service 2003). Spatially, these strata form a heterogeneous matrix of open, sub-canopied, and canopied habitat patches across the landscape, which in turn create a gradient of light intensities and thermal conditions necessary for habitat-specific behaviors. Temporally, this structural diversity is in constant flux, a process maintained by periodic disturbance, namely fire. Currently, Karner blue butterflies are restricted to fragmented pine barren remnants, highway and powerline rights-of-way, airports, military camps, and gaps in forest stands that support their obligate host plant, blue lupine (USFWS 2003).

1.2 Justification

Karner blue butterflies, as well as other members of the family Lycaenidae, are highly susceptible to environmental changes and population declines, which are a product of their host plant specificity, symbiotic relationship with attendant ants, low vagility, and small subpopulation size (Cushman and Murphy 1993, Grundel et al. 1999). Additionally, Karner blue butterflies have behavior-specific habitat requirements, where canopy heterogeneity is essential for successful mating, breeding, oviposition, and nectaring (Grundel et al. 1998b). Such specialization gives Karner blue butterflies the designation of an umbrella species. Not only do they serve as an indicator of habitat quality, but management for their stringent habitat requirements meets the needs of other state endangered and threatened wildlife species as well, thereby maximizing overall biodiversity throughout the community. Associated species include frosted elfins (*Incisalia irus*) and Persius duskywing skippers (*Erynnis persius persius*) whose larvae also feed solely on wild lupine, as well as pine barrens zanclognatha moths (*Zanclognatha martha*), eastern hognose snakes (*Heterodon platirhinos*), grasshopper sparrows (*Ammodramus savannarum*), and common nighthawks (*Chordeiles minor*).

The limiting factors for Karner blue butterflies have been compounded by a severe loss of habitat. Nearly 90% of historic pine barren communities along the Merrimack River have been lost (Helmbolt and Amaral 1994). Without enough suitable habitats to support a viable population, Karner blue butterflies became extirpated in New Hampshire in 2000 (Amaral 2000), and were subsequently reintroduced.

1.3 Protection and Regulatory Status

- National Plant Protection Act: promotes the preservation of blue lupine, blunt-leaved milkweed, and golden heather (*Hudsonia ericoides*) on state lands, but provides no protection on private property (VanLuven 1994)
- RSA 217-A, Native Plant Protection Act: blue lupine is threatened in New Hampshire and thus cannot be disturbed on public land

1.4 Population and Habitat Distribution

The distribution of Karner blue butterflies is largely dependant on the availability of blue lupine, the larval food source, and preferred native nectar sources (Schultz and Dlugosch 1999). These plants occur in pine barrens habitat. These pine barren communities occur primarily on glacially deposited sand, shale, and serpentine soil types in parts of eastern North America (Sutton 1925). In New Hampshire, this community type once spanned the Merrimack River valley from Canterbury to Nashua, occupying Windsor sandy loams and Hinckley cobbly sandy loams (VanLuven 1994). Today, only one site in New Hampshire, the Concord pine barrens, supports a population of Karner blue butterflies. Prior to their extirpation in 2000, Karner blue butterflies inhabited 2 sites within the 227 ha (563 ac) of the Concord Pine Barrens (Schweitzer 1983). A reintroduction program has since been initiated to restore viable metapopulations of Karner blue butterflies throughout their range.

Locally, the Concord population represents the easternmost extent of this species' distribution and is separated from the nearest population in New York by over 225 km (140 mi) (Helmbolt and Amaral 1994). Regionally, Karner blue butterflies formerly occurred in a band extending across 12 states from Minnesota to Maine and in the province of Ontario, Canada, but now only occur in the 7 states of Minnesota, Wisconsin, Indiana, Michigan, New York, New Hampshire, and Ohio (USFWS 2003).

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

Incomplete

1.7 Sources of Information

Information on Karner blue butterfly habitat, population distribution, and status was collected from habitat and recovery conservation plans, technical field reports, agency data, and scientific journals.

1.8 Extent and Quality of Data

The Karner blue butterfly is one of the most intensely managed and monitored species in New Hampshire. The Concord pine barrens have been monitored for Karner blue butterflies for at least the past 20 years and results are well documented.

1.9 Distribution Research

A captive rearing and reintroduction program initiated by TNC in 1992 and then continued under the direction of NHFG in 2000 has worked towards restoring viable metapopulations of Karner blue butterflies throughout their historic range. Dispersal and colonization rates have been monitored to adequately assess habitat utilization, movement patterns, and reintroduction success (Fuller et al. 2003). Current distribution data should be acquired, and historic observations in Webster, Manchester, Milford, and south Merrimack warrant further investigation.

Element 2: Species/Habitat Condition

2.1 Scale

Conservation Zones as delineated under the Concord Municipal Airport Development and Conservation Management Agreement (2000) will be used as the conservation-planning unit for Karner blue butterflies. Outlying historic populations and remnant habitat patches may be treated independently.

2.2 Relative Health of Populations

Historically, Karner blue butterflies occurred in 5 sites in New Hampshire: Milford (1880), Merrimack (1880), Webster (1896), Manchester (no date), and Concord (New Hampshire Natural Heritage Bureau 2005). Of these sites, the Concord pine barrens supported the last remaining native population in the state. In 1980, an estimated 3,700 butterflies occu-

pied this area but the population was soon reduced to less than 50 by 1994 (Schweitzer 1983, Peteroy 1998). Extirpation followed in 2001, resulting in the initiation of a captive rearing and reintroduction program (USFWS 2003). Translocation success is difficult to measure in the short term, but survey results suggest that more than 100 Karner blue butterflies completed their life cycles in the wild during 2003. The New Hampshire population will be designated as fully recovered upon the establishment of one metapopulation of at least 1,500 first brood or second brood adults that is sustained for a minimum of 5 years (USFWS 2003).

2.3 Population Management Status

Release of translocated captive-reared butterflies has been underway at Concord Municipal Airport since 2001 (USFWS 2003). Habitat restoration and reserve design has been developed in a metapopulation context, with intensive restoration sites connected by managed corridors (Fuller et al. 2003).

2.4 Relative Quality of Habitat Patches

The minimum habitat requirements of Karner blue butterflies include: 1) suitable habitat and occupied sites greater than 0.25 ha, 2) small areas (0.25-5 ha [) having at least 500 blue lupine stems per 0.4 ha or 810 blue lupine stems per 0.4 ha, 3) larger habitat areas (>5 ha) having at least 0.1 blue lupine stem per m^2 or 405 blue lupine stems per 0.4 ha, 4) available nectar for each adult butterfly flight period, and 5) habitat heterogeneity (USFWS 2003). Based on these criteria, the South Airport Conservation Zone (144 ha) and the North Airport Conservation Zone (24 ha), both of which support the largest population of blue lupine and nectar plants, are considered the highest quality and most critical habitat patches (VanLuven 1994).

2.5 Habitat Patch Protection Status

Approximately 227 ha of the remnant Concord pine barrens are protected through the Concord Municipal Airport Development and Conservation Management Agreement (2000). Conservation Zones have been established on the 227 ha of airport land, which will be managed to enhance and restore critical habitat for Karner blue butterflies as well as a suite of other rare species. The land is owned by the city of Concord, with an 11 ha conservation easement granted to the USFWS. The conservation easement is open to the public but wheeled vehicles are forbidden. The 1 ha left of the historic main site, located along a powerline right-of-way, is privately owned, and maintained by Public Service of New Hampshire.

2.6 Habitat Management Status

Current habitat management and restoration techniques used in the Conservation Zones include native plant propagation, vegetation management using specialized mowers and feller bunchers, and prescribed fire. These techniques are used to create sandy and herbaceous openings within a matrix of heath, scrub-shrublands, and woodlands. Habitat monitoring is completed before and after management implementation. The goal is to create a shifting mix of native grassland, shrubland, and woodland features (Fuller et al. 2003).

2.7 Sources of Information

Information on habitat protection and management was obtained from Concord pine barrens recovery and management plans.

2.8 Extent and Quality of Data

The Karner blue butterfly is one of the most intensely monitored and studied species in New Hampshire. The Concord pine barrens have been monitored for Karner blue butterflies for at least the past 20 years. Blue lupine has been mapped and/or monitored for almost 10 years.

2.9 Condition Assessment Research

Habitat quality and restoration feasibility of the Goldstar Farms easement in Canterbury, New Hampshire needs to be evaluated. Further investigation of historic occurrence records associated with this location is needed.

Element 3: Species and Habitat Threat Assessment

3.1.1 Development (Habitat Loss and Conversion)

(A) Exposure Pathway
The properties associated with pine barrens communities (i.e., sandy soils, high stability, high permeability, low compaction, and ease of excavation) make them optimal for development. Both commercial and residential developments contribute to habitat reduction and fragmentation. As habitat is lost and becomes more fragmented, colonization of the remaining habitat patches becomes increasingly difficult. Population reduction and extirpation or extinction is the ultimate result if habitat conditions are not improved. Karner blue butterfly populations fluctuate widely. As local populations become extinct, it is improbable that recolonization will occur.

(B) Evidence
Karner blue butterflies have a positive association with habitat areas that are large, have high light intensity, and are recently managed (Smallidge et al. 1996). Extensive commercial and residential development of the Concord pine barrens has severely reduced habitat for Karner blue butterflies. About 5-10% of the original Concord pine barrens remains today, and virtually all pine barrens south of Concord have been lost (Helmbolt and Amaral 1994).

3.1.2 Scarcity (Natural Variation on Reproductive Success)

(A) Exposure Pathway
Cool/wet and hot/dry conditions can delay or accelerate Karner blue butterfly larval hatching and development, reduce adult flight times, mating opportunities, and oviposition rates, and upset host plant-larvae synchronicity (Schweitzer 1989). Natural variation in weather may result in wide population fluctuations. Added to depressed population size, wide population fluctuations may result in local extinction.

(B) Evidence
Monitoring trends for northeastern populations show that annually, Karner blue butterfly populations fluctuate widely (S. Fuller, NHFG, unpublished data, K. O'Brien, New York Endangered Species Program, unpublished data). Captive rearing programs at the Toledo Zoo in Ohio and Concord, New Hampshire report that mating and oviposition are related to environmental factors (New Hampshire Fish and Game unpublished data, Toledo Zoo unpublished data). The especially cool wet spring during the 2003 Karner blue butterfly season in New York resulted in a population crash of first brood adults (K. O'Brien, New York Endangered Species Program, personal communication).

3.1.3 Development (Dispersal Barriers)

(A) Exposure Pathway
Development is occurring rapidly in the area surrounding the Concord Municipal Airport. Karner blue butterflies utilize grassy openings, but paved areas, buildings, and closed-canopy forest stands are increasingly dominant on the landscape. As a result, dispersal is limited, even when high quality habitat is restored.
Land managers face the challenge of not only maintaining quality habitat, but also ensuring that habitat patches are situated over the landscape in a manner that allows movement and genetic exchange among patches (Grundel et al. 1999). The presence of nectar sources between sites can enhance inter-site dispersal (King 1998b).

(B) Evidence
The implications of disrupted metapopulation processes are well documented in the literature for Lepidoptera. Dispersal between subpopulations may be depressed in metapopulations fragmented by paved areas, limiting the establishment of new colonies and viability of existing ones. Karner blue butterflies are less likely to fly over paved areas, around buildings, or through closed-canopy forest stands (King 1998a, Grundel et al. 1999, Fuller, unpublished data). Karner blue butterflies may become 'stuck' at the edges of paved areas. Shopping centers, an industrial park, and the Concord Municipal Airport fragment remnant habitat patches.

3.1.4 Introduced Species (Introduced Insects)

(A) Exposure Pathway
Biological controls for horticultural pests may be

detrimental to Karner blue butterfly populations via multiple pathways. Ladybird beetles (*Coccinella septempunctata*) and parasitic wasps that are used to control aphids may prey on Karner blue butterfly larvae. Aphids feed on the fluids of blue lupine, causing the plants to wilt and become unsuitable food for Karner blue larvae.

(B) Evidence
Koch et al. (2003) observed that Asian lady beetles (*Harmonia axyridis*) that are used for biological control of aphid species were a significant predator of immature monarch butterflies (*Danaus plexippus*). Escaped parasitic wasps and flies have been known to utilize native lepidopteran hosts.

3.1.5 Altered Natural Disturbance Regime (Natural Succession)

(A) Exposure Pathway
Suppression of wildfires can lead to succession of pine barrens communities to closed-canopy forest communities, eliminating suitable habitat for blue lupine and Karner blue butterflies. A lack of a regular mild fire regime may result in fuel loading. In a fuel-loaded system, fires may reach a higher intensity than fires in a well-maintained system, which would impact the remnant habitat patches more broadly and severely and potentially lead to direct mortality of Karner blue butterfly populations.

(B) Evidence
Before intense management practices were initiated at the Concord pine barrens in 1994, the area had reverted to closed-canopy pine forests and woodlands, mixed scrub thickets, and disturbed grassy openings (VanLuven 1994). Karner blue butterflies prefer early to mid-successional habitats whose suitability can deteriorate in a few years in the absence of disturbance (Grundel et al. 1999). Woodland management policies that do not promote opening of canopies often negatively affect Karner blue butterfly habitat (Grundel et al. 1998a). Increased canopy cover is a major factor implicated in the decline of Karner blue butterflies at many locales (Grundel et al. 1998b).

3.1.6 Predation and Herbivory

(A) Exposure Pathway
Access to protected Karner blue butterfly habitat is limited for hunters and predators. Heavy browsing of blue lupine plants by white-tailed deer (*Odocoileus virginianus*) and woodchuck (*Marmota monax*) could severely reduce blue lupine populations and result in Karner blue butterfly mortality by accidental ingestion of eggs and larvae.

(B) Evidence
Approximately 80% of the blue lupine plants that were planted in 2 restoration plots (including a captive breeding release site) had their flower stalks removed by grazing during 2004 (NHFG, unpublished data). Significant browse is common in blue lupine populations (USFWS 2003).

3.1.6 Altered Natural Disturbance Regime (Mowing)

(A) Exposure Pathway
The majority of extant Karner blue butterfly habitat has been maintained inadvertently via non-conservation land uses, such as maintenance of powerline rights-of way and airport runway safety zones. The optimal window (April-August) for mechanical vegetation management practices such as mowing coincides with the blue lupine growing season and sensitive phases of the Karner blue butterfly life cycle. Mowing during this period may cause blue lupine mortality, reduce seed production, reduce forage for emerging larvae, dislodge eggs and larvae from hosts, or cause direct mortality of any life stage. There is currently no established forum for communication between wildlife managers and other land managers to reduce these impacts.

(B) Evidence
Extensive mowing occurs on the Concord Municipal Airport to manage the runway safety and approach areas. Mowing also occurs along fence-lines for security purposes. In spite of regulatory efforts, mowing and other non-compatible land-uses have inadvertently occurred. It is difficult to document direct mortality because plant cuttings (blue lupine) can easily be spread far from established plants by rotating blades.

3.2 Sources of Information

Information on threats was taken from the Karner blue butterfly recovery plan, habitat conservation plan, scientific journal articles, and personal communications and observations.

3.3 Extent and Quality of Data

Threats to Karner blue butterflies and their habitat are well documented in management and conservation plans. While there may be little evidence documenting the actual occurrence of certain threats, the potential for the threat to occur is well documented.

3.4 Threat Assessment Research

- Identify threatening introduced insect species
- Assess impact of herbivory on butterflies
- Evaluate impacts of maintenance mowing on Karner blue butterflies

Element 4: Conservation Actions

4.1.1 Habitat Management

(A) List of Direct Threats Affected: Habitat loss, succession, and barriers to dispersal

(B) Justification
Habitat management will increase the availability of suitable habitat in areas currently or potentially occupied by Karner blue butterflies by converting closed-canopy stands to an early-successional structure. Standard habitat management techniques including forestry, fire, and herbicide have well-documented efficacy in reducing the cover of canopy-forming, shade-tolerant, and fire-sensitive species. The technique, frequency, and intensity of management will be prescribed to increase light reaching the herbaceous strata, to create soil disturbances, and to connect existing blue lupine populations. Open-canopy corridors will offset failed dispersal and foraging in impermeable and/or unsuitable landscapes, such as the edges of runways and roads.

Blue lupine and early-successional nectar plant species abundances increase in response to a broad range of vegetation management techniques (Smallidge et al. 1996). Management creates areas of open or semi-open habitat that provide a range of light intensity and diverse vegetation, all necessary for successful dispersal, foraging, and oviposition (Grundel 1998a). Habitat heterogeneity satisfies microhabitat needs and moderates the impact of large-scale environmental events (USFWS 2003). Habitat management also provides connectivity among resource-rich habitat patches, increasing dispersal rates, colonization, and overall suitable habitat area.

Karner blue butterfly populations have persisted in landscapes of similar structure and lesser size than the area managed in Concord. Habitat management is necessary to prevent the loss of protected habitat to succession, but is not adequate to secure unprotected remnants and buffer existing conservation land from development.

Restorative management intensity is high in the short-term, but can be reduced to a sustainable maintenance level in the long-term. Depending upon the intensity of management, beneficial responses can be observed in 0-3 years, and maintained with management on a 5-10 year rotation.

The densities of blue lupine and other early successional plants can be controlled and maximized by adjusting the frequency and intensity of habitat management to modify current densities of canopy species and scrub oak. The prescription may be adapted to guide management in new habitat areas.

(C) Conservation Performance Objective
The habitat management performance objective is to create a matrix of interconnected grasslands, shrublands, and woodlands by manipulating the densities of woody species in key vegetative strata. Management schedules and target levels for management units by strata and species are described in Fuller et al. (2003). Progress toward target levels (i.e., reduction in canopy and shrub strata) will indicate the performance of habitat management.

(D) Performance Monitoring
Densities of woody species will be monitored as prescribed in Fuller et al. (2003) prior to implementation of management and in subsequent years.

(E) Ecological Response Objective
The habitat management response objective is to increase the densities of blue lupine, key nectar plant species, and the proportion of early successional veg-

etative strata. Target levels for management units by strata and species are described in Fuller et al. (2003). Progress toward target levels (i.e., increase in blue lupine and nectar plant species densities and in proportion to sand, herbaceous, and heath strata) will indicate a beneficial response to habitat management.

(F) Response Monitoring
The density of blue lupine and richness of other key habitat plants will be monitored as prescribed in Fuller et al. (2003) prior to implementation of management and in subsequent years.

(G) Implementation
NHFG, NHDRED, the New Hampshire Army National Guard, USFWS, the Federal Aviation Administration, and the City of Concord will cooperate to implement habitat management as per the Concord Municipal Airport Development and Conservation Management Agreement (2000), the management plan (Fuller et al., 2003), and under the guidance of the management team.

(H) Feasibility
The partnership described has successfully implemented habitat management. Future feasibility is limited only by funding, which is secure through 2012.

4.1.2 Education and Outreach

(A) List of Direct Threats Affected
Habitat loss, barriers to dispersal, succession, mowing during critical periods

(B) Justification
Engaging the public to propagate habitat plants on public and private land will increase the habitat available to Karner blue butterflies. School children have successfully planted over 1,000 blue lupine plants. Informing the public about native plants will increase the availability of habitat in developed landscapes, and reduce the frequency of mowing habitat plants during critical periods.

Karner blue butterflies have been documented ovipositing and feeding on blue lupine planted by schoolchildren. In areas outside Concord where mowing has been controlled, Karner blue butterfly populations have flourished. Studies have shown that Karner blue butterflies use commercial and residential landscape plants to augment 'natural' habitat.

Karner blue butterfly populations and restoration efforts are currently restricted to Concord, New Hampshire. Efforts will be targeted towards decision-makers, professionals, landowners, and school children within the Concord community.

Restoration and recovery of Karner blue butterflies and their habitat is ongoing and the importance of this work needs to be addressed now and in the long term. Children that plant blue lupine today will provide an immediate benefit, and may support recovery efforts as adults.

Education and outreach can be molded to meet different target audiences (landowners vs. school children) or habitat areas (private land vs. public land), and evolve as new techniques are developed. Content of educational materials can be geared towards specific threats to Karner blue butterflies and their habitat.

(C) Conservation Performance Objectives
- Increase the number of blue lupine plants planted by schoolchildren and other volunteers to more than 500 plants per year for the next 5 years
- Within 5 years, increase the proportion of residential or commercial landowners adopting Karner blue butterfly-friendly management and landscaping practices to more than one-half for buildings currently existing within the potential habitat area
- Within 5 years, increase the proportion of new developments maintained in Karner blue butterfly-friendly management and landscaping practices to more then one-half of the new development plans approved by local planning boards within the potential habitat area
- Increase volunteer participation in restoration activities to more than 20 per year for the next 5 years.

(D) Performance Monitoring
Performance may be monitored via: documentation of the number of blue lupine plants planted each year by school children and other volunteers; random surveys of Concord Heights landowners to determine current land management practices; documenting number of approved plans that adopt Karner blue butterfly-friendly landscaping and management practices; and documenting the number of competent and reliable volunteers.

(E) Ecological Response Objective
The desired ecological response is to increase the availability of blue lupine and nectar plants within and between habitat restoration areas. Successful education and outreach will be indicated by Karner blue butterfly utilization of plants propagated by school children and by Karner blue butterfly utilization of new and existing developed landscapes managed under Karner blue butterfly-friendly programs.

(F) Response Monitoring
Karner blue butterfly use of plants propagated by school children will be documented when it is observed during structured population monitoring as described in the management plan (Fuller et al. 2003). As suitable landscaping is cultivated in the landscape surrounding restoration areas, monitoring will be adapted (with landowner permission) to document Karner blue butterfly movements through habitat between restoration areas.

(G) Implementation
Continue and expand the elementary classroom blue lupine planting program. This is a yearly program partnering NHFG, the National Wildlife Federation, the Roger Williams Park Zoo in Providence, Rhode Island, and the Concord school district funded by grants from Disney and Conservation License plates. Teachers participate in a training session on blue lupine propagation and pine barrens ecology, incorporate the material into curricula, and coordinate a hands-on field trip. Since 2000, over 2300 2nd and 4th graders from 8 local Concord grade schools have completed the program, and over 1,000 blue lupine plants have been planted in the wild. Schoolchildren from local Concord schools grow blue lupine in their classrooms in February and then transplant them in restored Karner blue butterfly habitat at the USFWS Karner Blue Butterfly Easement in May.

Provide native seed mixes to local residents, landscapers and business owners to incorporate into their landscaping. A training program for local landscapers and developers on how to incorporate native seed mixes and plantings into their landscape designs will be developed, along with providing native landscaping guidelines and sources for native seeds and plants. NHFG is collaborating with DRED, Roger Williams Park Zoo and local plant nurseries to collect native seed and prepare seed mixes for distribution. Initially these mixes will be used for NHFG conservation projects, and will be available to the public once a substantial seed bank is accrued.

Present to the Concord planning board and Conservation Commission lectures or materials that focus on ways to minimize impact to Karner blue butterflies and their habitat. NHFG will be contacted to review plans for projects that could potentially impact Karner blue butterflies and pine barrens, and offer guidance to minimize those impacts. Developers will be encouraged to landscape with native vegetation in areas adjacent to pine barrens.

Plan college level educational field trips to the captive rearing lab and pine barrens, targeting university wildlife management and biology students for volunteer and internship opportunities. Encourage butterfly and garden clubs to visit the pine barrens, and volunteer with plant propagation or captive rearing. Develop a volunteer recruitment, training, and maintenance program to involve volunteers in captive rearing and habitat management.

(H) Feasibility
The limiting factor in educational implementation is funding and personnel resources. NHFG is limited in staff and funding to carry out restoration and recovery work. More integration with the Public Affairs Division is needed to focus on education and outreach. Resources must be made available for targeted education material development and training. The National Wildlife Federation has assisted with blue lupine planting by school children and will continue to do so.

4.2 Conservation Action Research

Continue to monitor Karner blue butterfly populations, and search for additional areas where this species could flourish, particularly as pine barrens habitats are restored.

Element 5: References

5.1 Literature:

Cushman, J. H. and D. D. Murphy. 1993. Susceptibility of Lycaenid butterflies to endangerment. Wings 17:16-21.

Grundel, R., N.B. Pavlovic, and C.L. Sulzman.

1998a. The effect of canopy cover and seasonal change on host plant quality for the endangered Karner blue butterfly *(Lycaeides Melissa samuelis).* Oecologia 114: 243-50.

Grundel, R., N. B. Pavlovic, and C. L. Sulzman. 1998b. Habitat use by the endangered Karner blue butterfly in oak woodlands: the influence of canopy cover. Biological Conservation 85: 47-53.

Grundel, R., R. L. Knutson, and J. R. Kwilosz. 1999. Movement patterns and population characteristics of the Karner blue butterfly (*Lycaeides melissa samuelis*) at the Indiana Dunes National Lakeshore. Natural Areas Journal 19:109-120.

Grundel, R., N. B. Pavlovic and C. L. Sulzman. 2000. Nectar plant selection by the Karner blue butterfly (*Lycaeides melissa samuelis*) at the Indiana Dunes National Lakeshore. American Midland Naturalist 144: 1-10.

Helmbolt, K and M. Amaral. 1994. Status of the Karner blue butterfly in New Hampshire. Pages 123-128 *in* D.A. Andow, R.J. Baker, and C.P. Lane, eds. Karner blue butterfly: a symbol of a vanishing landscape. Minnesota Agricultural Experiment Station. St. Paul, Minnesota, USA.

King, R. 1994. Annual summary for Necedah National Wildlife Refuge. Necedah National Wildlife Refuge, Necedah, Wisconsin. USA.

King, R. S. 1998a. Dispersal of Karner blue butterflies (*Lycaeides melissa samuelis)* on Necedah National WildlifeRefuge. Transactions of the Wisconsin Academy of Science, Arts and Letters. 86:101-110.

King, R. S. 1998b. Spatial ecology, dispersal patterns and monitoring methods for the Karner blue butterfly, *Lycaeides melissa samuelis* on Necedah National Wildlife Refuge. Report submitted to the National Fish and Wildlife Foundation, U.S. Fish and Wildlife Service, and the Forest Industry. Necedah, Wisconsin. USA.

Konch, R. L. 2003. The multicolored Asian Lady beetle, *Harmonia azyridis*: A review of its biology, uses in biological control, and non-target impacts. Journal of Insect Science 3:32.

Peteroy, A. 1998. 1998 Karner blue butterfly monitoring results: Concord Pine Barrens, New Hampshire. The Nature Conservancy. Concord, New Hampshire, USA.

Schweitzer, D. F. 1983. Preliminary report on rare Lepidoptera of the Concord, New Hampshire pine barrens. U.S. Fish and Wildlife Service New England Field Office, Concord New Hampshire, USA.

Schultz, C. B., and K. M. Dlugosch. 1999. Nectar and hostplant scarcity limit populations of an endangered Oregon butterfly. Oecologia 119: 231-38.

United States Fish and Wildlife Service. 2003. Final recovery plan for the Karner blue butterfly (*Lycaeides melissa samuelis*). US Fish and Wildlife Service, Fort Snelling, Minnesota, USA

VanLuven, D. E. 1994. Site conservation plan for the Concord Pine Barrens, Concord New Hampshire. The Nature Conservancy, Concord, New Hampshire, USA.

5.2 Data Sources

New Hampshire Natural Heritage Bureau. 2005. Database of Rare Species and Exemplary Natural Community Occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

SPECIES PROFILE

Persius Duskywing

Erynnis persius persius

Federal Listing: Not listed
State Listing: Endangered
Global Rank: G5T1T3
State Rank: S1
Author: Alina, J. Pyzikiewicz, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The Persius duskywing is an associate of the Karner blue butterfly (*Lycaeides melissa samuelis*) and inhabits the grassy openings of the pine barrens (Schweitzer 1992, Kirk 1996). Blue lupine (*Lupinus perennis*) is the larval host plant for Persius duskywing larvae in the Northeast (Schweitzer 1992). Adult Persius duskywing skippers fly from May to mid-June, 1 to 2 weeks before the Karner blue butterfly (Schweitzer 1992, Kirk 1996). Eggs are laid on the underside of blue lupine leaves, and larvae live in rolled up leaf nests where pupa overwinter and pupate in the spring (Kirk 1996). For a detailed habitat description, see the Karner blue butterfly and pine barrens profiles.

1.2 Justification

The Persius duskywing, along with the Karner blue butterfly and frosted elfin (*Callophrys* [*Incisalia*] *irus*), is an indicator of the health of the pine barrens habitat. It is in severe decline in the eastern part of range and disappears before the Karner blue butterfly and frosted elfin as habitats degrade due to habitat loss and fire suppression (Schweitzer 1992). Nearly 90% of historic pine barren communities along the Merrimack River have been lost, leaving 560 fragmented acres, primarily in Concord (Helmbolt and Amaral 1994). The Persius duskywing is also extremely difficult to identify in the field due to its similarity to other members of the *Erynnis* genus, and therefore, there is some uncertainty about larval food plants and specific habitat requirements (Schweitzer 1992).

1.3 Protection and Regulatory Status

The persius duskywing is protected under the state endangered species act (RSA 212). Blue lupine is listed as threatened in New Hampshire under the Native Plant Protection Act (RSA 217-A).

1.4 Population and Habitat Distribution

Extant populations of the Persius duskywing occur in New England, New York, Pennsylvania, New Jersey, Michigan, Wisconsin, and Minnesota (Kirk 1996, NatureServe 2005). Persius duskywing are presumed extirpated in Ontario, along with the Karner blue butterfly and frosted elfin (NatureServe 2005).

In New Hampshire, the Persius duskywing skippers were documented in the pine barrens that ran along the southern portion of the Merrimack River in Merrimack (1879), Milford (1879), Hudson (1975), and Concord (1983, 1988, and 1990) (NHNHB 2005). Despite yearly lepidopteran surveys, the Persius duskywing has not been recorded since 1990 (Mello 1998, Chandler 2001).

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

N/A

1.7 Sources of Information

Sources of information include technical field reports, agency data, scientific journal articles, and element occurrence databases.

1.8 Extent and Quality of Data

There are only 6 documented occurrences of the persius duskywing in New Hampshire (NHNHB 2005). Since this species is very similar to other members of the *Erynnis* genus, proper identification in the field is challenging.

1.9 Distribution Research

Persius duskywing are extremely difficult to identify in the field. Before initiating surveys for this species, voucher specimens are needed and distinguishing characteristics should be noted.

Elements 2-4: *See Karner Blue Butterfly and Pine Barrens profiles.*

Element 5: References

5.1 Literature

Chandler, D.S. 2001. New Hampshire Army National Guard butterfly and moth survey, Concord, New Hampshire. University of New Hampshire, Durham, New Hampshire, USA.

Helmbolt, K., and M. Amaral. 1994. Status of the Karner blue butterfly in New Hampshire. Pages 123-128 *in* Karner blue butterfly: a symbol of a vanishing landscape, D.A. Andow, R.J. Baker, and C.P. Lane, editors. Minnesota Agricultural Experiment Station. St. Paul, Minnesota, USA.

Kirk, K. 1996. The Karner blue community: understanding and protecting associated rare species of the barrens. Wisconsin Department of Natural Resources, Madison, Wisconsin, USA.

Mello, M. 1998. Survey of state-listed and other rare Lepidoptera at proposed Army National Guard, Army Aviation Support Facility lease property, Regional Drive, at Concord Municipal Airport and at other sites within Concord New Hampshire's pine barrens. Lloyd Center for Environmental Studies, South Dartmouth, Massachusetts, USA.

Schweitzer, D. 1992. *Erynnis persius persius* and *Incisalia irus*. The Nature Conservancy, Memorandum of March 3, 1992.

5.2 Data Sources

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. Accessed 2005 April 4.

New Hampshire Natural Heritage Bureau. 2005. Database of rare species and exemplary natural community occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

SPECIES PROFILE

Phyllira Tiger Moth

Grammia phyllira

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G4
State Rank: S1
Author: NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The Phyllira tiger moth is a grassland species occurring in open, grassy areas including sand prairies, savannas, and pine barrens (NatureServe 2005). In New Hampshire, *Grammia phyllira* utilizes extensive areas of sandy soils associated with pine barrens or old fields (VanLuven 1994). This species is a generalist, with forbs, and presumably grasses, being the primary host plants (NatureServe2005, Wagner personal communication). The flight period of the *G. phyllira* is April to early October (Colvell 1984). For a detailed habitat description, refer to the pine barrens profile.

1.2 Justification

Incomplete

1.3 Protection and Regulatory Status

NHNHB (2005) has identified the *G. phyllira* as a species of very high importance, but the species is currently not protected.

1.4 Population and Habitat Distribution

There are several disjunct ranges for the *G. phyllira*, including the Atlantic coastal region from Maine to Florida as well as the Great Lakes Region from Colorado to Texas (NatureServe 2005, Ferguson et al. 1999). In New Hampshire, *G. phyllira* historically occurred in the towns of Lee, Jaffrey, and Webster. Only one specimen has been collected from the Concord Pine Barrens, in 1993.

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

See Karner blue butterfly species profile and the pine barrens habitat profile.

1.7 Sources of Information

Technical field reports, agency data, scientific journal articles, and element occurrence databases were used to determine *G. phyllira* habitat and distribution.

1.8 Extent and Quality of Data

Data for *G. phyllira* in New Hampshire are limited to the recorded sightings in Concord, Lee, Jaffrey, and Webster. Other areas where pine barrens habitat occurs in New Hampshire have not been surveyed for *G. phyllira*.

1.9 Distribution Research

Additional surveys should be conducted in known and potential sites to determine distribution, habitat requirements, and life history traits of *G. phyllira*. Current populations should be monitored for trends, and new sites containing key habitat elements should be surveyed.

Elements 2-4: *See Karner Blue Butterfly and Pine Barrens profiles.*

Element 5: References

5.1 Literature

Covell, C.V. Jr. 1984. Peterson Field Guides: Eastern Moths. Houghton Mifflin Company, New York, New York, USA.

5.2 Data Sources:

Ferguson, D.C., C.E. Harp, P.A. Opler, R.S. Peigler, M. Pogue, J.A. Powell, and M.J. Smith. 1999. Moths of North America. Jamestown, ND: Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/distr/lepid/moths/mothsusa.htm (Version 12DEC2003).

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. Accessed 2005 March 30.

New Hampshire Natural Heritage Bureau. 2005. Database of rare species and exemplary natural community occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

SPECIES PROFILE

Pine Barrens Zanclognatha

Zanclognatha martha

Federal Listing: Not listed
State Listing: Threatened
Global Rank: G4
State Rank: S1
Author: NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Zanclognatha martha occupies pine barrens (NatureServe 2005), an early-successional community occurring in coarse-textured, nutrient-poor, droughty soils and dominated by pitch pine (*Pinus rigida*) and scrub oak (*Quercus ilicifolia*) (Sperduto and Nichols 2004). The unique habitats vital to *Z. martha* are maintained by frequent disturbance (Wagner et al 2003, Sperduto and Nichols 2004). In New Hampshire, *Z. martha* is associated with open pitch pine forests with a scrub oak-ericaceous understory or closed pitch-scrub oak within the pitch pine-scrub oak woodland system (Mello 1998). The natural history of *Z. martha* has not been fully described. It is thought that the larvae overwinter on the forest floor at the fourth instar stage. Pitch pine was previously considered to be the larval host plant, but more recent research has revealed that *Z. martha* is a detritivore, feeding on dead organic matter, most likely oak leaves (Warren Kiel, personal communication 1994, Massachusetts Natural Heritage 1999). Adults are nocturnal and fly from mid-July to early August (Van Luven 1994).

1.2 Justification

Like other pine barrens lepidoptera, *Z. martha* is an indicator of habitat health. As habitat is lost and fragmented, pine barrens transition to a closed canopy system. As a result, *Z. martha* dies off.

1.3 Protection and Regulatory Status

Z. martha is listed as threatened under the state Endangered Species Act (RSA 212). Refer to the pine barrens profile for habitat protection status.

1.4 Population and Habitat Distribution

Z. martha occurs in Maryland, Virginia, New York, Pennsylvania, New Jersey, Connecticut, Massachusetts, Maine, New Hampshire, Rhode Island, and Vermont (NatureServe 2005). It is very common in parts of New Jersey, but is localized in the remainder of its range (Massachusetts Natural Heritage 1999), NatureServe 2005). In New Hampshire, *Z. martha* has been recorded at 3 sites, including the West Branch of the Ossipee Pine Barrens (1995), the Concord Pine Barrens surrounding the Concord Municipal Airport (1992, 2001), and in the city of Manchester along an old railroad bed flanking the Piscataquog River (2001). Populations are most abundant in mature pitch pine-dominated woodlands (Chandler 2002). Despite encroaching development, *Z. martha* appears capable of maintaining populations within these forests (Chandler 2002).

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

1.7 Sources of Information

Habitat and distribution information was obtained from the NatureServe website, state agency literature, field guides, and habitat recovery and conservation plans.

1.8 Extent and Quality of Data

Very little is known about the distribution and natural history of *Z. martha* because of its rarity. Occurrence data were obtained from lepidopteran moth surveys conducted by NHFG, TNC, and university biologists.

1.9 Distribution Research

Additional surveys should be conducted in known and potential sites to determine distribution, habitat requirements, and life history traits of *Z. martha*. Current populations should be monitored for trends, and new sites containing key habitat elements should be surveyed for new occurrence data.

Elements 2-4: See the Karner blue butterfly profile and the pine barrens profile.

Element 5: References

5.1 Literature

Chandler, D.S. 2002. New Hampshire Army National Guard butterfly and moth survey, 2001 final report. University of New Hampshire. Durham, New Hampshire, USA.

Farquhar, D.W. 1933-35. List of the Lepidoptera of New England. Unpublished thesis, Harvard University. Collected in Webster, New Hampshire.

Mello, M.J. 1998. Survey of state-listed and other rare Lepidoptera at proposed New Hampshire Army National Guard, Army Aviation Support Facility lease property, Regional Drive at Concord Municipal Airport and at other sites within Concord New Hampshire's Pine Barrens. Report submitted to the New Hampshire Army National Guard, by the Lloyd Center for Environmental Studies. South Dartmouth, MA.

Schweitzer, D.F. 1983. Rare Lepidoptera of the concord, N.H. Pine Barrens with Suggestions for a Potential Preserve. Prepared for the Nature Conservancy, Boston, Massachusetts, USA.

5.2 Data Sources

Kiel, W. 1985. March 20 1994 letter to Julie Malech NHFG from Warren J. Kiel

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. Accessed 2005 March 30.

New Hampshire Natural Heritage Bureau. 2005. Rare plants, rare animals, and exemplary natural communities in New Hampshire towns. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

SPECIES PROFILE

Pine Pinion Moth

Lithophane lepida lepida

Federal Listing: Not listed
State Listing: Threatened
Global Rank: G4T3T4
State Rank: S1S2
Author: NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

In New Hampshire, the pine pinion occupies pine barrens (NatureServe 2005), early-successional communities dominated by pitch pine (*Pinus rigida*) and scrub oak (*Quercus ilicifolia*) (Sperduto and Nichols 2004). Larval host plants of the pine pinion include red pine (*Pinus resinosa*) and other hard pines (NatureServe 2005, Wagner personal communication). The flight period is from October to late March or early May. Individuals eclose in the fall, overwinter as adults, and emerge again in the spring. For a detailed habitat description, refer to the pine barrens profile.

1.2 Justification

The pine pinion, along with other pine barrens specialists, serves as an indicator of ecological condition. As the habitat goes unmanaged and reverts to a closed canopy system, pine pinion populations become increasingly vulnerable to extirpation.

1.3 Protection and Regulatory Status

The pine pinion is listed as threatened under the New Hampshire State Endangered Species Act.

1.4 Population and Habitat Distribution

Regionally, the pine pinion is spottily distributed from Nova Scotia to Saskatchewan and north to the Pas, Manitoba in Canada. In the United States, it is found in Maine, New York, New Hampshire, and Michigan (NatureServe 2005). In New Hampshire, the species is limited to the xeric pine habitat in the south-central and southern part of the state (Letter from Warren J. Kiel to Julie Malech, 20 March 1994) where it has been documented in the town of Webster and, more recently, in West Branch Pine Barrens in Madison (Farquhar 1933-1935).

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

See Karner blue butterfly species profile as well as the pine barrens habitat profile.

1.7 Sources of Information

Technical field reports, agency data, scientific journal articles, and element occurrence databases were used to determine pine pinion habitat and distribution.

1.8 Extent and Quality of Data

Lepidopteran surveys have been conducted at the Concord Pine Barrens and the West Branch Pine Barrens Reserve. Other areas where pine barrens habitat occurs in New Hampshire have not been surveyed for pine pinions.

1.9 Distribution Research

Additional surveys should be conducted in known and potential sites to determine distribution, habitat requirements, and life history traits of the pine pinion. Current populations should be monitored for

trends, and new sites containing key habitat elements should be surveyed.

Elements 2-4: *See Karner Blue Butterfly and Pine Barrens profiles.*

Element 5: References

5.1 Literature

Farquhar, D.W. 1933-35. List of the Lepidoptera of New England. Unpublished thesis, Harvard University. Collected in Webster, New Hampshire.

Helmbolt, K., and M. Amaral. 1994. Status of the Karner blue butterfly in New Hampshire. Pages 123-128 *in* Karner blue butterfly: a symbol of a vanishing landscape, D.A. Andow, R.J. Baker, and C.P. Lane, editors. Minnesota Agricultural Experiment Station. St. Paul, Minnesota, USA.

Schweitzer, D.F. 1983. Rare Lepidoptera of the Concord, N.H. Pine Barrens with suggestions for a potential preserve. Prepared for the Nature Conservancy, Boston, MA.

5.2 Data Sources

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. Accessed 2005 March 30.

New Hampshire Natural Heritage Bureau. 2005. Rare plants, rare animals, and exemplary natural communities in New Hampshire towns. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

SPECIES PROFILE

Puritan Tiger Beetle

Cicindela puritana

Federal Listing: Threatened
State Listing: Not listed
Global Rank: G1
State Rank: SH
Author: Alina, J. Pyzikiewicz, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Puritan tiger beetles inhabit wide or narrow sandy beaches adjacent to clay banks or bluffs along the bends of big rivers. Puritan tiger beetles feed on small invertebrates such as amphipods, ants, and flies (Nothngale 1992, United States Fish and Wildlife Service (USFWS) 1993, Leonard and Bell 1999). There are two distinct populations of puritan tiger beetles, one along the Connecticut River in Massachusetts and Connecticut and the other along Chesapeake Bay in Maryland. Larval habitat requirements differ between these two populations (Nothngale 1992, USFWS 1993, Omland 2002). Along the Connecticut River, larvae burrow between sparse herbaceous vegetation (20-30% cover) in fine to medium sand particles (0.125-0.5 mm) at the upper margins of sandy beaches and occasionally near the water's edge (Nothngale 1992, USFWS 1993, Omland 2002). Along Chesapeake Bay in Maryland, larvae burrow in long, high, sandy, and non-vegetated bluff faces (USFWS 1993, Omland 2002).

2.2 Justification

Puritan tiger beetles are the rarest of the New England tiger beetles (Dunn 1986). Succession has degraded suitable habitat, and damming along the Connecticut River has permanently altered the dynamic geological processes that created and maintained habitat. The number of known puritan tiger beetle populations has decreased from 11 to 2 (USFWS 1993).

Minor disturbances to riverine beaches may render the habitat unsuitable for puritan tiger beetle larvae. Because of the 2-year larval period and restricted habitat type, larvae are particularly susceptible to long-term flooding, vegetation encroachment, and other natural or man-made changes to beaches and bluffs (USFWS 1990, Nothnagle 1992, USFWS 1993). Other threats include recreational disturbance, population growth, development, and shore erosion control projects (USFWS 1990, USFWS 1993).

2.3 Protection and Regulatory Status

The puritan tiger beetle is federally Threatened and is protected under the Endangered Species Act.

2.4 Population and Habitat Distribution

Puritan tiger beetles have been historically collected from 11 sites along the Connecticut River from Claremont, New Hampshire to Cromwell, Connecticut (Dunn 1981, USFWS 1993). The upper Connecticut River populations became extirpated in the early 1900s due to dam construction and riverbank stabilization (USFWS 1993). Only 2 Connecticut River populations remain, one near Hadley, Massachusetts and one in Cromwell, Connecticut (USFWS 1990, Nothnagle 1992, USFWS 1993, Omland 2002). Another population of puritan tiger beetles, distinct from the Connecticut River populations, occurs along Chesapeake Bay in Maryland (USFWS 1990, Nothnagle 1992, USFWS 1993, Omland 2002). In New Hampshire, puritan tiger beetles have been historically collected along the Connecticut River in Claremont and Charlestown, and have not been ob-

served in the state since the mid 1930s (Dunn 1978, Dunn 1981).

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

1.7 Sources of Information

Sources of information include the species recovery plan, tiger beetle identification guides, peer-reviewed literature, field surveys, and technical reports.

1.8 Extent and Quality of Data

The life history and habitat requirements of puritan tiger beetles are well documented, although most sources are over 10 years old. Current locations of puritan tiger beetles are well known, but historic New England locations are poorly documented. Dispersal patterns are not well known and need further research.

1.9 Distribution Research

Identify and resurvey current and historical locations of puritan tiger beetles.

Element 5: References

5.1 Literature

Dunn, G. A. 1978. Tiger beetles of New Hampshire (Coleoptera: Cicindelidae). Thesis, University of New Hampshire, Durham, New Hampshire, USA.

Dunn, G. A. 1981. The tiger beetles of New Hampshire. Cicindela. 13: 1-28.

Dunn, G. A. 1986. Tiger beetles of New England (Coleoptera: Cicindelidae). Entomological Society Quarterly. 3: 27-41.

Leonard, J. G. and R. T. Bell. 1999. Northeastern tiger beetles: a field guide to tiger beetles of New England and Eastern Canada. CRC Press, Boca Raton, Florida, USA.

Nothngale, P. J. 1992. Puritan tiger beetle monitoring in 1992, and inventory of other species of tiger beetles in the Montague sandplain. A report submitted to the Massachusetts Natural Heritage Program, Westborough, Massachusetts, USA.

Omland, K. S. 2002. Larval habitat and reintroduction site selection for Cicindela puritana in Connecticut. Northeastern Naturalist. 9: 433-450.

United States Fish and Wildlife Service. 1990. Endangered and threatened wildlife and plants; determination of threatened status for the Puritan tiger beetle and the northeastern beach tiger beetle. Federal Register 55: 32088-32094.

United States Fish and Wildlife Service 1993. Puritan tiger beetle (Cicindela puritana G. Horn) recovery plan. United States Fish and Wildlife Service, Hadley, Massachusetts, USA.

SPECIES PROFILE

Ringed Boghaunter

Williamsonia lintneri

Federal Listing: Not listed
State Listing: Endangered
Affected Species: NA
Global Rank: G3
State Rank: S1
Author: Kim A. Tuttle, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Ringed boghaunters are restricted to sphagnum peatlands and the surrounding upland or mesic forests (Cairns 1998). Ringed boghaunters breed in acidic fens, which are weakly minerotrophic peatlands that receive some nutrients from groundwater springs, seeps, and streams (Lundgren 1999). In New England, breeding and larval habitats include dwarf shrub fens, graminoid-dominated fens, and sphagnum-filled pools or basins. Shrubs, robust sedges and rushes with persistent stems provide places for larvae to emerge in the spring. Aquatic species of Sphagnum are likely an important component of breeding areas and critical for overwintering (Lundgren 1999). Adults may require relatively intact upland forests to rest, develop, and feed before mating (Biber 2002).

1.2 Justification

The majority of ringed boghaunter populations in the United States are located in eastern Massachusetts, Rhode Island, and Wisconsin (NatureServe 2004). New Hampshire and Maine represent the northernmost extent of the known breeding range in the Northeast. Populations that remain in the eastern United States from southern Maine to New Jersey are vulnerable to development. In New Hampshire, ringed boghaunter populations are limited to the southeastern portion of the state, where development pressure is greatest.

There may be more than 50 occurrences of ringed boghaunters in the United States and ongoing surveys will likely reveal new sites, but populations appear to be small with usually fewer than 50 adults (NatureServe 2004). Ringed boghaunters are at risk because of their unique acidic fen habitats that are not well understood. Another Williamsonia dragonfly, the ebony boghaunter (Williamsonia fletcheri), is found in similar sphagnum bog and fen habitats. Like the ringed boghaunter, it is not found in all sphagnum peatlands within its range and its particular habitat requirements remain unknown. The ebony boghaunter appears to be more common than the ringed boghaunter with 8 new sites found in New Hampshire in 2003 and 2004 (P. Hunt, ASNH, personal communication), but is listed as endangered in Maine and Massachusetts where it reaches the southern extent of its range.

1.3 Protection and Regulatory Status

The ringed boghaunter is listed as state endangered in the New Hampshire Endangered Species Conservation Act (RSA 212-A). Fill and Dredge in Wetlands; NHDES (NHDES) (RSA 483-A). See Peatlands profile for other state and federal protection pertaining to ringed boghaunters.

1.4 Population and Habitat Distribution

The ringed boghaunter has a patchy distribution throughout the Northeast. It has recently been documented in Wisconsin and Michigan (NatureServe 2004). In New England, the ringed boghaunter is known from sites in Maine, Massachusetts, Connecticut, New Hampshire, and Rhode Island. Rhode Island accounts for the majority of sites in New Eng-

land with at least 20 occurrences (NatureServe 2004). Only 2 or 3 sites occur in Connecticut (NatureServe 2004). A single breeding site in Maine was found in 1995 at a complex of 5 adjacent fens in southern York County after unsuccessful surveys at approximately 250 potential sites between 1988 and 1995 (Maine Inland Fisheries and Wildlife 2004).

Documented ringed boghaunter breeding locations in New Hampshire are restricted to 4 towns in the southeastern region of the state (Amherst, Litchfield, Kingston, and Durham). It is not known whether historic populations existed beyond this area. In 1990, an adult was collected in Barrington and placed in the Entomology Collection at the University of New Hampshire (UNH) at Durham, but no other details about the site have been located. Another adult was seen at Spruce Hole in Durham in the spring of 1990 by UNH entomology professor Donald Chandler. Spruce Hole is described as a classic kettlehole bog, which is not typical habitat for this species. Ginger Carpenter, the odonatologist at The Nature Conservancy (TNC) Rhode Island Field Office suggested that Spruce Hole might not have supported a breeding population (McCarthy 1995). An adult was seen in Dover south of the easternmost extension of the Bellamy Reservoir by Audubon Society of New Hampshire biologists Pam Hunt and Laura Deming on 4 June 2004. Also in 2004, a resting adult ringed boghaunter was observed at a small cattail marsh near the Massabesic Audubon Center in Auburn. Although these adult dragonflies were not necessarily seen at emergence sites, these observations suggest the presence of additional populations in other parts of the state (P. Hunt, Audubon Society of New Hampshire, personal communication).

3.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

Known ringed boghaunter breeding sites were mapped. Peatland habitats were mapped for the CWCS (See Peatlands profile).

1.7 Sources of Information

NatureServe (2004) was used as a source for species status and ranking information. A survey by the NHFG Nongame and Endangered Species Program conducted in 2004 and earlier New Hampshire Natural Heritage Bureau (NHNHB) surveys were used to determine the range of the ringed boghaunter in New Hampshire. The UNH Entomology Collection at Durham was the source of the Barrington record. Further information was taken from published literature, technical field reports, and personal communications. Pam Hunt (Audubon Society of New Hampshire) and M. Marchand (NHFG) provided comments on drafts of this document.

1.8 Extent and Quality of Data

The unique habitat requirements of the ringed boghaunter appear to limit its distribution. While there are only a few sites to monitor for this species, peatlands can be physically difficult to survey for larvae and teneral adults, especially if affected by high water levels in the spring. The early spring emergence of flying adults, well before the bulk of most dragonfly species, has probably caused this species to be overlooked. Growing interest in dragonflies by qualified amateur observers may reveal new breeding locations.

1.9 Distribution Research

Identifying suitable sphagnum peatland habitats and surveying them for exuviae and teneral adults in the spring will help identify new breeding locations for ringed boghaunters. In particular, searches are needed in suitable habitats near the South Berwick site in York County, Maine. A documented occurrence here would extend the distribution of the species in the state. Atlantic White Cedar (Chamaecyparis thyoides) swamps may provide ringed boghaunter habitat (Briggs 1994). It would be relatively easy to survey the limited number of known swamps in southern New Hampshire.

There is a need to create and maintain an Odonate database that is coordinated between NHFG, NHNHB, the New Hampshire Odonate Club, New Hampshire Audubon (P. Hunt), and universities (e.g., University of New Hampshire, Don Chandler). The collection and analysis of these data would allow a more systematic and scientific assessment of the condition of Odonates in New Hampshire. Directing observers to priority sites would enhance the probability of finding new occurrences of at-risk species.

Element 2: Species/Habitat Condition

2.1 Scale

The known breeding populations of ringed boghaunters in New Hampshire are few and restricted to sphagnum peatlands and adjacent woodlands. Individual sites and complexes of sites are appropriate conservation planning units.

2.2 Relative Health of Populations

The Durham Point Sedge Meadow site is the best-documented location of breeding ringed boghaunters in New Hampshire. While small, this population appears to be stable. A 1994 survey of the site by TNC found the minimum estimated population to be 41 individuals (McCarthy 1996). A NHFG survey in 2004 counted at least 41 individuals (exuviae and teneral adults). In most years, the numbers of individuals have been much less, but this may be the result of survey effort and timing that misses the period of peak emergence. The breeding site and surrounding woodland is owned and maintained by TNC. The sedge meadow lies adjacent to Durham Point Road and several adults were observed resting on the road pavement in spring 2004. Continuing residential development and the subsequent rise in traffic volume may increase the likelihood of road mortality to flying and resting adult dragonflies at this site.

Ponemah Fen in Amherst has not been consistently monitored to assess population trends. It had been considered the best site in New Hampshire for ringed boghaunters by TNC because of its large population size, amount of habitat, and relatively undisturbed wetland and surrounding upland (McCarthy 1996). A 1994 survey by TNC determined the minimum population size to be 61 individuals. The 1994 search was the most extensive known at Ponemah Fen, lasting approximately 2 hours by 3 observers (McCarthy 1995). Although much larger in size than any other occupied site, the surrounding upland is being developed rapidly. An adult ringed boghaunter was observed resting on pavement in a nearby driveway in a NHFG survey in 2004.

Three-Way Basin in Litchfield is a complex of basins in a residential neighborhood. The largest number of ringed boghaunters in the complex was documented at the Brenton Street Basin by NHFG in 2004. Despite high water conditions, two people collected 20 ringed boghaunter exuviae in a 45-minute search. The vegetation within and at the edge of this fen remains undisturbed and the large, unfragmented woodlands of Litchfield State Forest to the south may provide refuge and foraging areas for flying adults. The Brenton Sreet Basin may function as a source population for the other smaller basins in the complex that are surrounded by residential development.

Garden Street Fen in Litchfield, located north of Three-Way Basin, is less than 0.4 ha (1 ac). In a survey by TNC in 1994, 3 people found 10 exuviae and 1 teneral adult in a 50-minute search (McCarthy 1995). Until recently, access to the fen for surveys had been somewhat restricted, so the relative health of this population remains unknown.

At the Pow Wow River / Webster Wildlife Area in Kingston, a teneral male was observed in 2000. The site was revisited by NHFG in 2004 when 1 adult was observed resting at the edge of an inactive gravel pit near the entrance to the Webster Wildlife Area. Further efforts are required to adequately survey these extensive aquatic and wooded habitats.

2.3 Population Management Status

Past NHNHB surveys, beginning in the early 1990s, focused on peatlands that contain both Sphagnum and open water. A major peatlands inventory, begun by NHNHB in 1997, identified more potential ringed boghaunter sites. Suitable wetlands north of known locations were identified and partially surveyed in 1998, especially around the New Hampshire border near an adult ringed boghaunter record in Fryeburg, Maine, (Cairns 1998). The NHFG Nongame and Endangered Species Program and TNC have conducted other surveys.

2.4 Relative Quality of Habitat Patches

In 1994, TNC acquired the Durham Point Sedge Meadow and most of its watershed to protect and manage the sedge meadow specifically for the conservation of ringed boghaunters (McCarthy 1996). Contaminated runoff entering the wetland from the adjacent Durham Point Road may threaten the health of this small habitat.

Larger sphagnum peatlands surrounded by intact wetland or upland forests appear to have the most

potential for the long-term persistence of ringed boghaunters. Ponemah Fen and Three-Way Basin (especially Brenton St. Basin) may be of sufficient size and quality to offset the negative effects of adjacent residential development if further upland habitat losses are slowed. The proximity of Three-Way Basin to the large area of woodlands in Litchfield State Forest enhances the long-term viability of this population. The long-term biological cost of adult road mortality and increased predation by domestic animals and subsidized predators is not known. Land fragmentation from residential development around the Garden Street Fen may affect the future viability of this site.

The Pow Wow River / Webster Wildlife Area may be capable of maintaining a viable ringed boghaunter population because of its large size and protected status.

2.5 Habitat Patch Protection Status

TNC owns and protects the Durham Point Sedge Meadow property. Ponemah Fen is privately owned and parcels of the remaining woodlands are distributed among various private owners. The Three-Way Basin Complex is held in several private ownerships, but the Division of Forests and Lands of the State of New Hampshire own the nearby woodlands of Litchfield State Forest. The Litchfield Conservation Commission recently protected the Garden Street Fen. The Pow Wow River / Webster Wildlife Area is owned by the NPNHF.

2.6 Habitat Management Status

Habitat management for the ringed boghaunter is limited to the Durham Point Sedge Meadow and consists of cattail removal to maintain some open water in this small peatland. It is unknown whether this activity has benefited the species.

2.7 Sources of Information

Ringed boghaunter inventory and monitoring reports of New Hampshire sites contain survey data and conservation concerns. Pam Hunt of ASNH and Sara Cairns of NHNHB provided information regarding the protection status of known breeding sites, as well as habitat quality indicators.

2.8 Extent and Quality of Data

The quality of ringed boghaunter reports is very good. Expert observers conducted all surveys and the identification of ringed boghaunter exuviae and adults is relatively easy. The early seasonal hatch and flight period in May eliminates confusion with the majority of dragonfly species whose flight periods begin weeks or months later.

The condition of ringed boghaunter populations in New Hampshire is not well understood. Inconsistency in surveying efforts between years and sites make it difficult to compare between and within populations. Site conditions, especially water levels, greatly influence monitoring results. The flight period for this species is short and early, and exuviae are delicate and easily dislodged from the stems of emergent vegetation by wind or high water. Therefore, the absence of individuals during a single survey does not prove the habitat is unoccupied.

2.9 Condition Assessment Research

The status of the species and its habitat should be regularly monitored because the number and distribution of breeding locations are limited. Additional surveys following up on sightings of flying adults are needed to determine the locations of source populations, particularly at Auburn and Dover sites. Continued surveys for likely wetland habitats are essential to determine and update the status of this species in New Hampshire.

Research is needed to determine the water quality parameters of occupied wetland habitats and to understand the extent of woodland use, including adult dispersal ranges.

A standardized methodology is needed to compare ringed boghaunter populations between years and sites. A consistent survey methodology could reduce the survey effort required to monitor the species (e.g., semi-annual schedule).

Element 3: Species and Habitat Threat Assessment

3.1.1 Altered Hydrology

(A) Exposure Pathway

The dredging and filling of peatlands and related hy-

drologic alterations is considered the greatest threat to ringed boghaunter populations, specifically to breeding and larval habitat. In New Hampshire, most of the known locations are protected from dredging and filling, but the long-term effects of altered hydrology by adjacent residential development are uncertain. High water levels and springtime floods in peatland habitats can drown or dislodge teneral adults. Conversely, culvert installation may lower the water or drain small sites adjacent to roads. Low water may expose ringed boghaunter larvae and teneral adults to increased avian and mammalian predation or make the sites unsuitable for aquatic Sphagnum. It is not known whether any small sites have been lost to dredging or filling in the past.

(B) Evidence
While ringed boghaunters do not require permanent standing water to survive, likely because of similar adaptations documented in other Odonates, the length and timing of the hydroperiod at breeding sites may be important for long-term persistence (Biber 2002). The 2-month period between the time ringed boghaunters oviposit in early May and the time of seasonal dry-down may be critical to larval development. Larvae that are not well developed may succumb to desiccation at sites that dry too quickly (Biber 2002).

3.1.2 Development (Habitat Loss and Conversion)

(A) Exposure Pathway
Adult ringed boghaunters use upland woodlands surrounding breeding sites.

(B) Evidence
Agricultural, residential, or commercial development may eliminate or disrupt the upland areas that may be required by adult ringed boghaunters to rest, develop, and feed (Biber 2002). The dispersal distances and extent of upland habitat use are not well known.

3.1.3 Transportation Infrastructure

(A) Exposure Pathway
Ringed boghaunter populations appear isolated from each other, partially because of their habitat distribution. Local populations may become more isolated because of development and roads. Little is known regarding dispersal distances for this species. Adult ringed boghaunters are low flyers that can be found resting on sunny surfaces on the ground or asphalt, which exposes them to vehicle mortality. Ringed boghaunters may not be able to recolonize vulnerable smaller sites near roads or other development if catastrophic events destroy a local population.

(B) Evidence
The proximity of the Garden Street Fen to the complex of sites at Three-Way Basin in Litchfield may ensure viable populations if one or more locations need to be recolonized in the future. However, if the Durham Point Sedge Meadow population were lost, the closest known New Hampshire breeding site is in Kingston or possibly Dover. Surveys for ringed boghaunters in Maine may locate additional York County breeding sites closer to the Durham location.

3.1.4 Altered Natural Disturbance (Natural Succession)

(A) Exposure Pathway
The loss of open water through succession or the proliferation of invasive plants such as cattail may crowd out the aquatic Sphagnum and emergent vegetation needed by ringed boghaunters. Fertilizers and leachfield runoff in residential areas may hasten succession.

(B) Evidence
Ringed boghaunters are one of the first odonates to emerge in New Hampshire in the spring, often in the first week of May. Sites that lack old stems and new spring shoots of emergent vegetation, such as Carex and Dulichium, are not likely to be suitable breeding sites (Lundgren 1999). Aquatic species of Sphagnum seem to be an important component of breeding areas (Lundgren 1999). Cattails have been removed at Durham Sedge Meadow to maintain open water.

3.2 Sources of Information

Mike Marchand (NHFG) and Pam Hunt (Audubon Society of New Hampshire) reviewed threats. Scientific literature was used for evidence in the threat assessment.

3.3 Extent and Quality of Data

Since the known breeding sites for ringed boghaunter in New Hampshire are few and accessible, current conditions at each location are noted. The effects of altered hydrology on ringed boghaunter populations is not well understood or documented.

3.4 Threat Assessment Research

Continued monitoring of individual boghaunter breeding sites for habitat and population conditions.

Element 4: Conservation Actions

4.1.1 Protection of ringed boghaunter sites, Habitat Protection

(A) Direct Threats Affected
Development (Habitat Loss and Conversion)

(B) Justification
1) Protecting and managing ringed boghaunter sites will reduce the impact of development on this species.
2) Ringed boghaunter populations depend on the survival of breeding adults. Removing threats to increase adult emergence and successful breeding will help ensure long-term viability.
3) Known ringed boghaunter sites have been mapped and are afforded additional protection under the New Hampshire Endangered Species Conservation Act.
4) Ringed boghaunter sites are few and isolated. All sites are located in southern New Hampshire where development pressures are high. Every ringed boghaunter breeding site needs to be protected quickly with adequate adjacent woodland to prevent population extirpation.
5) Locations of new ringed boghaunter breeding populations should be prioritized for land protection.

(C) Conservation Performance Objective
Protect all known ringed boghaunter breeding sites and adjacent woodlands. The minimum extent of upland use by adults needs to be determined for the purpose of protection. Undiscovered breeding sites are at the greatest risk. These locations, especially those that are extremely small in size, may go undetected during the wetland review process and may be subject to damage from filling or logging before protection. New occurrences of adult ringed boghaunters need to be located in a timely fashion.

(D) Performance Monitoring
Continue ringed boghaunter inventories to monitor established sites and identify new sites for protection. Maintain a database of known ringed boghaunter sites, unprotected lands, and landowner contact information.

(E) Ecological Response Objective
Protect peatland breeding sites and an ample wooded buffer to help maintain viable populations of ringed boghaunters in New Hampshire.

(F) Response Monitoring
Monitor breeding sites for population stability and colonization of nearby suitable peatland breeding habitat.

(G) Implementation
Secure protection for Ponemah Fen and any remaining adjacent woodlands and the Three-Way Basin Complex, especially the larger Benton Street Basin. Work with appropriate conservation partners to secure easements or purchase land outright. Use occupied sites to prioritize landscape level habitat protection.

(H) Feasibility
The NHFG is limited in its ability to protect land through easement or purchase. Protection efforts may rely on the involvement of conservation commissions and planning boards, particularly in Amherst and Litchfield.

4.1.2 Communicate to landowners, abutters, town administrators and departments, local conservation organizations and commissions about ringed boghaunter status and habitat, Education and Outreach.

(A) Direct Threats Affected
Development (Habitat Loss and Conversion), Altered Natural Disturbance (Natural Succession)

(B) Justification

1) Most people, including natural resource professionals, are unaware of the presence of a state-endangered dragonfly in New Hampshire.
2) Sites are primarily adjacent to residential development. Removing threats associated with residential development through education will help increase the probability of long-term survival of local ringed boghaunter populations.
3) Efforts will be directed towards specific locations where ringed boghaunter populations have been documented.
4) Sites are at immediate risk from uninformed actions by private individuals and those authorized by public agencies (i.e., application of lawn chemicals near peatlands and mosquito control larvicides).
5) Brochures or other educational materials can be updated with new information to benefit ringed boghaunters conservation.

(C) Conservation Performance Objective

Increase awareness of the ringed boghaunter and its peatland and upland habitats. Reduce direct and incidental damage to peatlands by chemical application and runoff from landowners and abutters.

(D) Performance Monitoring

Regularly monitor ringed boghaunter sites and communicate with local conservation commissions and residents to discuss problems.

(E) Ecological Response Objective

Outreach and education should increase the probability that local ringed boghaunter populations will persist into the future.

(F) Response Monitoring

Develop baseline water quality indicators for peatlands and regularly sample to detect changes in water chemistry at specific peatland sites. Monitoring is especially needed at unprotected sites that are surrounded by residential development and would benefit from education and outreach efforts (e.g., Three-Way Basin, Ponemah Fen).

(G) Implementation

Work with NHFG Public Affairs Division or other organizations such as TNC to develop a brochure featuring the ringed boghaunter. Distribute brochures to ringed boghaunter site owners, abutters and town officials and departments whose activities may affect sites such as public works. Follow up on activities that are detrimental to ringed boghaunter sites with contact to specific individuals or relevant agencies.

(H) Feasibility

Brochures are a cost-effective way to inform people about ringed boghaunters.

4.2 Conservation Action Research

N/A

Element 5: References

5.1 Literature

Biber, E. 2002. Habitat analysis of a rare dragonfly (Williamsonia lintneri) in Rhode Island. Northeastern Naturalist 9:341-352.

Briggs, N. 1994. An ecological and behvioral study of Williamsonia lintneri (Hagen), the ringed boghaunter. Unpublished report to The Nature Conservancy, Rhode Island Field Office.

Cairns, S. J. 1998. Ringed boghaunter (Williamsonia lintneri) in New Hampshire: 1998 inventory and monitoring. New Hampshire Natural Heritage Bureau, Concord, New Hampshire, USA.

Cairns, S. J. 2000. Ringed boghaunter (Williamsonia lintneri) in New Hampshire: 1999 inventory and monitoring. New Hampshire Natural Heritage Bureau, Concord, New Hampshire, USA.

Lundgren, J. A. 1999. Characterization and classification of plant communities inhabited by the ringed boghaunter dragonfly (Williamsonia lintneri). The Nature Conservancy. Boston, Massachusetts, USA.

McCarthy, P. 1995. Banded bog skimmer (Williamsonia lintneri) in New Hampshire: 1994 inventory and monitoring. The Nature Conservancy. Concord, New Hampshire, USA.

McCarthy, P. 1996. Banded bog skimmer (Williamsonia lintneri) in New Hampshire: 1995 inventory and monitoring. The Nature Conservancy. Concord, New Hampshire, USA.

5.2 Data Sources

Maine Inland Fisheries and Wildlife. 2005. Ringed boghaunter in invertebrates listed in Maine. <http://www.state.me.us/ifw/wildlife/etweb/group/rbog.htm>. Accessed 2005 February 26.

NatureServe. 2004. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.1. NatureServe, Arlington, Virginia. <http://www.natureserve.org/explorer>. Accessed 2004 December 29.

New Hampshire Natural Heritage Bureau. 2005. Database of Rare Species and Exemplary Natural Community Occurrences in New Hampshire. Department of Resources and Economic Development. Concord, New Hampshire, USA.

SPECIES PROFILE

Sleepy Duskywing

Erynnis brizo brizo

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5T5
State Rank: S2
Author: Alina, J. Pyzikiewicz, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The sleepy duskywing is an associate of the federally endangered Karner blue butterfly (*Lycaeides melissa samuelis*) and inhabits the shrub-scrub layer of pine barrens (Scott 1986, Opler and Malikul 1992, Glassberg 1993). Sleepy duskywing larvae predominately feed on scrub oak (*Quercus ilicifolia*) leaves and buds, along with other shrubby oaks (Opler and Malikul 1992, Glassberg 1993, Mello 1998). Adult sleepy duskywings fly from April to June (Scott 1986, Opler and Malikul 1992, Glassberg 1993). Eggs are laid singly on scrub oak leaves and larvae live in rolled up leaf nests, eventually overwintering (Scott 1986). For a detailed habitat description, see Karner blue butterfly species profile and pine barrens habitat profile.

1.2 Justification

The sleepy duskywing can be found in the same habitat as the Karner blue butterfly and frosted elfin (*Callophrys* [*Incisalia*] *irus*), which are indicator species of the health of the pine barrens habitat. The sleepy duskywing is in severe decline in the eastern part of range due to habitat loss and fire suppression; nearly 90% of historic pitch pine-scrub oak barren communities along the Merrimack River have been lost, leaving a mere 560 fragmented acres, primarily in Concord (Helmbolt and Amaral 1994).

1.3 Protection and Regulatory Status

Although the sleepy duskywing is not state or federally listed, it is protected as an associate of blue lupine, which is listed as threatened in New Hampshire and protected under the Native Plant Protection Act (RSA 217-A).

1.4 Population and Habitat Distribution

The range of the sleepy duskywing extends across all of the eastern states to Minnesota and Texas, and in the west in parts of California, Arizona, New Mexico, Utah, and Colorado (Scott 1986, Opler and Malikul 1992,Glassberg 1993). In New Hampshire, the sleepy duskywing was documented in the Concord pine barrens in 1998 and 2001 and in the Ossipee pine barrens in 1985 (Chandler 2001, New Hampshire Natural Heritage Bureau 2005).

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

N/A

1.7 Sources of Information

Sources of information included technical field reports, field guides, and element occurrence databases.

1.8 Extent and Quality of Data

There are only 2 documented locations for the sleepy duskywing in New Hampshire (Chandler 2001, NHNHB 2005). Since this species is very similar to other members of the *Erynnis* genus, proper identification in the field is challenging.

1.9 Distribution Research

Before initiating surveys for this species, voucher specimens are needed and distinguishing characteristics should be noted.

Elements 2-4: See Karner blue butterfly profile or pine barrens habitat profile.

Element 5: References

5.1 Literature

Chandler, D.S. 2001. New Hampshire Army National Guard butterfly and moth survey, Concord, New Hampshire. University of New Hampshire, Durham, New Hampshire, USA.

Glassberg, J. 1993. Butterflies through binoculars: a field guide to butterflies in the Boston- New York –Washington region. Oxford University Press. New York, New York, USA.

Helmbolt, K., and M. Amaral. 1994. Status of the Karner blue butterfly in New Hampshire. Pages 123-128 *in* Karner blue butterfly: a symbol of a vanishing landscape, D.A. Andow, R.J. Baker, and C.P. Lane, editors. Minnesota Agricultural Experiment Station. St. Paul, Minnesota, USA.

Mello, M. 1998. Survey of state-listed and other rare Lepidoptera at proposed Army National Guard, Army Aviation Support Facility lease property, Regional Drive, at Concord Municipal Airport and at other sites within Concord New Hampshire's pine barrens. Lloyd Center for Environmental Studies, South Dartmouth, Massachusetts, USA.

Opler, P.A., and V. Malikul. 1992. Peterson field guides: eastern butterflies. Houghton Mifflin. New York, New York, USA.

Scott, J.A. 1986. The butterflies of North America: a natural history and field guide. Stanford University Press, Stanford, California, USA.

5.2 Data Sources

New Hampshire Natural Heritage Bureau. 2005. Database of rare species and exemplary natural community occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

SPECIES PROFILE

White Mountain Arctic

Oeneis melissa semidea

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5T2
State Rank: S2
Authors: Celine T. Goulet and Steven G. Fuller, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The White Mountain arctic is a subspecies of the Melissa arctic (*Oeneis melissa*) and is endemic to the alpine zone of the Presidential Range of New Hampshire (McFarland 2003). It inhabits alpine and subalpine communities above 4,900 ft, specifically the dwarf shrub/sedge-rush meadow community (Chandler 2001, McFarland 2003). Dwarf shrub/sedge-rush meadows are composed of 4 communities: alpine heath snowbank, Bigelow's sedge meadow, sedge-rush-heath meadow, and dwarf shrub-bilberry-rush barren. These communities occur at elevations ranging from 1,340 to 1,890 m on moderate slopes oriented to the northwest and are characterized by Bigelow sedge (*Carex bigelowii),* Highland rush (*Juncus trifidus*), and dwarf heath (*Vaccinium* spp.) (McFarland 2003, Sperduto and Nichols 2004). The ground cover is comprised of herbs, forbs, moss, lichen, and sparse, rocky openings interspersed with Bigelow sedge, the host plant for White Mountain arctic (Chandler 2001). Adults primarily feed on Moss campion (*Silene acaulis*), Mountain sandwort (*Arenaria groenlandica*), and *Vaccinium* species (McFarland 2003).

1.2 Justification

White Mountain arctic is limited to a 2,800 ac alpine zone of the White Mountain National Forest (WMNF). The species is highly susceptible to climate changes and population declines because of its fragile habitat, isolation, and host plant specificity (Halloy and Mark 2003, McFarland 2003). The structure, composition, phenology, and distribution of alpine habitat communities are extremely susceptible to climate change (Kimball and Weihrauch 2000, McFarland 2003, Lesica and McCune 2004). Alpine plant and animal species respond interdependently to environmental changes, expanding or contracting their ranges in relation to polarity and elevation (McFarland 2003, Lesica and McCune 2004). Asynchronous range fluctuations could disrupt plant-animal interactions such as pollination, seed dispersal, and food availability. This could lead to biotic feedbacks that are detrimental to overall ecosystem function (Bowman 2000, Walther et al. 2002). The obligate host plant of White Mountain arctic is Bigelow's sedge, a rare high-elevation plant that characterizes Bigelow's sedge meadows (S1) (McFarland 2003, Lesica and McCune 2004). Additional threats may emerge as climate continues to change, especially as climate interacts with other stressors such as habitat fragmentation, acid deposition, and increased solar ultraviolet radiation (McCarty 2001).

1.3 Protection and Regulatory Status

White Mountain arctic is designated as a WMNF sensitive species (Chandler 2001). Natural communities diagnostic of habitat are state-ranked (see above).

1.4 Population and Habitat Distribution

White Mountain arctic, a glacial relict, was once more widely distributed throughout New Hampshire, but has since become isolated as the climate warmed at the end of the last glaciation 13,000 years ago (McFarland 2003). Currently, disjunct popula-

tions of White Mountain arctic are restricted to the 2,800 ac alpine zone of the Presidential Range of the WMNF (Chandler 2001, McFarland 2003). Its presence depends on the abundance of host plants as well as ground temperature, moisture, and winter snow depth (Anthony 1970, McFarland 2003). White Mountain arctic populations tend to be locally abundant around sedge meadows, a community covering approximately 198 ac (7%) of the alpine zone within the Presidential Range (McFarland 2003). The northernmost record is from Mt. Jefferson and the southernmost from Mt. Monroe, with the greatest number of observations occurring at Monticello Lawn on Mt. Jefferson, Gulf Tanks along the Mt. Washington Cog Railway, the Cow Pasture, and the Bigelow Lawn on Mt. Washington (McFarland 2003).

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

See Alpine Habitat Profile; occupies only Presidential unit.

1.7 Sources of Information

Published literature and New Hampshire Natural Heritage Bureau (NHNHB) database.

1.8 Extent and Quality of Data

The New Hampshire distribution of White Mountain arctic is well documented.

1.9 Distribution Research

Three areas of research are needed to better understand and protect this species, including taxonomic study to determine species/subspecies status, identification of population trends, and determination of its population structure.

Element 2: Species/Habitat Condition

2.1 Scale

See Alpine Habitat Profile; occupies only Presidential unit.

2.2 Relative Health of Populations

Relative abundance within the Presidential Unit is unknown, however, the White Mountain arctic population is considered imperiled due to natural rarity (McFarland 2003) and susceptibility to climatic and atmospheric changes.

2.3 Population Management Status

Surveys have been conducted but long-term monitoring has not been implemented. Little or no targeted management has been implemented to date. Recommendations for research and monitoring will be provided upon approval of the Proposed Land and Resource Management Plan for the WMNF.

2.4 Relative Quality of Habitat Patches

High quality occurrences of alpine communities used by White Mountain arctic occur in Alpine Garden, Tuckerman Ravine, Oakes Gulf, Great Gulf, Mt. Eisenhower, Mt. Franklin, Monroe Flats, Bigelow Lawn, the upper slopes of Mt. Adams, Monticello Lawn, and on the north and west sides of the cone of Mt. Washington (Sperduto and Nichols 2004). Records of adult White Mountain arctic are most often reported from the following sedge meadows: Monticello Lawn on Mt. Jefferson, area surrounding Gulf Tanks along the Mt. Washington Cog Railway, the Cow Pasture, the Alpine Garden, and the Bigelow Lawn on Mt. Washington (McFarland 2003).

2.5 Habitat Patch Protection Status

Because White Mountain arctic is not protected under the Endangered Species Act or RSA 212, its habitat receives no special protection. See also Alpine Habitat Profile.

2.6 Habitat Management Status

Little or no targeted management has been implemented to date. Recommendations for research and monitoring will be provided upon approval of the Proposed Land and Resource Management Plan for the WMNF. See also Alpine Habitat Profile.

2.7 Sources of Information

Information regarding the management and protection of alpine habitat was obtained from the Proposed Land and Resource Management Plan for the WMNF; 2001 memorandum of understanding between the Bureau of Land Management (BLM), National Park Service (NPS), United States Forest Service (USFS), United States Department of Transportation, and National Endowment for the Arts; 1996 National Scenic Trail comprehensive management plans; and documents delineating the Wilderness Act.

2.8 Extent and Quality of Data

Abundance data are inadequate to allow rigorous population estimates.

2.9 Condition Assessment Research

Research priorities include evaluation of taxonomic status, population structure, and patterns of habitat use. A monitoring scheme featuring at least 20 randomly located transects throughout the alpine zone and surveyed utilizing the distance sampling method at least every 5 days throughout the flight period needs to be developed (McFarland 2003).

Element 3: Species and Habitat Threat Assessment

3.1.1 Climate Change

(A) Exposure Pathway
Climate change may reduce or extirpate local populations of Bigelow's sedge and other alpine flora. This could in turn limit the reproductive, foraging, and dispersal success of alpine lepidoptera, ultimately leading to extinction.

(B) Evidence
The interaction between topography and climate determines alpine plant community distribution (Kimball and Weihrauch 2000). Climate change could significantly alter the range and composition of alpine habitat (Kimball and Weihrauch 2000). Species respond by shifting their ranges poleward and upward in elevation, resulting in a rise in treeline (Roland et al. 2002, Walther et al. 2002, McFarland 2003). This often displaces alpine meadow species with lower-elevation species (McFarland 2003, Lesica and McCune 2004). Smaller and more isolated alpine meadows may pose challenges for alpine species to disperse among them and maintain populations (Roland et al. 2002). Movement of the alpine butterfly *Parnissius smintheus* is severely reduced by forests encroaching into meadow habitats (Roland et al. 2002).

3.1.2 Climate Change

(A) Exposure Pathway
Climate change may result in asynchronous timing of phenological responses of Bigelow's sedge and other alpine flora with alpine Lepidoptera, reducing availability of host plants, larval forage, and nectar plants.

(B) Evidence
A significant correlation exists between phenological patterns and environmental cues, primarily snowpack, in alpine communities (Walker et al 1995). The timing of snow release greatly affects initiation of growth and flowering of most alpine species; this is an adaptation to limited moisture and short growing season (Walker et al. 1995). The timing of lepidopteran life history stages and behavioral patterns is heavily influenced by temperature. In New Hampshire, temperatures have increased by 0.7 degrees°F, 2 to 3 times the regional average, (New England Regional Assessment 2001, Harvey 2003). As a response, freeze-free periods in many subalpine/alpine regions are lengthening and duration of snow and ice cover is decreasing (Walther et al. 2002). Several studies have documented long-term phenological changes of both alpine vegetation and lepidoptera induced by climate change, leading to perturbations in inter-specific relationships and availability of host and nectar plants (Walther et al. 2002).

3.1.3 Climate Change

(A) Exposure Pathway
Elevated solar UV-B radiation associated with stratospheric ozone depletion can significantly alter plant chemistry, impacting the level of herbivory, food plant availability, and rate of larval development, and increasing susceptibility to population declines (Caldwell et al 1998, Nigel 2005).

(B) Evidence
Elevated solar UV-B radiation associated with stratospheric ozone depletion can significantly alter the plant chemistry, inducing changes in leaf morphology, nitrogen concentration, and phenology (Caldwell et al 1998, Nigel 2005). UV-B changes in plant-herbivore interactions can be attributed to alterations in plant nitrogen or sugar content resulting from elevated solar UV-B radiation levels (Caldwell et al. 1998, Nigel 2005). UV-B responses are expected to interact adversely with the effects of climate change (Caldwell et al. 1998).

3.2 Sources of Information

Information regarding threats to White Mountain arctic was compiled from management plans, technical field reports, and scientific journals.

3.3 Extent and Quality of Data

Threats affecting White Mountain arctic and its habitat are well-documented in the scientific literature, with extensive research on habitat alteration and range shifts due to climate change as well as increasing atmospheric pollution.

3.4 Threat Assessment Research

Further research should focus on habitat alterations resulting from climate change and acid deposition, including changes in community and species distributions, abundance, and phenology. Changes in plant chemical composition and morphology induced by increased UV-B radiation need investigation.

Element 4: Conservation Actions

- List White Mountain arctic Under FIS 1000, Regulation, and Policy (see Strategies, Agency Regulation and Policy, Revise/Enforce RSA 212 and FIS 1000)
- List White Mountain arctic on Extinction Advisory, Regulation, and Policy (see Strategies, Regional Coordination, Advise IAFWA)
- Advise Trail Managers on Mitigation for Habitat Impacts, Regulation and Policy (see Alpine Habitat Profile, see also Strategies, Recreational Management)
- Develop White Mountain arctic Captive Breeding Methods, Population Management (see Strategies, Population Management, Captive Breeding in Zoos)
- Monitor White Mountain arctic Habitat Plants, Monitoring (see Strategies, Monitoring, Indicators of Climate Change)
- Monitor White Mountain arctic , Monitoring (see Strategies, Monitoring, Indicators of Climate Change)

4.2 Conservation Action Research

Develop methods to perpetuate habitat; delineate potential habitat for translocation.

Element 5: References

5.1 Literature

Anthony, S.G. 1970. Field work on the population structure of *Oeneis melissa semidea* (Satyridae) from the Presidential Range, New Hampshire. Journal of Research on the Lepidoptera 7(3):133-148.

Bowman, W.D. 2000. Biotic controls over ecosystem response to environmental change in alpine tundra of the Rocky Mountains. AMBIO: A Journal of the Human Environment 29:396-400.

Caldwell, M.M., L.O. Bjorn, J.F. Bornman, S.D. Flint, G. Kulandaivelu, A.H. Teramura, and M. Tevini. 1998. Effects of increased solar ultraviolet radiation on terrestrial ecosystems. Journal of Photochemistry and Photobiology B: Biology 46: 40-52.

Halloy, S.R., and A.F. Mark. 2003. Climate-change effects on alpine plant biodiversity: A New Zealand perspective on quantifying the threat. Arctic, Antarctic, and Alpine Research 35(2):248-254.

Kimball, K.D. and D.M. Weihrauch. 2000. Alpine vegetation communities and the alpine-treeline ecotone boundary in New England as biomonitors for climate change. USDA Forest Service Proceedings 15(3):93-101.

Lesica, P., and B. McCune. 2004. Decline of arctic-alpine plants at the southern margin of their range following a decade of climatic warming. Journal of Vegetation Science 15:679-690.

McCarty, J.P. 2001. Ecological consequences of re-

cent climate change. Conservation Biology 15(2): 320-331.

McFarland, K. 2003. Conservation assessment of two endemic butterflies (White Mountain arctic , *Oeneis melissa semidea*, and White Mountain fritillary, *Boloria titania montinus*) in the Presidential Range alpine zone, White Mountains, New Hampshire. Vermont Institute of Natural Science, Woodstock, VT.

National Park Service. 1981. Comprehensive Plan for the Protection, Management, Development and Use of the Appalachian National Scenic Trail. National Park Service, Appalachian Trail Project Office, Harpers Ferry, West Virginia, USA.

Paul, N. 2001. Plant responses to UV-B: time to look beyond stratospheric ozone depletion? New Phytologist 150(1):5-8.

Roland J., N. Keyghobadi, and S. Matter. 2002. Effects of rising treeline on connectivity of alpine meadows for butterfly populations. University of Alberta, Edmonton, Alberta, Canada.

Rusek, J. 1993. Air-pollution-mediated changes in alpine ecosystems and ecotones. Ecological Applications 3(3):409-416.

Sperduto, D.D., and W.F. Nichols. 2004. Natural communities of New Hampshire. New Hampshire Natural Heritage Bureau, Concord, New Hampshire, USA.

Walker, M.D., R.C. Ingersoll, and P.J. Webber. 1995. Effects of interannual climate variation on phenology and growth of two alpine forbs. Ecology 76: 1067-1083.

Walther, G.R., E. Post, P. Convey, A. Menzel, C. Parmesan, T.J. Beebee, J.M. Fromentin, O. Hoegh-Guldberg, and F. Bairlein. 2002. Ecological responses to recent climate change. Nature 416: 389-395.

USDA Forest Service. 2004. Land and Resource Management Plan for the White Mountain National Forest. USDA Forest Service, Eastern Region, USA.

SPECIES PROFILE

White Mountain Fritillary

Boloria titania montinus

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5T2
State Rank: S2
Authors: Celine T. Goulet and Steven G. Fuller, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The White Mountain fritillary, a subspecies of the Purple fritillary (*Boloria titania*), is endemic to the alpine zone of the Presidential Range of New Hampshire (McFarland 2003). White Mountain fritillary inhabits wet-mesic alpine communities above 1,220 to 1,860 m, specifically wet alpine meadows, alpine streamside communities, and snowbank communities (Chandler 2001, McFarland 2003). Wet-mesic alpine communities are typically sloped, have shallow organic soils, and are associated with late-melting snowbanks forming in lee positions of summits, ridges, outcrops, ravines, drainages, and at the alpine-treeline interface. Characteristic vegetation consists of *Geum peckii, Solidago cutleri, Spiraea septentrionalis, Scirpus cespitous, Salix spp.,* and *Vaccinium* spp. (Sperduto and Nichols 2004). The preferred habitat of White Mountain fritillary includes a ground cover composed of herbs and forbs, host and nectar sources, and proximity to water (Chandler 2001). No obligate larval host plants are known, although possible species include *Salix spp*., *Viola palustris*, *Viola adunca*, and *Vaccinium spp*. (McFarland 2003). Adults prefer *Solidago cutleri* but will also nectar on *Aster* species (McFarland 2003).

1.2 Justification

White Mountain fritillary is limited to the 2,800 ac alpine zone of the White Mountain National Forest (WMNF). The natural communities used most frequently by White Mountain fritillary ranked S1 in New Hampshire. Climate change will likely alter alpine habitat structure, composition, phenology, and distribution, all of which directly impact White Mountain fritillary populations (Kimball and Weihrauch 2000, McFarland 2003, Lesica and McCune 2004). Habitat isolation further increases the species' vulnerability (Halloy and Mark 2003, McFarland 2003). Interdependent responses to climate change could disrupt ecological interactions throughout the alpine community, reducing the ability of sensitive species to endure other environmental stresses, such as acid deposition and increased UV-B radiation (McCarty 2001).

1.3 Protection and Regulatory Status

White Mountain fritillary is designated as a WMNF sensitive species. Natural communities diagnostic of habitat are state-ranked (see above).

1.4 Population and Habitat Distribution

White Mountain fritillary, a glacial relict, was once widely distributed in New Hampshire, but has become isolated with post-glacial warming (McFarland 2003). Currently, disjunct populations of White Mountain fritillary are restricted to the 2,800 ac alpine zone of the Presidential Range of the WMNF (Chandler 2001, McFarland 2003). Habitat suitability depends on the abundance of host plants, particularly Alpine goldenrod, as well as ground temperature, moisture, and winter snow cover (Anthony 1970, McFarland 2003). White Mountain fritillary populations tend to

be locally abundant near herbaceous snow bank communities, a community covering approximately 7 ac (less than 1%) of the alpine zone within the Presidential Range (McFarland 2003). The northernmost occurrence is from Mt. Madison and the southernmost is Mt. Pierce at an elevation range of 1,220 to 1,860 m, with the highest densities at Cragway Spring and Wamsutta Trail (McFarland 2003). The only historical record occurring outside the Presidential Range alpine zone was a specimen collected by D. J. Lennox on 27 August 1966 in Jefferson Notch at 900 m elevation and deposited in the University of New Hampshire collections (McFarland 2003).

1.5 Town Distribution Map

A map is provided

1.6 Habitat Map

See Alpine Habitat profile; occupies only Presidential unit.

1.7 Sources of Information

Published literature and New Hampshire Natural Heritage Bureau (NHNHB) database

1.8 Extent and Quality of Data

The New Hampshire distribution of White Mountain fritillary is well documented.

1.9 Distribution Research

Three areas of research are needed to better understand and protect this species, including taxonomic study to determine species/subspecies status, identification of population trends, and determination of its population structure.

Element 2: Species/Habitat Condition

2.1 Scale

See Alpine Habitat profile; occupies only Presidential Unit.

2.2 Relative Health of Populations

Relative abundance within the Presidential Unit is unknown, however, the White Mountain fritillary population is believed to be imperiled due to natural rarity (McFarland 2003) and susceptibility to climatic and atmospheric changes.

2.3 Population Management Status

Surveys have been conducted but long-term monitoring has not been implemented. Little or no targeted management has been implemented to date. Recommendations for research and monitoring will be provided upon approval of the Proposed Land and Resource Management Plan for the WMNF.

2.4 Relative Quality of Habitat Patches

High quality alpine communities used by White Mountain fritillary occur in the Alpine Garden, Tuckerman Ravine, Oakes gulf, Great Gulf (Sperduto and Nichols 2004). Records of adult White Mountain fritillary are most often reported from Cragway Spring and Wamsutta Trail, each with high densities of *Solidago cutleri* (McFarland 2003).

2.5 Habitat Patch Protection Status

Because White Mountain fritillary is not protected under ESA or RSA 212, itshabitat receives no special protection. See Alpine Habitat Profile.

2.6 Habitat Management Status

Little or no targeted management has been implemented to date. Recommendations for research and monitoring will be provided upon approval of the Proposed Land and Resource Management Plan for the White Mountain National Forest. See also Alpine Habitat Profile.

2.7 Sources of Information

Information regarding the management and protection of alpine habitat was obtained from the Proposed Land and Resource Management Plan for the WMNF; 2001 memorandum of understanding between the Bureau of Land Management (BLM),

National Park Service (NPS), United States Forest Service (USFS), United States Department of Transportation (USDOT), and National Endowment for the Arts; 1996 National Scenic Trail comprehensive management plans; and documents delineating the Wilderness Act.

2.8 Extent and Quality of Data

Abundance data are inadequate to allow rigorous population estimates.

2.9 Condition Assessment Research

Research priorities include evaluation of taxonomic status, population structure, and patterns of habitat use. A monitoring scheme featuring at least 20 randomly located transects throughout the alpine zone and surveyed utilizing the distance sampling method at least every 5 days throughout the flight period needs to be developed (McFarland 2003).

Element 3: Threat Assessment

3.1.1 Climate Change
See O. m. semidea Profile

3.1.4 Recreation
See Alpine Habitat Profile

3.2 Sources of Information

Information regarding threats to White Mountain fritillary was compiled from management plans, technical field reports, and scientific journals.

3.3 Extent and Quality of Data

Threats affecting White Mountain fritillary and its habitat are well documented throughout the scientific literature, with extensive research concentrated on habitat alteration and range shifts due to climate change as well as increasing atmospheric pollution.

3.4 Threat Assessment Research
See O. m. semidea Profile and Alpine Habitat Profile

Element 4: Conservation Actions

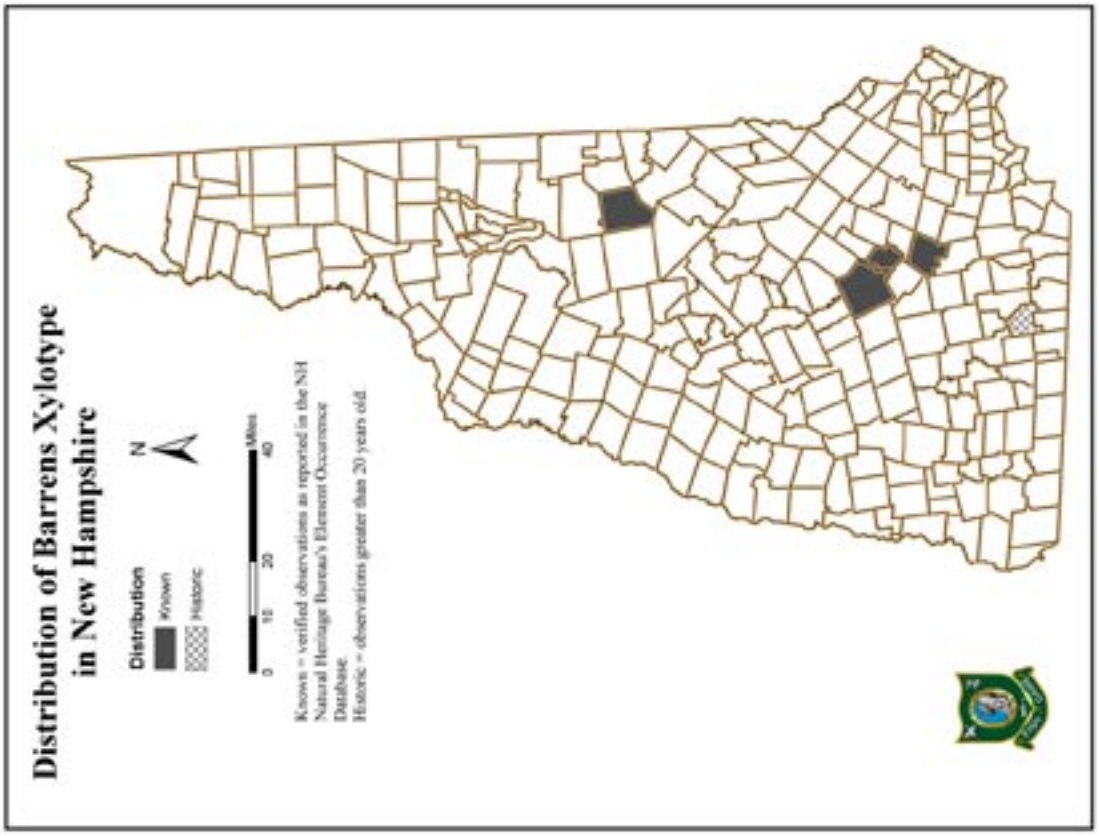
- List White Mountain fritillary Under FIS 1000, Regulation and Policy (see Strategies, Agency Regulation and Policy, Revise/Enforce RSA 212 and FIS 1000)
- List White Mountain fritillary on Extinction Advisory, Regulation and Policy (see Strategies, Regional Coordination, Advise IAFWA)
- Advise Trail Managers on Mitigation for Habitat Impacts, Regulation and Policy (see Alpine Habitat Profile, see also Strategies, Recreational Management)
- Develop White Mountain fritillary Captive Breeding Methods, Population Management (see Strategies, Population Management, Captive Breeding in Zoos)
- Monitor White Mountain fritillary Habitat Plants, Monitoring (see Strategies, Monitoring, Indicators of Climate Change)
- Monitor White Mountain fritillary, Monitoring (see Strategies, Monitoring, Indicators of Climate Change)

Element 5: References

5.1 Literature
See O. m. semidea Profile

5.2 Data Sources
See O. m. semidea Profile

Invertebrate Maps


Distribution of Barrens Xylotype in New Hampshire
Distribution
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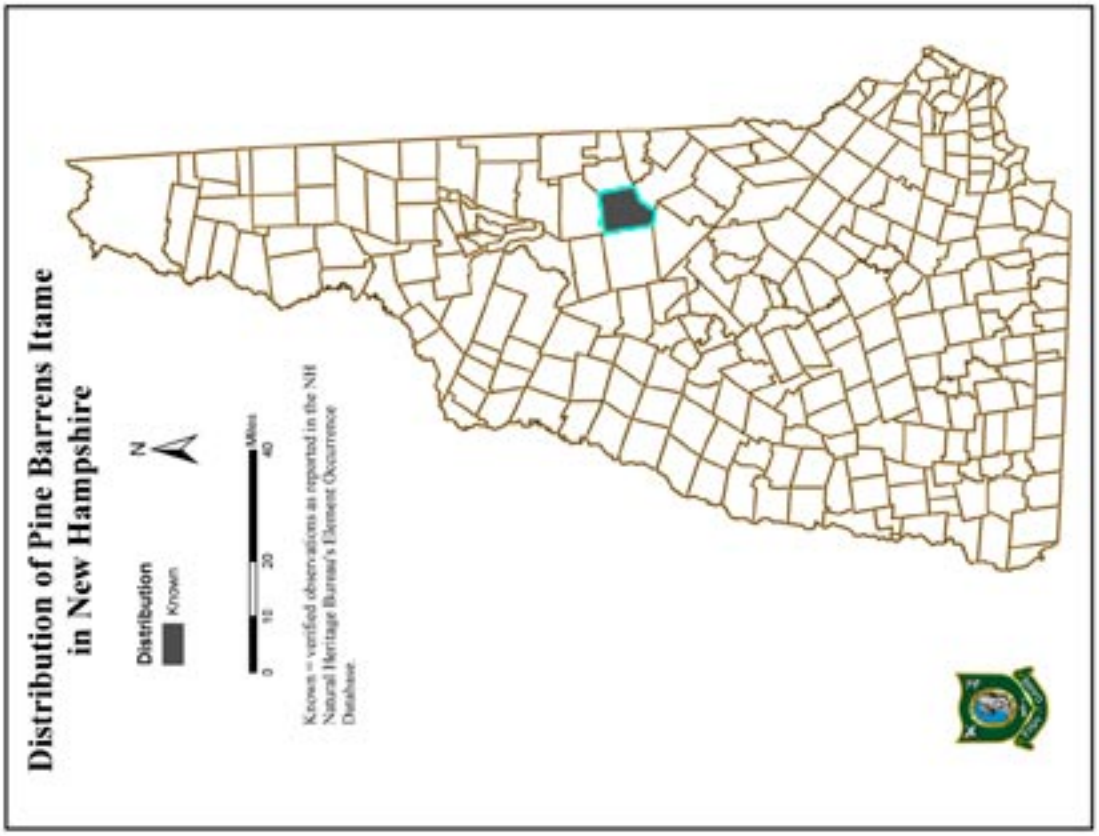
Historic
N
0 10 20 40
Miles
Known = verified observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database.
Historic = observations greater than 20 years old.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Miles
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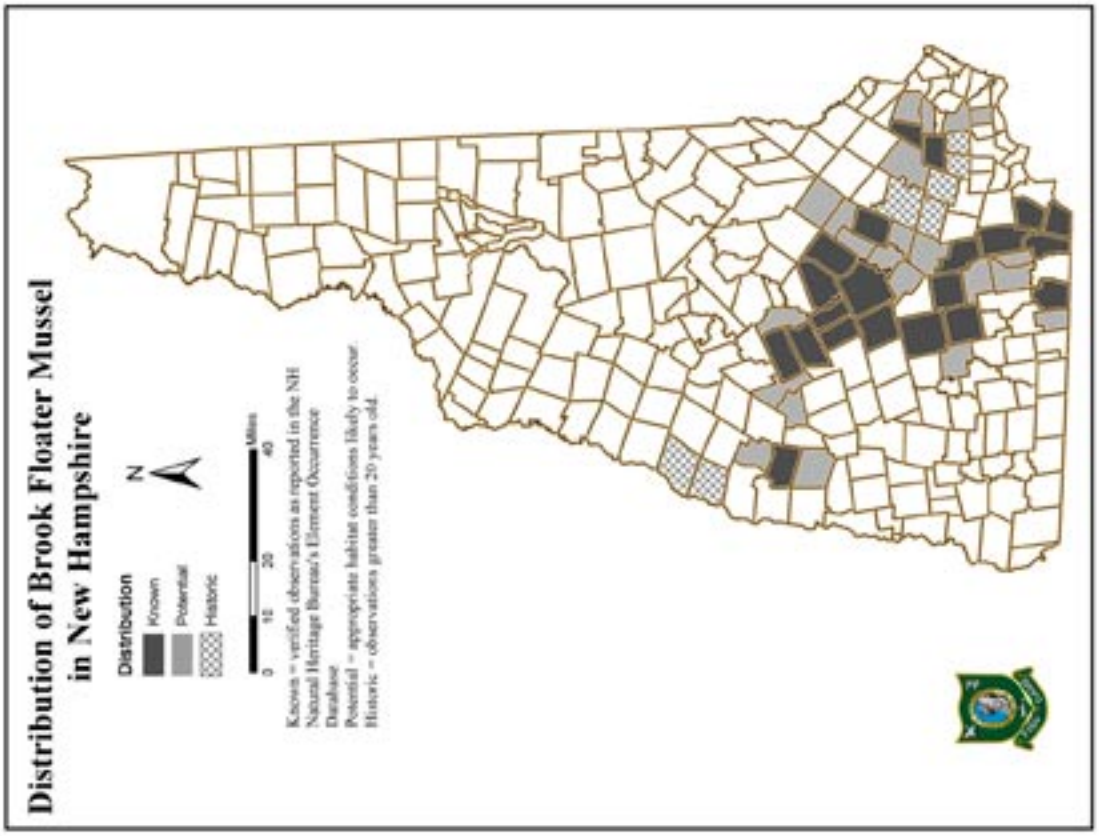
Distribution of Brook Floater Mussel
in New Hampshire
Distribution
Known
Potential
Historic
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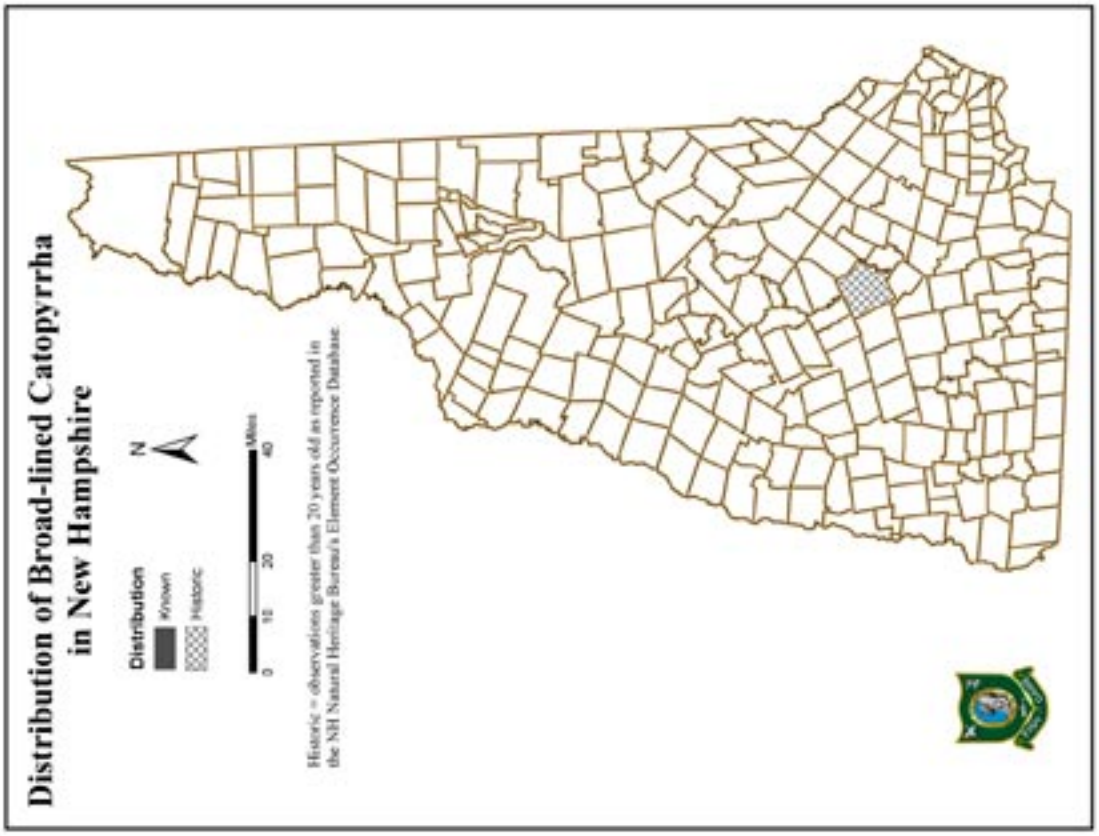
Known = verified observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database
Potential = appropriate habitat conditions likely to occur.
Historic = observations greater than 20 years old.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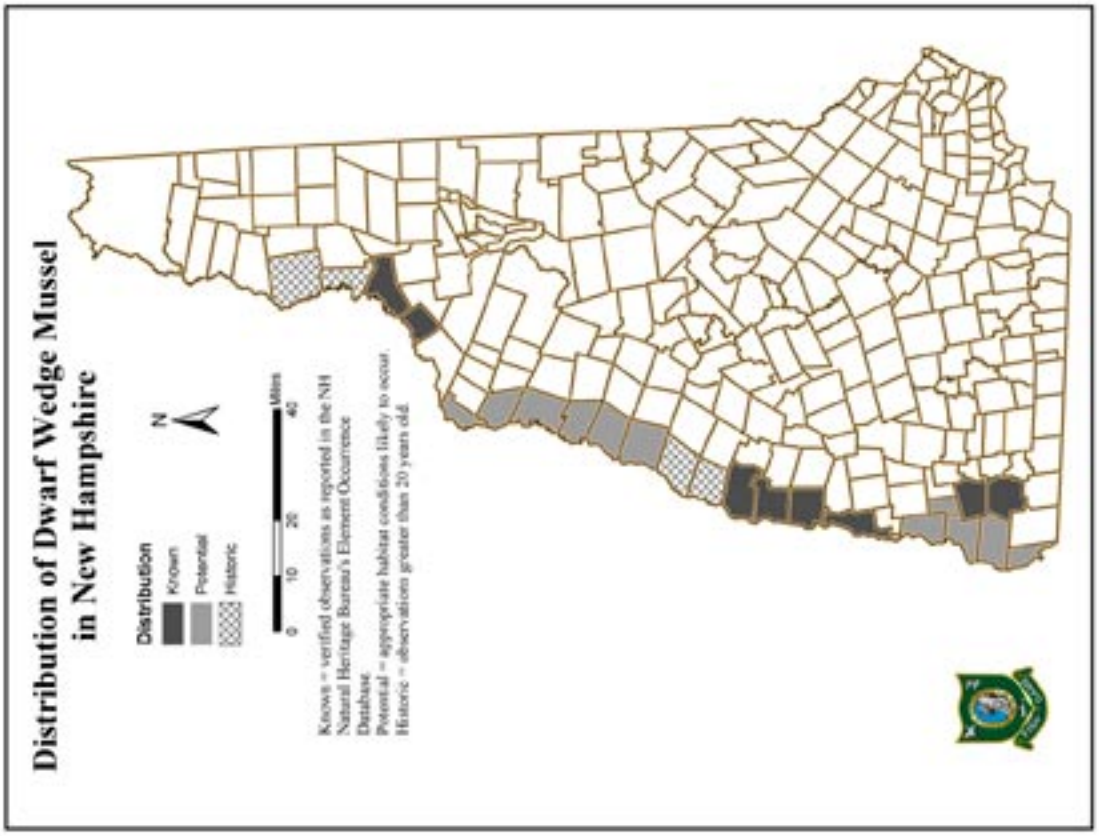
Historic = observations greater than 20 years old as reported in the NH Natural Heritage Bureau's Element Occurrence Database.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Distribution
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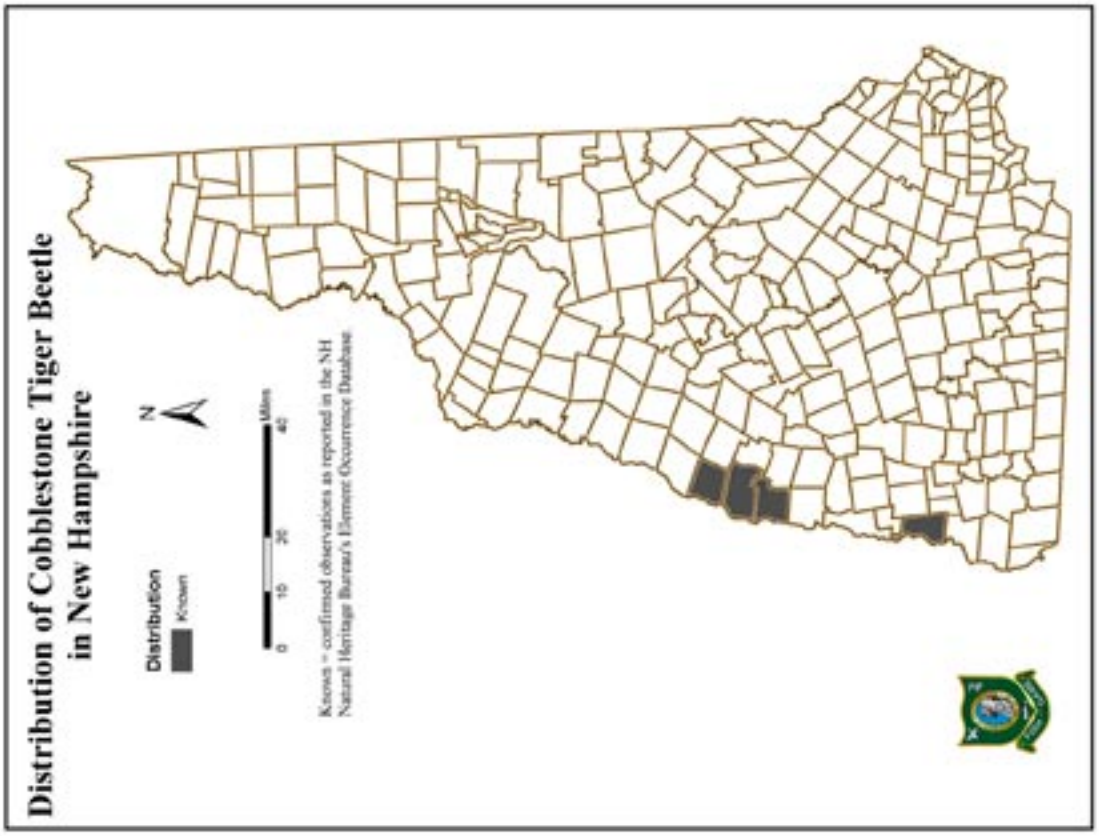
Database.
Potential = appropriate habitat conditions likely to occur.
Historic = observations greater than 20 years old.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in New Hampshire
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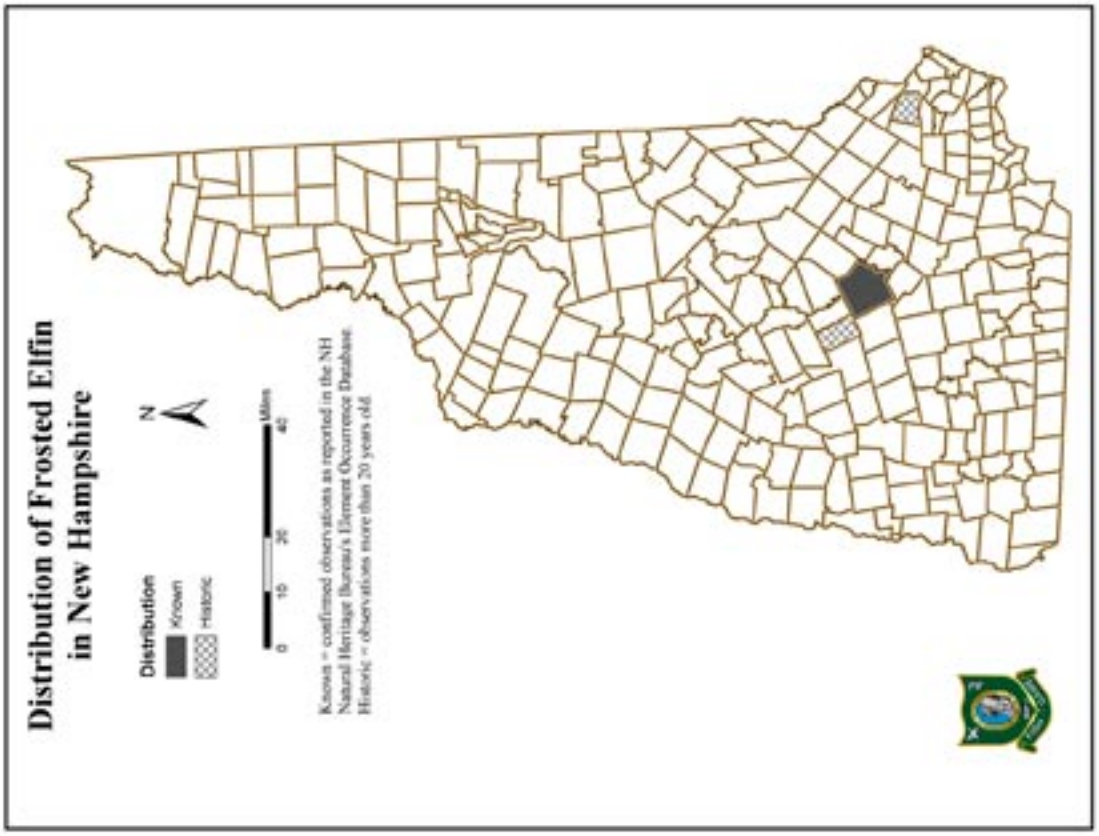
Distribution of Frosted Elfin
in New Hampshire
Distribution
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Historic
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Miles
Known = confirmed observations as reported in the NH
Natural Heritage Bureau's Element Occurrence Database.
Historic = observations more than 20 years old.

Distribution of Eastern Pond Mussel
in New Hampshire
Distribution
Known
Potential
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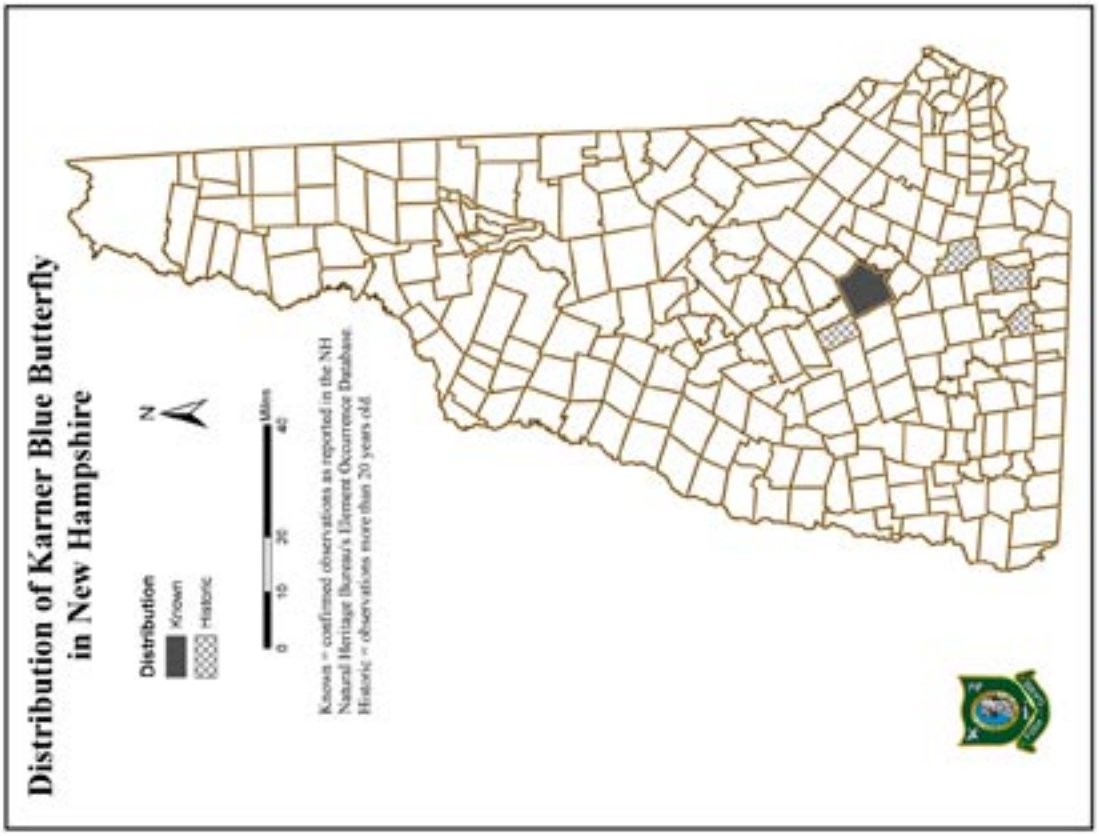
Miles
Known = verified observations are reported in the NH
Natural Heritage Bureau's Element Occurrence Database.
Potential = appropriate habitat conditions likely to occur.


Distribution of Karner Blue Butterfly
in New Hampshire
Distribution
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Historic
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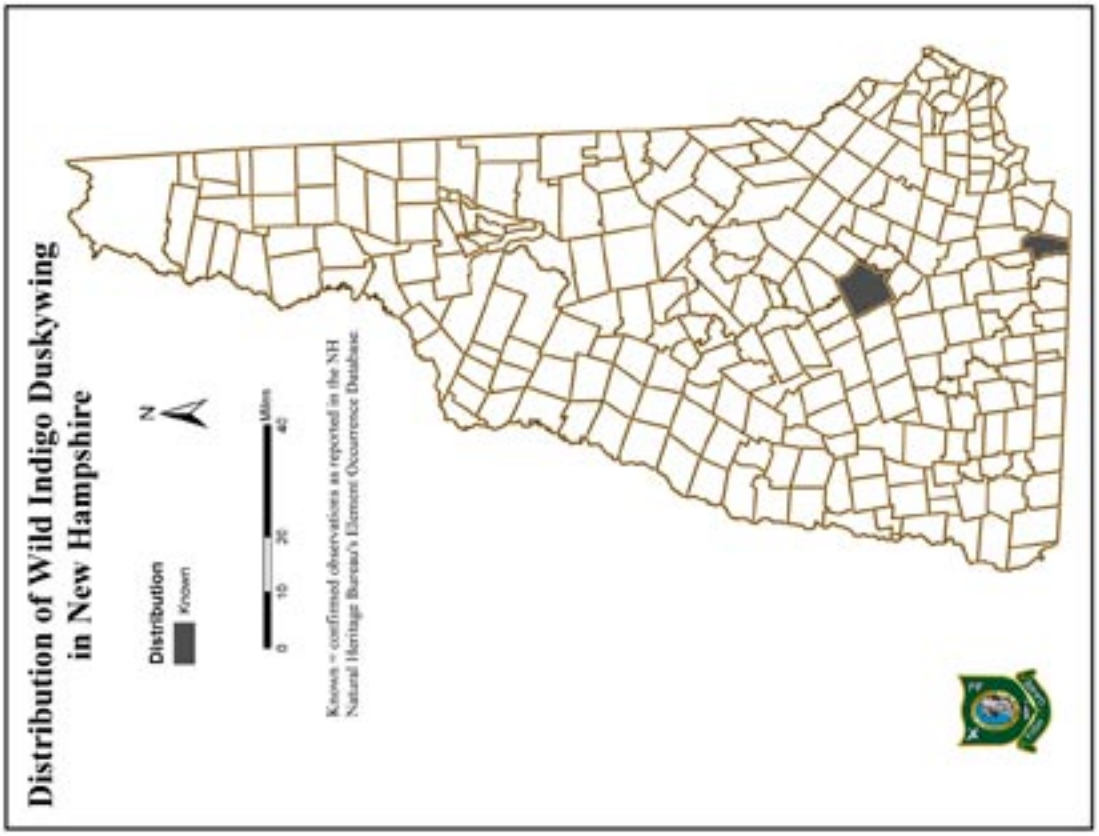
0 10 20 40 Miles
Known = confirmed observations as reported in the NH
Natural Heritage Bureau's Element Occurrence Database.
Historic = observations more than 20 years old.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Distribution
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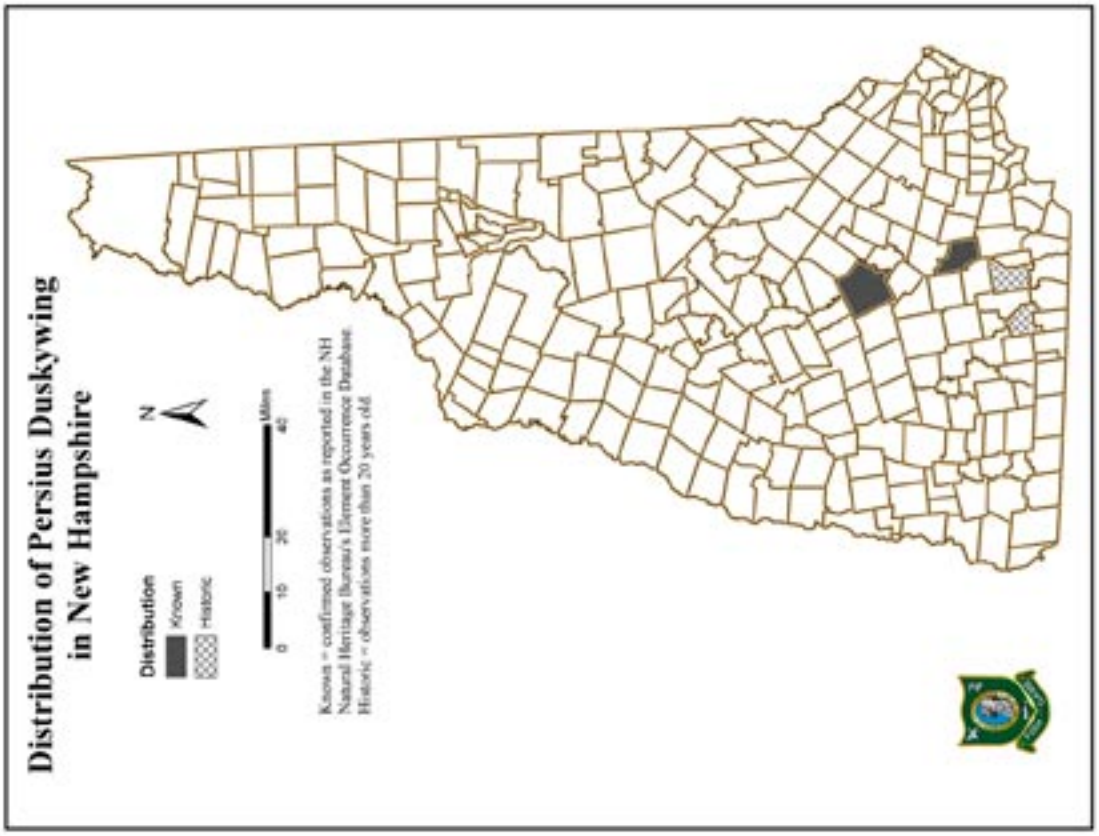
Known = confirmed observations as reported in the NH
Natural Heritage Bureau's Element Occurrence Database.


Distribution of Persius Duskywing
in New Hampshire
Distribution
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Historic
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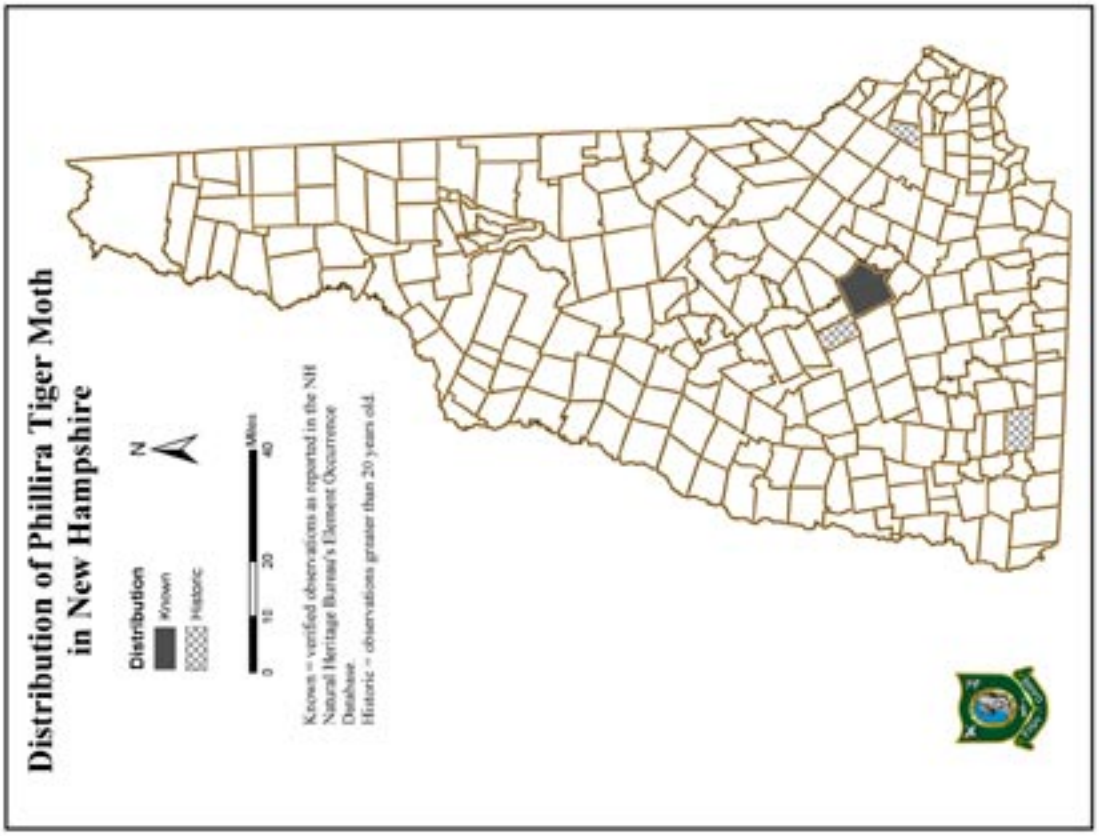
0 10 20 40
Miles
Known = confirmed observations as reported in the NH
Natural Heritage Bureau's Element Occurrence Database.
Historic = observations more than 20 years old.


Distribution of Phillira Tiger Moth
in New Hampshire
Distribution
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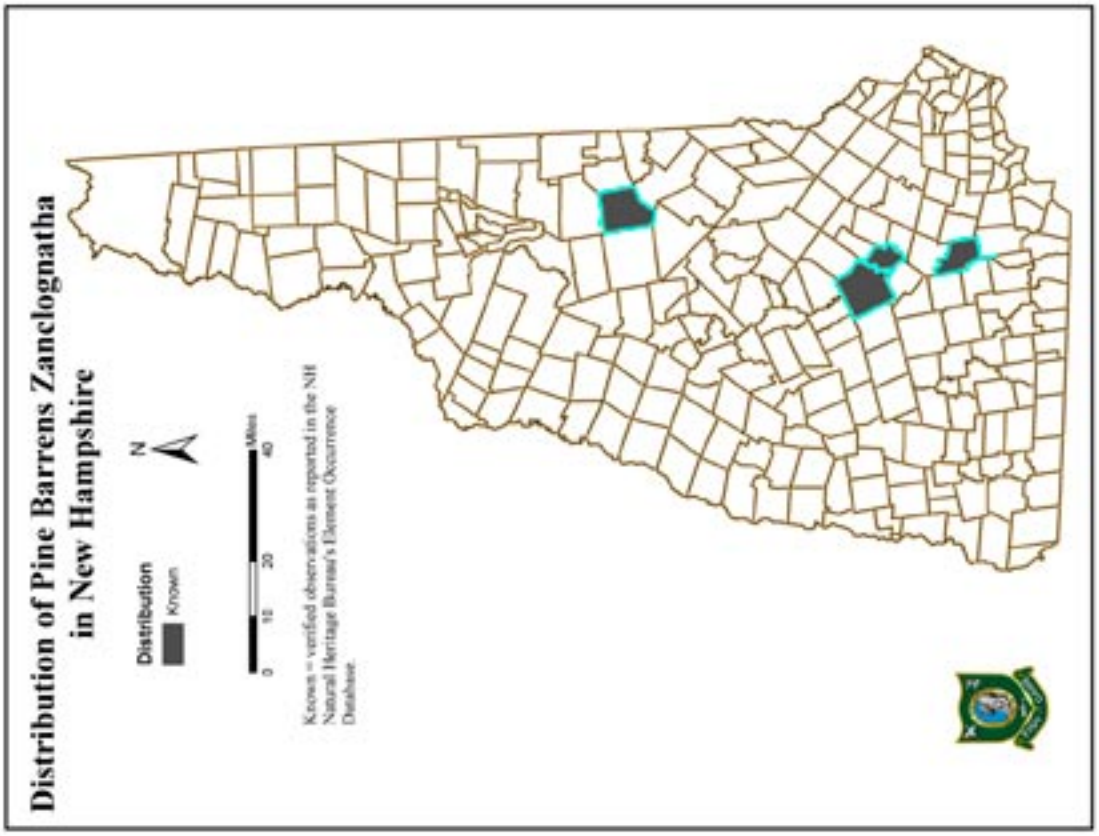
Miles
Known = verified observations as reported in the NH
Natural Heritage Bureau's Element Occurrence
Database.
Historic = observations greater than 20 years old.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Distribution
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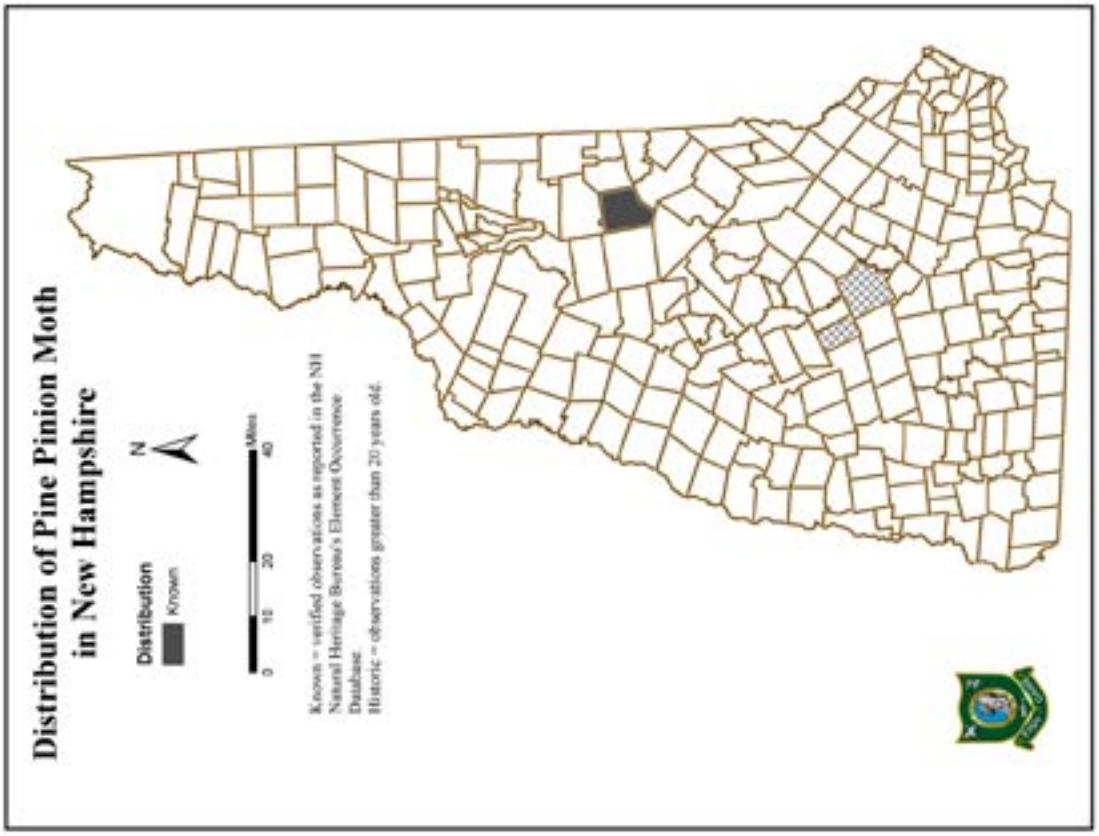
Miles
Known = verified observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database.


Distribution of Pine Pinion Moth in New Hampshire
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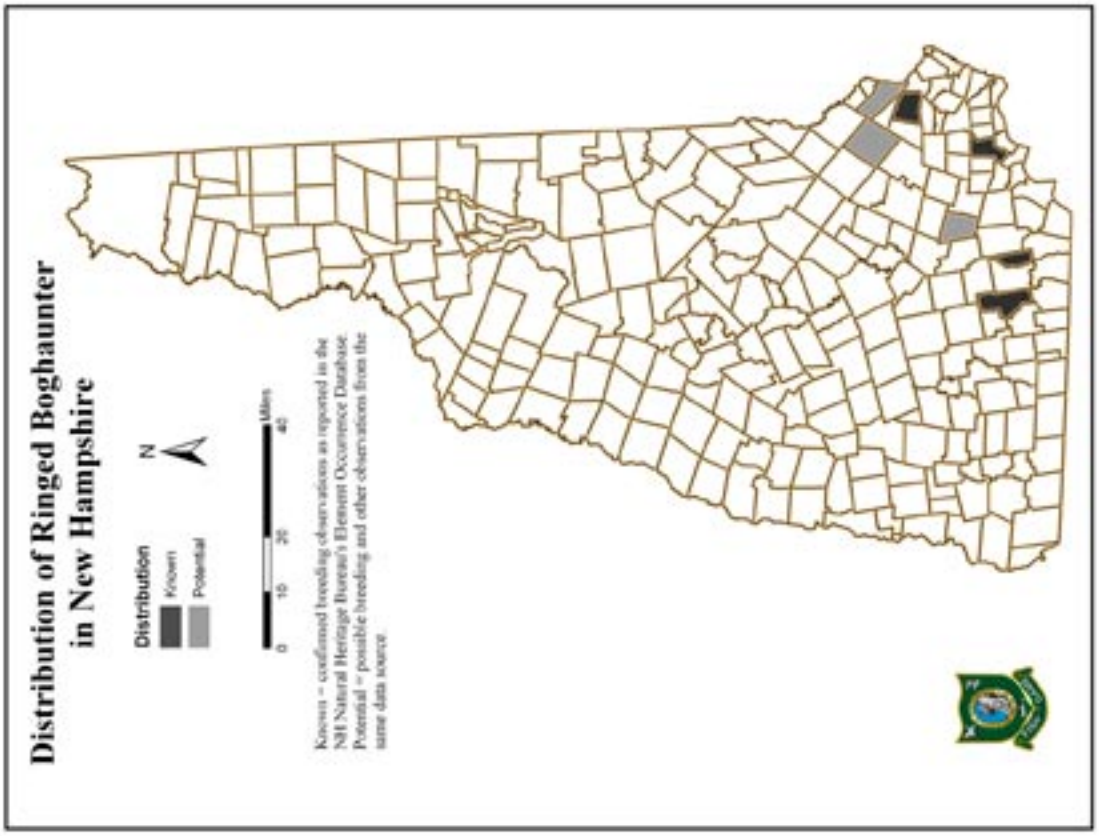
Miles
Known = verified observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database.
Historic = observations greater than 20 years old.


Distribution of Ringed Boghaunter in New Hampshire
Distribution
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Potential
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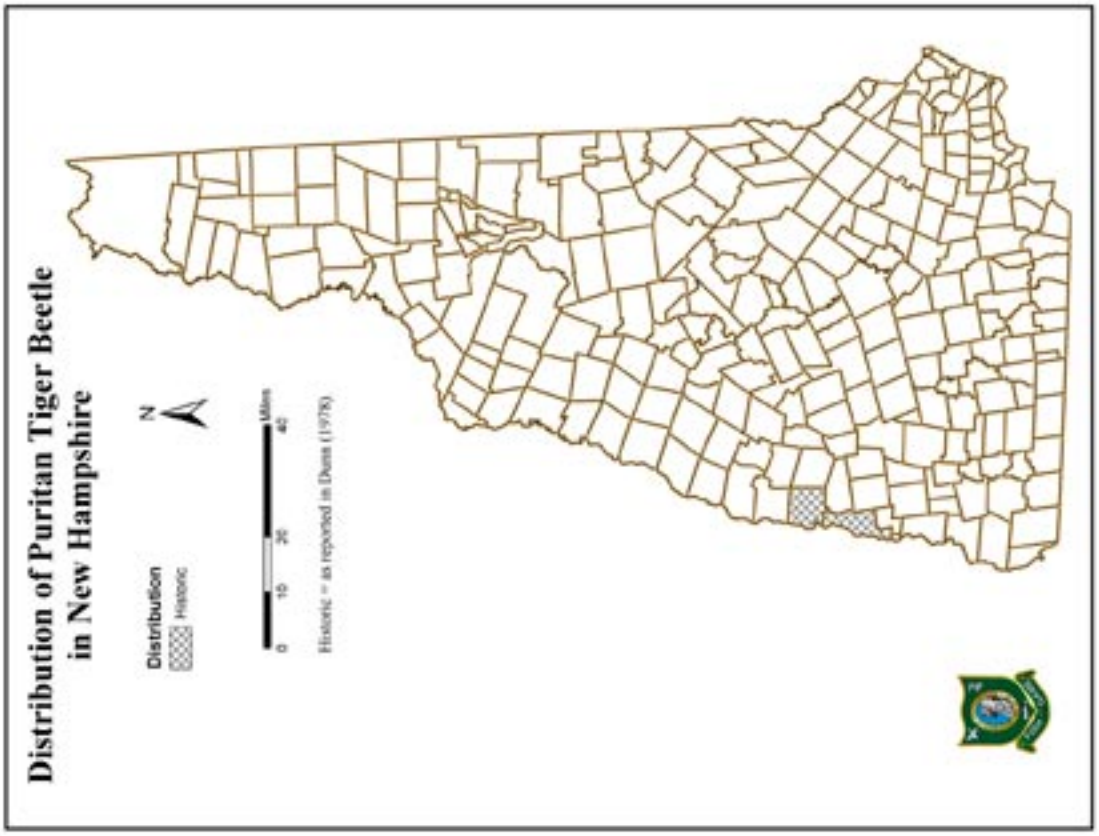
Known = confirmed breeding observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database.
Potential = possible breeding and other observations from the same data source.


Distribution of Puritan Tiger Beetle in New Hampshire
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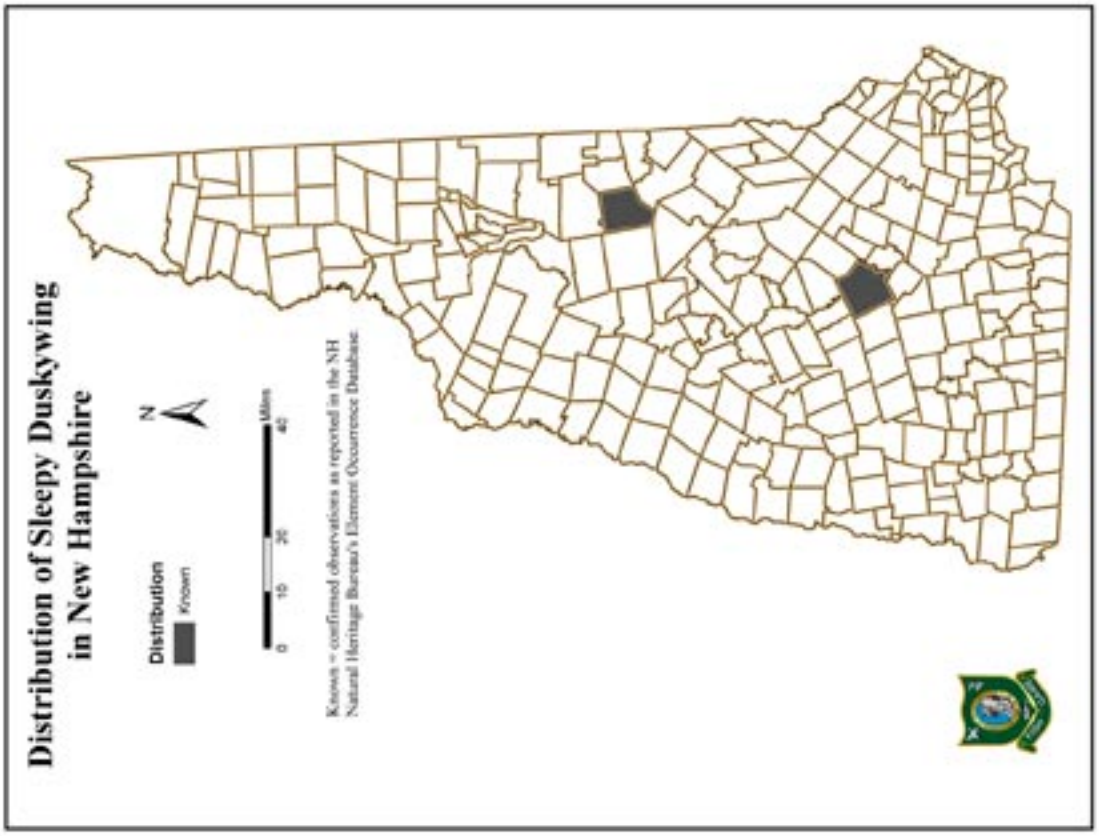
Miles
Historic = as reported in Dunn (1978)


Distribution of Sleepy Duskywing
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Distribution
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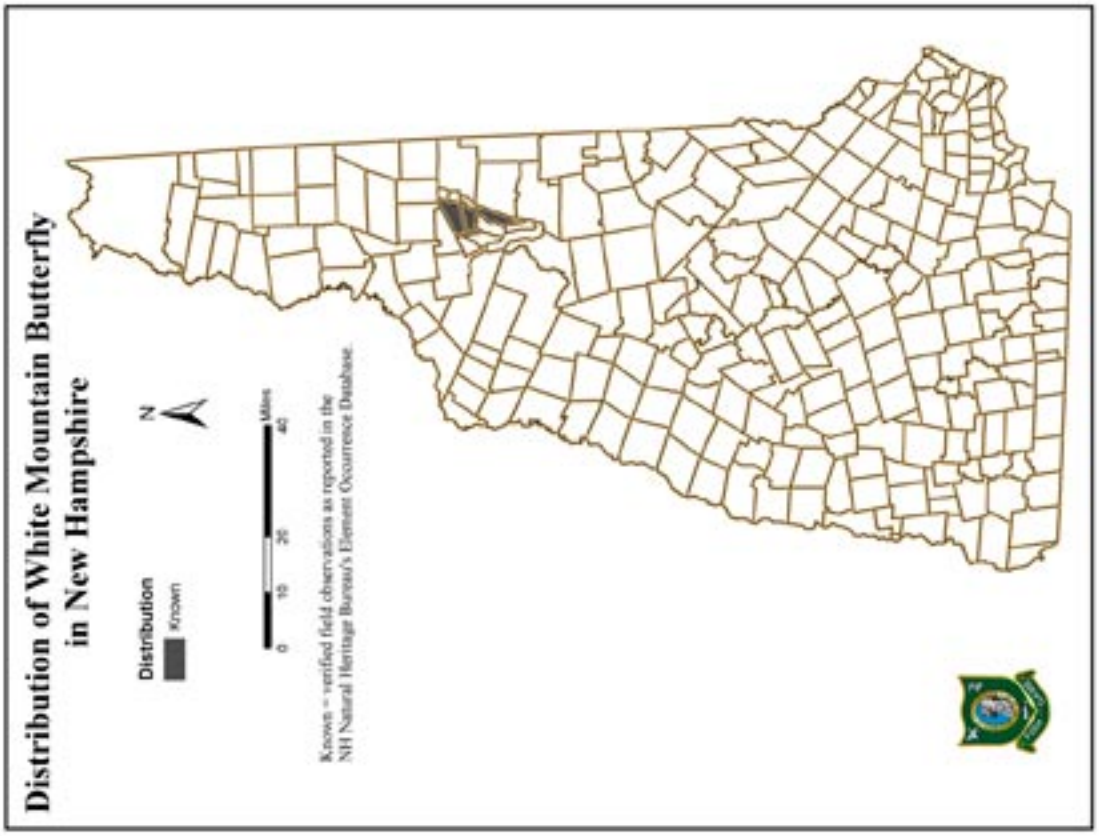
Known = confirmed observations as reported in the NH
Natural Heritage Bureau's Element Occurrence Database.


Distribution of White Mountain Butterfly
in New Hampshire
Distribution
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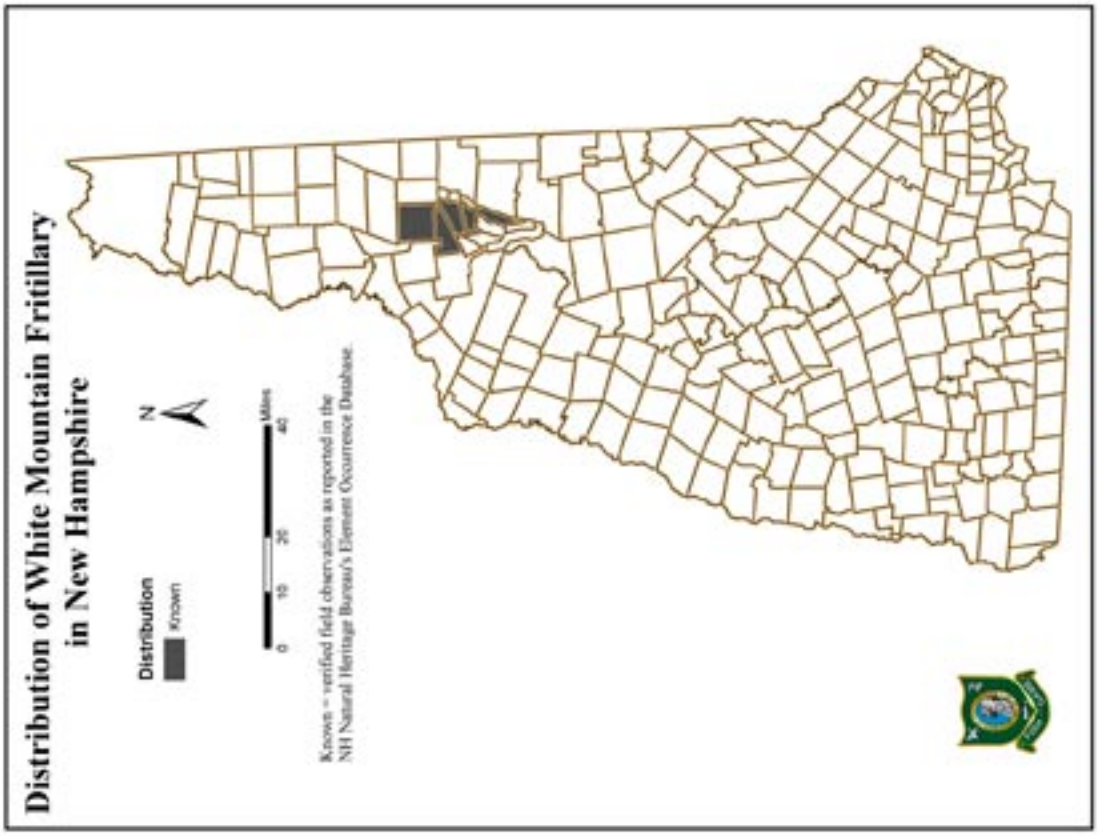
0 10 20 40 Miles
Known = verified field observations as reported in the
NH Natural Heritage Bureau's Element Occurrence Database.


Distribution of White Mountain Fritillary
in New Hampshire
Distribution
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Miles
Known = verified field observations as reported in the
NH Natural Heritage Bureau's Element Occurrence Database.

APPENDIX A

Species Profiles

Part Four: Mammals

American Marten....A-253
Bobcat....A-261
Eastern Pipistrelle....A-270
Eastern Red Bat....A-276
Eastern Timber Wolf....A-281
Hoary Bat....A-285
Indiana Bat....A-290
Canada Lynx....A-296
New England Cottontail....A-303
Northern Bog Lemming....A-312
Northern Myotis....A-317
Silver-Haired Bat....A-323
Eastern Small-Footed Bat....A-328
Mammal Maps....A-334

SPECIES PROFILE

American Marten

Martes americana

State Listing: Threatened
Global Rank: G5
State Rank: S2
Author: Jillian R. Kelly, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

In the Northeast, American marten are found in forests dominated by mid successional, coniferous, and deciduous stands, as well as in partially harvested stands (Chapin et al. 1997, Fuller 1999, Payer 1999). Complex horizontal and vertical structure is especially important to marten, and coarse woody debris is associated with prey access and abundance, denning and nesting sites, refuge from predators, and thermoregulation (Buskirk et al. 1988).

Because canopy cover in deciduous forests decreases dramatically in winter, conifers may be important to martens. During the winter, marten require more horizontal structure (e.g. coarse woody debris) for access to subnivean resting sites, thermal protection (Taylor and Buskirk 1994), and access to prey (Sherburne and Bissonette 1994). To compensate for scarce prey and higher metabolism during winter, marten have been known to shift to larger prey, such as snowshoe hare (Lachowski 1997), which provide more energy per volume than mice and voles (Zielinski 1986). At elevation, deep snow, unique soil composition, inclement weather, and infrequent logging all contribute to the conifer cover and coarse woody debris that marten seek. Thus, ridgelines and areas of high elevation may be particularly important for marten in New Hampshire. Marten compete with species such as the fisher.

1.2 Justification

In New Hampshire, marten were once common and economically important. By 1935, habitat loss and trapping had resulted in a drastic population decline. Marten remained scarce despite 2 reintroduction attempts and were one of the first species legally classified as threatened in New Hampshire.

Since the early 1980s, evidence of marten has been observed in towns throughout northern New Hampshire. Based on tracks, sightings and an examination of marten distribution, it appears that northern New Hampshire has an expanding population of marten. However, marten demographics are still poorly understood. In addition to being threatened in New Hampshire, marten are of particular concern because of their status as an "umbrella species"; their large range and sensitivity to disturbance make them broad indicators of ecosystem health.

1.3 Protection and Regulatory Status

American marten are listed as threatened in New Hampshire (RSA 212-A). Currently, New Hampshire has a Memorandum of Understanding with the majority of the large landowners, which requires consultation with New Hampshire Fish and Game (NHFG) when proposing to harvest timber above 2,700 ft. There is also an informal agreement with fisher trappers pertaining to the reporting and confiscation of marten carcasses if incidentally captured.

1.4 Populations and Habitat Distribution

Marten were once found throughout the state (except along the coast), but currently appear to be found only from the southern end of the White Mountains north to the town of Pittsburg, where populations are highest (Kelly 2005). Populations found further

south may be isolated by habitat fragmentation resulting from development and habitat differences (e.g., less snow, less coniferous and mixed coniferous/deciduous cover). High elevation habitat appears to be extremely important along the southern edge of their current distribution in New Hampshire.

1.5 Town Distribution Map

Figure 1

1.6 Habitat Map

Figure 2

1.7 Sources of Information

Information on marten habitat, population distribution, and status was collected from Kelly (2005), trappers, technical field reports, agency data (United States Forest Service (USFS), United States Fish and Wildlife Service (USFWS)) and scientific journals.

1.8 Extent and Quality of Data

Marten have been a priority research species for the past 3 years, during which time they were systematically sampled. Data on population demography and high-elevation populations are still lacking. Stand-level data, such as coarse woody debris and snag densities, are needed for better marten management.

1.9 Distribution Research

Distribution research has drawn on intense collection and observation data, as well as upon incidental captures data.

Element 2: Species Condition

2.1 Scale

Conservation planning units for American marten are based on watershed, landownership, and ecological subsection characteristics.

2.2 Relative Health of Populations

Historically, marten were likely most common around the Connecticut Lakes. Currently, it appears that marten are well established in the headwaters of the Connecticut River and Magalloway River drainages, and are scarce in the Indian Stream drainage. Marten continue to be common in the Mahoosuc and White Mountains, particularly at higher elevation where snowfall is deeper and coniferous cover is greater.

2.3 Population Management Status

Marten populations are not specifically managed, but see sections 2.4, 2.5, and 2.6 for details on habitat protection and management.

2.4 Relative Quality of Habitat Patches

The Connecticut Lakes subsection provides key ecological attributes for marten. The Connecticut Lakes Headwater Property makes up a large percentage of the subsection and has specific wildlife and timber management objectives that will benefit marten. Specific Special Management Areas (SMA) were set aside as marten habitat and require NHFG consultation before logging. Further restrictions on SMAs are also conducive to linking marten habitat.

The Mahoosuc-Rangeley also has excellent potential to provide key ecological attributes for marten. Large land ownerships make up a large percentage of this subsection and provide excellent opportunity to maintain or increase the amount of marten habitat. Larger ownerships in the subsection have recently experienced a high turnover in ownership, which has resulted in widespread, heavy cutting that has likely reduced the amount of habitat available to marten.

The White Mountain subsection, with its interconnected high elevation habitat patches, is well suited for martens. The White Mountain subsection is virtually all White Mountain National Forest (WMNF) and provides excellent opportunity to manage and monitor marten habitat.

2.5 Habitat Patch Protection Status

The Connecticut Lakes subsection is made up of landowners with conservation easements, as well as land that is owned in fee by the state of New Hampshire. The Connecticut Lakes Timber Company currently owns 146,400 acres of working forest with a comprehensive easement held by New Hampshire Department of Economic Resources and Development. NHFG owns in fee 25,000 acres within the

subsection. Habitat that remains unprotected includes Crystal Mountain and Blue Ridge, as well as the Sanguinary and Rice Mountain Ridge with associated lower elevation areas. Unincorporated towns in this subsection have some level of protection through zone districts.

The Mahoosuc-Rangeley subsection is virtually unprotected by ownership and/or easement. High elevation areas have the most protection under unincorporated town zoning and state ownership (e.g., Nash Stream), whereas lower elevation habitats have experienced extensive cutting over the past 10 years with little protection or zoning. Wildlife management objectives are incorporated whenever possible through NHFG's technical assistance program for large landowners. Under this program, compliance with biologists' recommendations is not mandatory. The White Mountain subsection is virtually entirely protected through ownership by the USFS.

2.6 Habitat Management Status

Under the Connecticut Lakes Headwaters Area (CLNA) Draft Stewardship Plan, a primary goal for the property is to establish and maintain wildlife habitats that provide for game and non-game wildlife species native to the Connecticut Lakes Ecoregion. Specific consideration will be given to the landscape context and habitat availability existing outside the boundaries of the CLNA, with emphasis on those species considered to be rare or of conservation concern (e.g., marten). Boreal forest species are also a specific target for this goal. Unincorporated places within the subsection have specific zoning for critical wildlife habitat (PD3 zones), wetlands (PD7 zones), and unusual areas (PD8).

Conserved land within the Mahoosuc-Rangeley subsection includes the Vicki Bunnell Preserve, Nash Stream State Forest, Kilkenny National Forest (part of WMNF), and the Randolph Town Forest, all of which have specific goals for promoting boreal forest and wildlife species within their boundaries. The majority of low-lying habitat remains in large ownerships with few easements and little protection, and is thus at risk of logging. Virtually all of the White Mountains subsection is made up of the WMNF. The age class objectives include having 59 to 63% of the softwood habitat as mature habitat, and 30% as old habitat.

2.7 Sources of Information

Information on habitat protection and management was obtained from literature review, expert review and consultation (W. Staats, NHFG, personal communication), pertinent research, the Connecticut Lakes Headwaters Forest Draft Stewardship Plan, the Draft Plan for Connecticut Lakes Natural Area, Zoning Ordinances for Coos County Unincorporated Places and the WMNF Proposed Land and Resource Management Plan.

2.8 Extent and Quality of Data

Habitat data on stand-level forest condition and landscape connectivity are lacking.

2.9 Condition Assessment Research

An extensive GIS database of habitat age, fragmentation, and management status is needed. Information could be derived from aerial photos and analyzed every 2 to 5 years, or from databases of specific properties held by large landowners.

Element 3: Species and Habitat Threat Assessment

3.1.1. Unsustainable Harvest (Forestry Operations and Management)

(A) Exposure Pathway
As a forest interior species, marten require that a certain percentage of their home range be mature forest.

(B) Evidence
Landscape use, composition, and connectivity are especially important to marten (Hargis et al. 1999, Chapin et al. 1998). In Maine, marten are nearly absent from landscapes where more than 0 to 40% of the landscape is in early successional forest (Hargis et al. 1999). Partially harvested forest stands are still utilized by marten as long as they maintain a basal area greater than 18 m^2/ha in live trees and snags, especially when the stands retain at least 25 to 30% of the stand in coniferous cover.

3.1.2. Development

(A) Exposure Pathway
Development results in direct loss of forested habitat for marten.

(B) Evidence
Marten are less likely to be captured in areas close to open habitat and in areas with increasing amount of high contrast edge (Hargis et al. 1999). Marten are a forest dependent species and are unable to use prey in agricultural lands associated with higher road and people densities. Indeed, marten populations have been shown to be lower near dense road networks (Robitaille and Aubry 2001).

3.1.3. Scarcity (Competition)

(A) Exposure Pathway
Interspecific competition between marten and fisher is likely related to the competition for prey (e.g., red squirrels and snowshoe hare) and denning locations (e.g., cavity trees). Habitat partitioning is likely more prevalent during the winter, when deeper snow limits fisher populations, though during non-limiting conditions marten and fisher habitat overlap extensively. When marten and fisher populations overlap, it is also likely that fisher eat marten.

(B) Evidence
Krohn et al. (1995) noted that age and recruitment ratios of marten differed significantly across areas where fisher and marten overlapped. Furthermore, in core marten habitat there was little to no fisher recruitment. In core fisher habitat, where marten were present, there was a higher percentage of juvenile marten, suggesting that fisher compete with marten where limitations to fisher populations are low (Krohn et al. 1995). Kelly (2005) compared catch per unit effort (CPUE) values between fisher and marten and found that areas with low CPUE for fisher were more likely to have higher CPUE values for marten.

3.1.4. Climate Change

(A) Exposure Pathway
Climate change, which has resulted in decreased snow depths in winter, may be pushing marten further north and into higher elevation habitats with more snow.

(B) Evidence
Marten are smaller, more agile, and more likely to hunt beneath the snow than fisher (Steventon 1979, Raine 1983). Subnivean air pockets can act as thermal insulators, further increasing the marten's advantage in deep snow (Taylor and Buskirk 1996).

3.1.5 Unregulated Take (Illegal or Unregulated Take)

(A) Exposure Pathway
Fisher trappers incidentally capture marten in fisher sets, sometimes killing them.

(B) Evidence
Fisher trappers are required to turn incidental marten kills over to the local conservation officer. Trappers are also required to keep a trapping journal, where incidental captures should be documented.

3.2 Sources of Information

Information on threats was taken from Kelly (2005), Krohn et al. (1995), Ray (2000), expert review, and consultation (W. Staats, NHFG).

3.3 Extent and Quality of Data

There is well-documented information on the effects of climate change, timber harvesting, and development on martens. The impacts of unregulated take and interspecific competition with fisher are more difficult to assess.

3.4 Threat Assessment Research

Potential threat assessment research would include an in-depth examination of the relationships between marten and fisher. The impacts of timber harvesting and development should also be closely monitored by monitoring marten populations across the landscape as cover distribution changes.

Element 4: Conservation Actions

4.1.1 Work with landowners to promote forest management that maintains marten habitat across the landscape, Restoration and Management

(A) Threats
Timber harvesting without regard for non-timber resources and development

(B) Justification
- Working with large landowners to promote mature forest characteristics will directly increase the amount of habitat available for marten.
- The ecological response for this objective is having at least 60% of the landscape in mature forest status (more than 18 m^2/ha of live trees and snags, with a mean height of more than 9 m and more than 7.6 m diameter at breast height (dbh) (Fuller, 1999)).
- The conservation action can be adapted to new information by shifting emphasis to innovative or altered management techniques.

(C) Conservation Performance Objective
The desired outcome is to maintain large forested blocks of habitat, to maintain connectivity, and to maximize sustainable forestry practices on those lands. Integration of landscape level wildlife management objectives should also be included in guidelines for Forest Certification programs. The desired period is the next 30 years.

(D) Performance Monitoring
Specific objectives will be to assess land cover dynamics using GIS and to examine how the changes in cover relate to potential marten habitat.

(E) Ecological Response Objective
The desired ecological response is the increase and maintenance of the amount of suitable marten habitat in New Hampshire by balancing marten habitat needs with sustainable forestry.

(F) Response Monitoring
Studies of marten densities and distribution can be used to assess the impacts of this action.

(G) Implementation
Implementation of each performance objective can be initiated by NHFG. Guidelines for forest certification should be examined and implemented by the forestry industry. Further marten distribution and density information can be collected where appropriate in coordination with cooperating agencies and academic institutions.

(H) Feasibility: 1.56

4.1.2 Encourage the maintenance of large forest ownerships, Policy and Regulation

(A) Threats
Timber harvesting without regard for non-timber resources, development

(B) Justification
Working to maintain large ownerships through tax incentives and conservation easements will minimize the threat of development. The conservation action can be adapted to new information by shifting priorities and methods based on circumstance and timing with landowner interest or turnover.

(C) Conservation Performance Objective
The desired outcomes of maintaining large forest ownerships are to maximize the effectiveness of landscape forest management, minimize development pressures and opportunity, and support local economies dependent on the forest products industry. The appropriate scale for this action is statewide, with a focus on the historic large ownerships found north of the White Mountains that are part of the greater Northern Forest. Maintaining large ownerships through tax incentives and conservation deals (e.g., the Connecticut Lakes Headwaters Area) will provide important management opportunities for specific species such as marten.

(D) Performance Monitoring
Property size and turnover rates can be tracked over time. Existing properties should be identified and prioritized according to immediate threats of development and parceling.

(E) Ecological Response Objective
Maintaining large ownerships will benefit marten populations and other wildlife with similar habitat requirements. This will be accomplished when the majority of large ownerships have long-term incentives to minimize parceling and development.

(F) Response Monitoring
Areas to monitor include properties without ease-

ments, including lands owned by T.R. Dillion, Bayroot, Plum Creek, and GMO. Baseline threats should be identified for each property, and properties should be prioritized based on current threats.

(G) Implementation
Maintaining large forest ownerships is a multi-agency, region-wide endeavor that will involve a large number of stakeholders. NHFG and other conservation organizations such as The Nature Conservancy, Society for the Protection of New Hampshire Forests, New Hampshire Timberland Owners Association, and Trust for Public Land should be integral to this process.

(H) Feasibility: 1.38

4.1.. Continue to monitor and manage fisher populations, Restoration and Management

(A) Threats: Interspecific competition

(B) Justification
Monitoring fisher populations, understanding habitat relationships between fisher and marten, and managing (e.g., trapping) fishers may benefit martens. The action can be adapted to new information, and new data can be collected as needed.

(C) Conservation Performance Objective
The desired outcome of monitoring and managing New Hampshire's fisher population is to minimize interspecific competition between marten and fisher, and to increase knowledge about fisher and marten demographics. The appropriate scale for this action is statewide. Trapper data can be supplemented by compiling track transect data from agencies and landowners who collect it (e.g., USFS and Dartmouth College Grant). This should be a long-term effort.

(D) Performance Monitoring
Trapper survey data should be logged and analyzed in the NHFG furbearer database, and these data should be analyzed to identify the best methods for tracking fisher and marten populations statewide.

(E) Ecological Response Objective
The desired ecological response of monitoring and managing fisher in New Hampshire is the increase in the number of resident, breeding marten in New Hampshire and the existence of a stable marten population. If appropriate, fisher seasons in core marten habitat may need to be liberalized to minimize interspecific competition between the 2 species.

(F) Response Monitoring
Potential areas for response monitoring include the CLNA and the WMNF. Baseline information should be collected on the WMNF to supplement limited fisher trapping data from the remote high elevation locations where marten are likely abundant.

(G) Implementation
Long-term monitoring and management, which for the most part are already taking place under direction of the furbearer biologist for NHFG, should be continued. Further analysis of marten and fisher interactions may be needed and could be coordinated by region 1 biologists.

(H) Feasibility: 3.06

4.1.4 Investigate, adopt and tailor (to minimize marten captures) Best Management Practices (BMPs) for fisher in New Hampshire, Regulation and Policy

(A) Threats: Unregulated take

(B) Justification
Investigating, adopting, and tailoring BMPs for fisher to minimize marten captures will likely decrease the number of marten incidentally killed in fisher traps.

(C) Conservation Performance Objective:
The desired outcome of using BMPs for fisher trapping in New Hampshire is to minimize the number of marten that are incidentally captured in fisher traps, while still maximizing the recreational, economic and management benefits that fisher trapping provides. The appropriate scale for this action is statewide. Marten distribution and abundance may be highly related to fisher distribution and abundance, and trapping data provide important insight into that relationship. The desired period is over the next 2 to 5 years.

(D) Performance Monitoring:
Current BMPs for fisher trapping will be examined, and modifications will be made when necessary. Specific factors to examine are the use of non-lethal traps in areas where marten densities are greatest, or adjusting trigger placement to minimize marten captures in traps. Both methods should be examined for effectiveness, feasibility, and trapper support.

(E) Ecological Response Objective
The desired ecological response of examining fisher BMPs is to minimize impacts on marten populations due to incidental captures. Successful implementation of fisher trapping BMPs will result in fewer than 5 marten incidentally captured per year and the maintenance of fisher trapping as a tool to minimize interspecific competition between marten and fisher.

(F) Response Monitoring
Areas for response monitoring include the CLNA, Dixville Notch, and the WMNF where there has been incidental captures of marten by fisher trappers.

(G) Implementation
Implementation can be accomplished through the furbearer working group, NHFG's furbearer biologist, and regional biologists assisting in the effort.

(H) Feasibility: 2.63

Element 5: References

5.1 Literature

Bateman, M.C., H.D. Smith, and J. Lawson. 1988. Winter habitat use, food habits and home range size of the marten, *Martes americana*, in western Newfoundland. Canadian Field-Naturalist 100: 58-62.

Buskirk, S.W. 1983. The ecology of marten in south-central Alaska. Dissertation, University of Alaska, Fairbanks, Alaska. 131pp.

Buskirk, S.W. 1984. Seasonal use of resting sites by marten in south-central Alaska. Journal of Wildlife Management 48(3):950-953.

Buskirk, S.W., H.J. Harlow, and S.C. Forest. 1988. Temperature regulation in American marten (*Martes americana*) in winter. National Geographic Research 4:208-218.

Buskirk, S.W., S.C. Forrest, M.G. Raphael, and H.J. Harlow. 1989. Winter resting site ecology of marten in the central Rocky Mountains. Journal of Wildlife Management 53:191-196.

Chapin T.G., D.J. Harrison, and D.M. Phillips. 1997. Seasonal habitat selection by marten in an untrapped forest preserve. Journal of Wildlife Management 61:707-717.

Chapin T.G., D.J. Harrison, and D.D. Katnik. 1998. Influence of landscape pattern on habitat use by American marten in an industrial forest. Conservation Biology 12:1327-1337.

Fuller, A.K. 1999. Influence of selection harvesting on American marten and their primary prey in north central Maine. Thesis, University of Maine, Orono, Maine.

Hargis C.D., J.A. Bissonette and D.L. Turner. 1999. The influence of forest fragmentation and landscape pattern on American martens. Journal of Applied Ecology 36:157-172.

Hargis, C.D., and D.R. McCullough. 1984. Winter diet and habitat selection of marten in Yosemite National Park. Journal of Wildlife Management 48:140-146.

Harlow, H.J. 1994. Trade-offs associated with the size and shape of American martens. Pages 391-403 in S. W. Buskirk, A. S. Harestad, M. G. Raphael, and R. A. Powell, editors. Martens, sables and fishers: biology and conservation. Cornell University Press, Ithaca, New York.

Hodgman, T.P., D.J. Harrison, D.M. Phillips, and D.D. Elowe. 1997. Survival of American marten in an untrapped forest preserve in Maine. Pages 86-99 in G. Proulx, H. N. Bryant, and P. M. Woodard, eds. Martes: Taxonomy, ecology, techniques, and management. Provincial Museum of Alberta Edmonton, Canada

Katnik, D.D. 1992. Spatial use, territoriality, and summer-autumn selection of habitat in an intensively harvested population of martens on commercial forestland in Maine. M.S. Thesis, University of Maine, Orono, Maine, USA.

Kelly, J.R. 2005. Recent distribution of American marten in New Hampshire, and potential factors impacting distribution and habitat. Thesis, University of Massachusetts, Amherst, Massachusetts, USA.

Koehler, G.M., and M.G. Hornocker. 1977. Fire effects on marten habitat in the Selway-Bitter-

root Wilderness. Journal of Wildlife Management 41(3):500-505.

Krohn W.B., K.D. Elowe, and R.B. Boone. 1995. Relations among fisher, snow, and martens: Development and evaluation of two hypotheses. The Forestry Chronicle 71(1)97-105.

Lachowski, H.J. 1997. Relationships among prey abundance, habitat, and American marten in northern Maine. Thesis, University of Maine, Orono, Maine. 73pp.

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life (web application). Version 4.2 NatureSErsve, Arlington, Virginia. http://www.natureserve.org/explorer.

Payer, D.C. 1999. Influences of timber harvesting and trapping on habitat selection and demography of marten. Ph.D. Dissertation, University of Maine, Orono.

Raine, R. M. 1983. Winter habitat use and responses to snow cover of fisher (Martes pennanti) and marten (Martes americana) in southeaster Manitoba. Canadian Journal of Zoology 61:25-34.

Raine, R.M. 1987. Winter food habits and foraging behaviur of fishers (*Martes pennanti*) and marten (*Martes americana)* in southern Manitoba. Canadian Journal of Zoology 61:25-34.

Robitallie, J.F., and K. Aubry. 2000. Occurrence and activity of American martens *Martes americana* in relation to roads and other routes. Acta Theriologica 45(1):137-143.

Ray, J.C. 2000. Mesocarnivores of Northeastern North America: Status and Conservation Issues. WCS Working Papers No. 15, June 2000.

Ray, J.C. 2000. Mesocarnivores of Northeastern North America: Status and Conservation Issues. WCS Working Papers No. 15, June 2000.

Ruggiero, L.F., D.E. Pearson, and S.E. Henry. 1998. Characteristics of American marten den sites in Wyoming. Journal of Wildlife Management 62: 663-673.

Sherburne, S.S., and J.A. Bissonette. 1994. Marten subnivean access point use: response to subnivean prey levels. Journal of Wildlife Management 58: 400-405.

Sholander, P.F., V. Walters, R. Hock, and L. Irving. 1950. Body insulation of some arctic and tropical mammals and birds. Biological Bulletin 99: 225-236.

Silver, H. 1957. A history of New Hampshire game and furbearers. New Hampshire Fish and Game, Concord NH. Survey Report No. 6. 466pp.

Soutiere, E. 1979. Effects of timber harvesting on marten in Maine. Journal of Wildlife Management 43:850-860.

Spencer, W.D., R.H. Barrett, and W.J. Zielinski. 1983. Marten habitat preferences in the Northern Sierra Nevada. Journal of Wildlife Management 47:1181-1186.

Spencer, W.D. 1987. Seasonal rest-site preferences of pine martens in the northern Sierra Nevada. Journal of Wildlife Management 51:616-621.

Staats, W. New Hampshire Fish and Game. Region1 Wildlife Biologist. 2005.

Steventon, J.D., and J.T. Major. 1982. Marten use of habitat in a commercially clear-cut forest. Journal of Wildlife Management 46:175-182.

Steventon, J.D., and J.T. Major. 1982. Marten use of habitat in a commercially clear-cut forest. Journal of Wildlife Management 46:175-182.

Taylor, S.L., and S.W. Buskirk. 1996. Dynamics of subnivean temperature and wind speed in subalpine forests of the Rocky Mountains. Journal of Thermal Biology 21:91-99.

Thompson, I.D. 1994. Marten populations in uncut and logged boreal forests in Ontario. Journal of Wildlife Management 58:272-280.

Thompson, I.D., and A.S. Harestad. 1994. Effects of logging on American martens, and models for habitat management. Pages 355-367 *in* S.W. Buskirk, A.S. Harestad, M.G. Raphael, and R.A. Powell, editors. Marten, sables, and fishers, biology and conservation. Cornell University Press, Ithaca, New York, USA.

Thompson, I.D., and W.J. Curran. 1995. Habitat suitability for marten of second-growth balsam fir forests in Newfoundland. Canadian Journal of Zoology 73:2059-2064.

Wilbert C.J., S.W. Buskirk, and K.G. Gerow. 2000. Effects of weather and snow on habitat selection by American martens (*Martes americana*). Canadian Journal of Zoology 78:1691-1696.

Zielinski, W.J. 1986. Relating marten scat contents to prey consumed. California Fish and Game 72: 110-116.

SPECIES PROFILE

Bobcat

Lynx rufus

Federal Listing: Appendix II of CITES
State Listing: Protected
Global Rank: G5
State Rank: S4
Authors: John A. Litvaitis and Jeffery P. Tash, University of New Hampshire

Element 1: Distribution and Habitat

1.1 Habitat Description

Bobcats (*Lynx rufus*) occupy wooded habitats that provide cover and allow for stalking or ambush (Anderson and Lovallo 2003). In the northeastern United States, lagomorphs are an important prey and thus affect the distribution and abundance of bobcats (Litvaitis et al. 1986*a*, Litvaitis 1993). In New Hampshire, bobcats are associated with uplands or wetlands with dense understory vegetation, and with rugged terrain that may include rocky outcrops.

1.2 Justification

Bobcats are 1 of 5 felids endemic to the northeastern United States. The other felids have been extirpated [cougars (*Felis concolor*)] or are considered threatened [lynx (*Lynx canadensis*)]. In recent decades, bobcat populations in New Hampshire have declined precipitously. Much of this decline is due to the maturation of early-successional forests that dominated New Hampshire during the first half of the twentieth century (Litvaitis et al. 2005).

1.3 Protection and Regulatory Status

Bobcats are a protected species, and trapping and hunting seasons in New Hampshire have been closed since 1989. They are also included in Appendix II of CITES (Convention on International Trade of Endangered Species of Wild Fauna and Flora). This list includes species that are not necessarily threatened with extinction but that may become so unless trade is closely controlled. As a result, state wildlife agencies that allow harvests of bobcats must provide population trends, harvest data, harvest areas, and habitat evaluation to the USFWS.

1.4 Population and Habitat Distribution

Historic accounts of bobcats in New Hampshire are limited. Seton (1925) suggested that bobcats initially benefited from land clearing by early European settlers. His map of the pre-Columbian distribution of bobcats only included southwestern New Hampshire, and he suggested that the range of bobcats expanded north and east as forests were cleared for subsistence agriculture. Based on the distribution of bounty harvests between 1931 and 1965, core bobcat habitat appears to have been predominately in the southwestern New Hampshire (figure 1). This area continues to support a disproportionate number of bobcats (figure 2).

1.5 Town Distribution Map

Recent observations and incidental captures (n = 90) between 1990 and 2004 indicate that a large portion of the state is still occupied by bobcats.

1.6 Habitat Map

Methods

Historic harvest records and recent observations were used to investigate environmental factors that may affect the distribution of present-day bobcat habitats. Habitat associations and suitability were modeled with GIS using two approaches, empirical and mechanistic or process oriented.

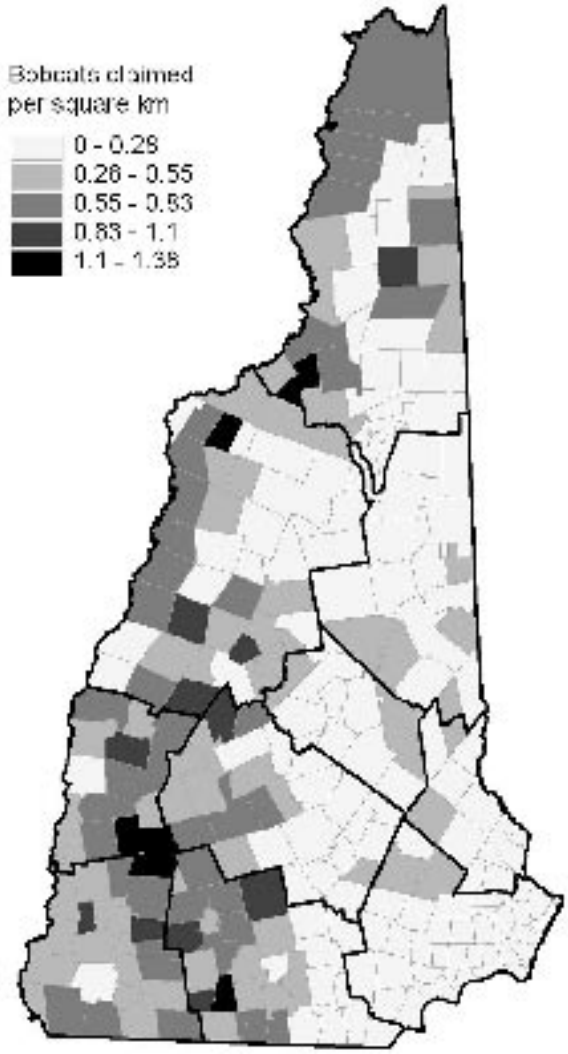


FIGURE 1. Distribution of bobcat harvests by township in New Hampshire from 1931 to 1965.

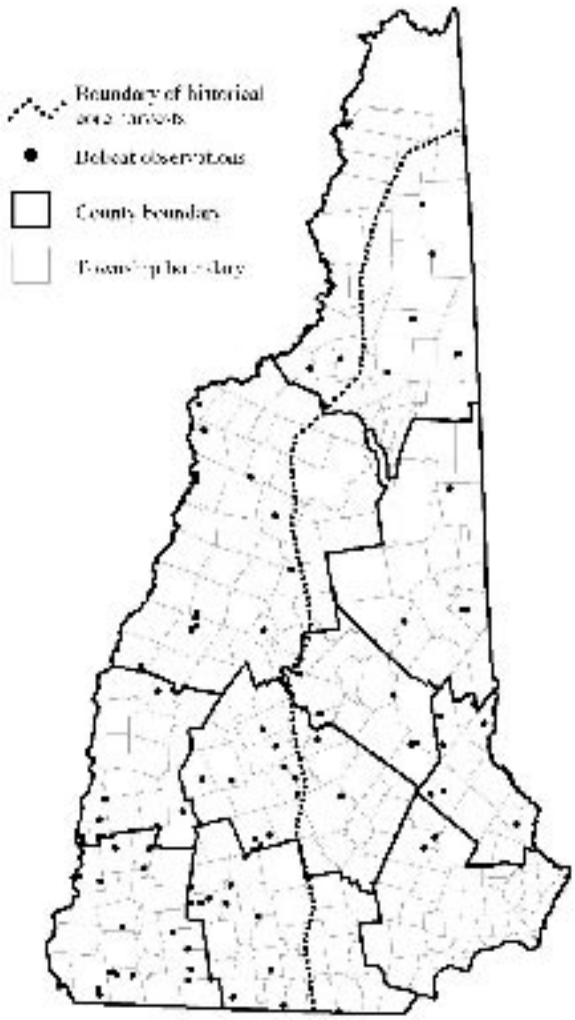


FIGURE 2. Locations of incidental captures, direct observations, and vehicle-killed bobcats (total = 90) during 1990 – 2004. The region to the west of the dashed line represents 49% of the state and it contained 74% of the >9,000 bobcats between 1931 and 1965. Seventy-two percent of the recent observations occurred in this area.

The empirical approach relied on a comparison of habitat features (55 variables) associated with recent (1990 – 2004) observations of bobcats to features associated with a comparable set of random locations within the state. Each known location was buffered with a 34-km^2 area (3.3 km radius). This area is equivalent to the average home range of female bobcats in neighboring Massachusetts (Berendzen 1985) and Maine (Litvaitis et al. 1986*a*). We chose an area equivalent to the range size of female bobcats because females are more closely associated with habitat features that influence survival (especially prey abundance) than are male bobcats (Litvaitis et al. 1986*a*). This approach is similar to the methods used to model felid habitats in other regions (Palma et al. 1999, Woolf et al. 2002, Hoving et al. 2005).

The process-oriented model was similar to the mechanistic approach used in creating habitat suitability models (e.g., Donovan et al. 1987). To identify environmental features that likely affected the distribution and abundance of bobcats, the townships where the majority of bobcats were taken during 1931 – 1965 were examined. This period was selected because harvest regulations were consistent

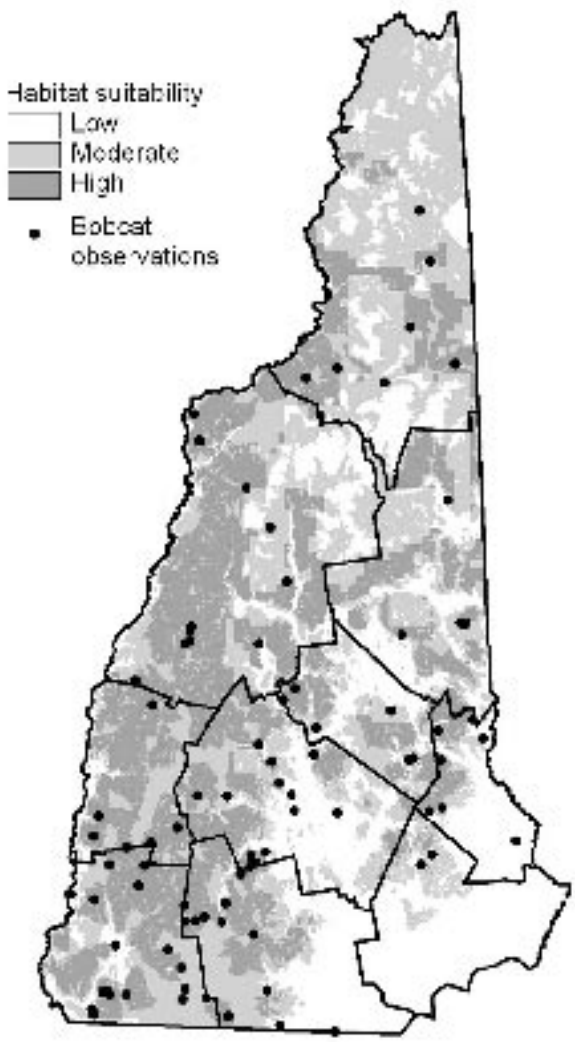


FIGURE 3. Modeled bobcat habitats where suitabilities were based on threshold values of elevation, minimum area of forest or wetland not fragmented by class I or class II roads, and annual snowfall.

in comparison to subsequent years. Based on previous research, these models focused on forest cover, elevation, and annual snowfall. These characteristics seemed to differentiate townships in the "core area" from townships where few bobcats were harvested. Minimum and maximum threshold values were then determined for each variable by visually comparing the spatial distribution of values to the historic core area. Each variable was then coded as suitable or not suitable based on selected thresholds. Habitat suitability of each cell was ranked using the sum of all variables inventoried (Berry 2004). The resulting model would have values between 0 (not suitable, no habitat components) and 3 (high suitability).

Results

Data screening of the empirical model yielded 9 variables that differed between known bobcat locations and random sites. Topographic slope, annual snowfall, area in beech/oak forest, and total forest area were most significant. Accuracy of the resulting model was poor, with only 52% of known locations and 75% of random sites correctly identified.

For the process-oriented model, threshold values for annual snowfall (<2500 mm), elevation (200 - 750 m above sea level), and minimum area of forest or wetland not fragmented by class 1 or 2 roads (34-km^2) seemed to differentiate the core area from areas where few harvests occurred, and were used to construct a habitat suitability model. Map cells were classified as low, moderate, and high suitability. A comparison of the resulting map with recent observations revealed that 79 of 90 (87.8%) of these areas contained some habitats that were classified at high suitability (figure 4). If we consider only the dominant habitat within the 34-km^2 buffer, 52% were classified at high suitability and 32% were classified at moderate suitability.

1.7 Sources of Information

Specific habitat, landscape, and climate features that influence bobcat distributions was based on previous research that examined bobcat-habitat associations in Maine (Litvaitis et al. 1986*a*, Major and Sherburne 1987), New Hampshire (MacLachlin 1981), Massachusetts (McCord 1974, Berendzen 1985), Pennsylvania (Lovallo 1999), Wisconsin (Lovallo and Anderson 1996*a*,*b*), Minnesota (Fuller et al. 1985), Montana (Smith 1984, Knowles 1985), Idaho (Knick 1990), Washington (Koehler and Hornocker 1991), Oregon (Witmer and deCalesta 1986), and British Columbia (Apps 1996). Information was used from the northern portion of the range because bobcats likely respond to a different set of environmental conditions than southern populations. Of particular note for populations in New Hampshire was the effect of snow (Petraborg and Gunvalson 1962, Litvaitis et al. 1986*a*, Matlack and Evans 1992) and low temperatures in winter (Gustafson 1894, Mautz and Pekins 1989).

Data on historic harvests (by township) were obtained from the files of C. L. Stevens, deceased professor at UNH, who conducted a long-term investiga-

tion on bobcats during the 1950s through the early 1960s (some of his work was subsequently published by Litvaitis et al. 1984). Stevens compiled a detailed review of bounty records from 1809 to 1965, and when combined with recent information, provides good information on the abundance of bobcats in New Hampshire during the past 200 years.

Data used to develop the habitat models included the New Hampshire Land Cover Assessment 2001 database from the Complex Systems Research Center of the University of New Hampshire (Justice et al. 2002). Measures of topography, including elevation, slope, and aspect were derived from statewide USGS digital elevation models obtained from Complex Systems Research Center at UNH. The NHDOT statewide database was used to inventory roads. Mean annual snowfall from 1971 to 2,000 was obtained from Spatial Climate Analysis Service at Oregon State University.

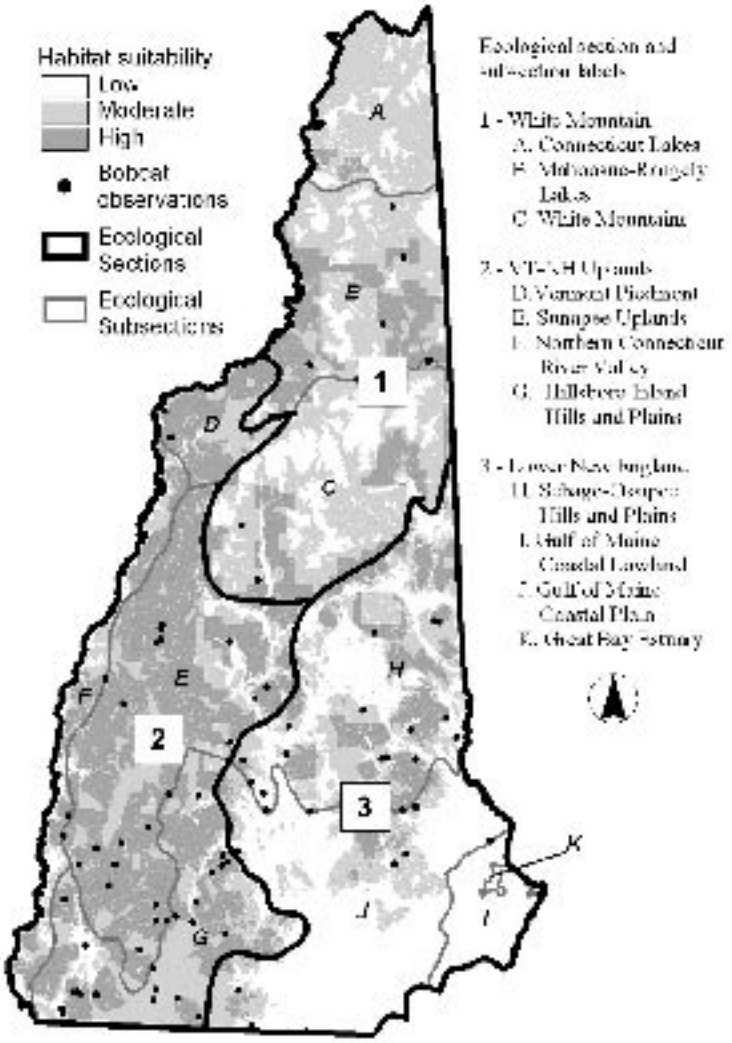


FIGURE 4. Distribution of recent (1990 – 2004) incidental captures and observations in Ecological Sections of New Hampshire.

1.8 Extent and Quality of Data

The variables included in the process-oriented model may not reveal cause-and-effect relationships, but may be functioning as surrogates. For example, threshold values for elevation probably described landscapes with varied topographic relief. Rugged terrains may be important because they incorporate a number of habitat features of bobcats, including loafing sites (Rollings 1945, Anderson 1990), dens (Bailey 1974), stalking cover (Koehler and Hornocker 1989) or refugia from potential competitors or predators (Koehler and Hornocker 1991) and may help to limit the number of human encounters (Nielsen and Woolf 2001).

Annual snowfall is functioning as a surrogate variable in the model for snow depth, a feature that directly influences bobcat mobility and prey acquisition (the deeper the snow the more bobcat movements become restricted) (Marston 1942). Juvenile and female bobcats seem most hampered by snow because the small prey they exploit may be more difficult to capture after snow accumulates (Litvaitis et al. 1986*b*). Higher elevations, although rugged, were probably avoided because annual snowfall increased with elevation. Apps (1996) reported a similar associated with mid-level elevations among bobcats in British Columbia.

Additionally, the process-oriented model only looks at landscape scale variables that may limit bobcat abundance and distribution. However, habitat selection by carnivores occurs at several spatial scales (Brown and Litvaitis 1995). Selection at a local scale is likely influenced by other features, including prey

distribution and stalking cover (e.g., Litvaitis et al. 1986*a*). Information on bobcat selection at a finer resolution (i.e., patch or forest stand) is limited for bobcats in New Hampshire. MacLachlin (1981) investigated habitat selection at the stand scale by snow-tracking bobcats along 76 km of tracks in Sullivan County. Unfortunately, this limited data set could not be analyzed statistically. Ranking habitat use, however, suggested a preference for softwood stands (MacLachlin 1981:20). Some effort should be made to obtain information on factors affecting stand-scale selection by bobcats if we are to understand what may limit the current distribution and abundance of this species.

1.9 Distribution Research

- Nothing is known about bobcat habitat selection at the stand scale. Lacking this information limits the ability to understand how forest management and other land uses may affect suitability of bobcat habitats.
- Understanding stand-scale selection patterns will require information on understory vegetation because the feature directly affects prey abundance. Developing methods of obtaining this information using remote-sensing technologies is a priority.
- The influence of class I and II roads is supported by previous research but is not completely clear. Additional information on the influence of traffic volume versus road density is needed to clearly understand how these landscape elements affect regional distribution and local demography.
- Inventory and monitoring protocols should be developed. These protocols would be most likely to be applied if they address multiple species (e.g., forest carnivores).

Element 2: Species Habitat Condition

2.1 Scale

Based on the large home range of individual bobcats, it may be most appropriate to group suitable habitats using the ecological sections defined by Sperduto and Nichols (2004). These 3 sections (Vermont-New Hampshire Upland, Lower New England, and White Mountain) and their respective subsections provide a logical framework to discuss status, distribution, and limiting factors of bobcats in the state (figure 4).

2.2 Relative Health of Populations

Available information suggests that the species may span a larger portion of the state today than at the time of European settlement. However, bobcats are confronting increasingly modified landscapes and new threats (e.g., vehicle collisions). Maintaining viable populations of bobcats will require an understanding of how such factors influence local populations.

2.3 Population Management Status

Bobcats have apparently consistently occupied the southwestern portion of the state for more than 400 years, and portions of that region remain the most productive habitat for bobcats after centuries of human activity. Increasing human development will likely degrade existing bobcat habitats. Maintaining large blocks of continuous forest, a recognized conservation goal in New Hampshire (Thorne and Sunquist 2001), would be beneficial to maintaining current populations of bobcats.

2.4 Relative Quality of Habitat Patches

Approximately 56% of the Vermont-New Hampshire Uplands are highly suitable; within this area, the Sunapee Uplands and Vermont Piedmont were dominated by high quality habitat (68 and 57%, respectively). The Hillsboro Inland Hills and Plains in addition to the Sebago-Ossipee Hills and Plains subsection also contain tracts of high suitability habitat (43 and 26%, respectively).

2.5 Habitat Patch Protection Status

The White Mountains ecosection has the greatest proportion of conservation lands (39%), but this region does not contain much high suitability habitat for bobcats. Twelve percent of the Vermont-New Hampshire Uplands section is in conservation land, some of which is in large parcels (103 that are more than 200 ha; appendix 4). The Hillsboro Inland Hills and Plains and the Sebago-Ossipee Hills and Plains subsections contain lesser amounts of conservation lands.

2.6 Habitat Management Status

Beyond efforts to maintain large blocks of habitat in public lands or in conservation easement, there is no active management of bobcat habitats.

2.7 Sources of Information

Land use and land cover data were obtained from the New Hampshire Land Cover Assessment 2001 database at the Complex Systems Research Center of UNH.

2.8 Extent and Quality of Data:

There is essentially no information on stand or patch-specific features that affect habitat use and fitness of bobcats.

2.9 Condition Assessment Research

An inventory and monitoring protocol could provide an appraisal of bobcat demographics and patch-specific habitat features (Carroll et al. 1999). The USFS *National Forest Inventory* could be used to link habitat and land-use changes to changes in bobcat abundance and distribution (Zielinski et al. 2000). Such an inventory/monitoring program could be designed using a variety of platforms (e.g., snow tracks, sooted panels, or remotely-triggered cameras) and could gather information on a number of mesocarnivores (e.g., bobcats, fishers, and pine marten), making it cost attractive (Zielinski and Kucera 1995).

Element 3: Species Threat Assessment

3.1 Transportation Infrastructure (Mortality, Fragmentation, Dispersal Barriers)

(A) Exposure Pathway
Because bobcats are wide-ranging carnivores, they are likely to encounter and cross roads, where collisions are more likely. Such collisions will reduce local populations and deter immigrants from reaching unoccupied or low-density habitats.

(B) Evidence
The influence of class I and II roads is supported by previous research (Lovallo and Anderson 1996*a*), yet it is not completely clear how roads are affecting bobcats. Crooks (2002) indicated that bobcats were intermediate in their sensitivity to habitat fragmentation, but recommended that connectivity of habitats be considered as essential for bobcats in landscapes undergoing development. Increased mortality from vehicle collisions may reduce local populations or limit immigration from surrounding landscapes. In Maine, Litvaitis et al. (1987) reported that vehicles collisions were the second most frequent cause of mortality (after legal trapping and hunting) among radio-tagged bobcats. However, Nielsen and Woolf (2002) found that vehicle collisions did not limit an unharvested population of bobcats in southern Illinois. Therefore, additional information on the additive versus compensatory nature of vehicle-related mortalities and the influences of traffic volume and road density on immigration rates is needed if we are to understand and mitigate the effects of roads on bobcats in developing landscapes.

3.2 Sources of Information

A building body of literature indicates that high traffic volume roads can affect the viability of local bobcat populations (e.g., Crooks 2002).

3.3 Extent and Quality of Data

There are no field data on New Hampshire populations.

3.4 Threat Assessment Research

Consider telemetry-based study in occupied habitats that contain a range of traffic volume conditions.

Element 4: Conservation Actions

4.1.1 Maintain large tracts of forests without class I and II roads.

See section 3.1.1

Element 5: References

5.1 Literature

Anderson, E.M. 1987. A critical review and annotated bibliography of literature on bobcat. Special Report

Number 62. Colorado Division of Wildlife.

Anderson, E.M. 1990. Characteristics of bobcat diurnal loafing sites in southeastern Colorado. Journal of Wildlife Management 54:600-602.

Anderson, E.M., and M.J. Lovallo. 2003. Bobcat and lynx. Pages 758-782 *in* Wild mammals of North America: biology, management, and conservation (2nd edition), G.A. Feldhammer, B.C. Thompson, and J.A. Chapman, editors. John Hopkins Press, Baltimore, Maryland, USA.

Apps, C.D. 1996. Bobcat (*Lynx rufus*) habitat selection and suitability assessment in southeast British Columbia. M.S. Thesis, University of Calgary, Calgary, Alberta, Canada

Bailey, T.N. 1974. Social organization in a bobcat population. Journal of Wildlife Management 38: 435-446.

Berendzen, S.L. 1985. Ecology and status of the bobcat in western Massachusetts. M.S. Thesis, University of Massachusetts, Amherst, Massachusetts, USA.

Berry, J.K., 2004. Map Analysis: Procedures and Applications in GIS Modeling. Online book at www.innovativegis.com/basis/. Accessed 9 January 2005.

Brown, A.L., and J.A. Litvaitis. 1995. Habitat features associated with predation of New England cottontails: what scale is appropriate? Canadian Journal of Zoology 73:1005-1011.

Carroll, C., W.J. Zielinski, and R.F. Noss. 1999. Using presence/absence data to build and test spatial habitat models for the fisher in the Klamath region, U.S.A. Conservation Biology 13:1344-1359.

Conner, L.M., B.D. Leopold, and M.J. Chamberlain. 2001. Multivariate habitat models for bobcats in southern forested landscapes. Pages 51-55 *in* A. Woolf, C.K. Nielsen, R.D. Bluett, editors. Proceedings of a symposium on current bobcat research and implications for management. The Wildlife Society 2000 Conference, Nashville, Tennessee, USA, pp. 4-17.

Crooks, K.R. 2002. Relative sensitivities of mammalian carnivores to habitat fragmentation. Conservation Biology 16:488-502.

Dettki, H., R. Löfstrand, and L. Edenius. 2003. Modeling habitat suitability for moose in coastal northern Sweden: empirical *vs* process-oriented approaches. Ambio 32:549-556.

Donovan, M.L., D.L. Rabe, and C.W. Olson, Jr. 1987. Use of geographic information systems to develop habitat suitability models. Wildlife Society Bulletin 15:574-579.

Fuller, T.K., W.E. Berg, and D.W. Kuehn. 1985. Bobcat home range size and daytime cover-type use in northcentral Minnesota. Journal of Mammalogy 66:568-571.

Gustafson, K.A. 1984. The winter metabolism and bioenergetics of the bobcat in New York. M.S. Thesis, State University of New York, Syracuse, New York, USA.

Hoving, C.L., D.J. Harrison, W.B. Krohn, R.A. Joseph, and M. O'Brien. 2005. Broad-scale predictors of Canada lynx occurrence in eastern North America. Journal of Wildlife Management: In press.

Justice, D., A. Deely, and F. Rubin. 2002. New Hampshire land cover assessment: final report. Complex Systems Research Center, University of New Hampshire, Durham, New Hampshire.

Knick, S.T. 1990. Ecology of bobcats relative to exploitation and a prey decline in southeastern Idaho. Wildlife Monographs 108:1-43.

Knowles, P.R. 1985. Home range size and habitat selection of bobcats, *Lynx rufus,* in north-central Montana. Canadian Field-Naturalist 99:6-12.

Koehler, G.M., Hornocker, M.G., 1989. Influences of seasons on bobcats in Idaho. Journal of Wildlife Management 53, 197-202.

Koehler, G.M., and M.G. Hornocker. 1991. Seasonal resource use among mountain lions, bobcats, and coyotes. Journal of Mammalogy 72:197-202.

Litvaitis, J.A. 1993. Response of early successional vertebrates to historic changes in land use. Conservation Biology 7:866-873.

Litvaitis, J.A., A.G. Clark, and J.H. Hunt. 1986*b*. Prey selection and fat deposits of bobcats (*Felis rufus*) during autumn and winter in Maine. Journal of Mammalogy 67:389-392.

Litvaitis, J.A., J.T. Major, and J.A. Sherburne. 1987. Influence of season and human-induced mortality on spatial organization of bobcats (*Felis rufus*) in Maine. Journal of Mammalogy 68:100-106.

Litvaitis, J.A., J.A. Sherburne, and J.A. Bissonette. 1986*a*. Bobcat habitat use and home range size in relation to prey density. Journal of Wildlife Management 50:110-117

Litvaitis, J.A., C.L. Stevens, and W.W. Mautz. 1984. Age, sex, and weight of bobcats in

relation to winter diet. Journal of Wildlife Management 48:632-635.

Litvaitis, J.A., J.P. Tash, and C.L. Stevens. 2005. The rise and fall of bobcats in New Hampshire: relevance of historical harvests to understanding current patterns of distribution and abundance. Biological Conservation: In review.

Lovallo, M.J. 1999. Multivariate models of bobcat habitat selection for Pennsylvania landscapes. PhD dissertation, Pennsylvania State University, State College, Pennsylvania, USA.

Lovallo, M.J., and E.M. Anderson. 1996a. Bobcat movements and home ranges relative to roads in Wisconsin. Wildlife Society Bulletin 24:71-76.

Lovallo, M.J., and E.M. Anderson. 1996*b*. Bobcat home range size and habitat use in northwestern Wisconsin. American Midland Naturalist 135: 241-252.

Lovallo, M.J. G.L. Storm, D.S. Klute, and W.M. Tzilkowski. 2001. Multivariate models of bobcat habitat selection for Pennsylvania landscapes. Pages 4-17 *in*: A. Woolf, C.K. Nielsen, R.D. Bluett, editors. Proceedings of a symposium on current bobcat research and implications for management. The Wildlife Society 2000 Conference, Nashville, Tennessee, USA, pp. 4-17.

MacLachlin, W.S. 1981. Bobcat studies in New Hampshire. M.S. Thesis, University of New Hampshire, Durham, New Hampshire, USA.

Major, J.T., and J.A. Sherburne. 1987. Interspecific relationships of coyotes, bobcats, and red foxes in western Maine. Journal of Wildlife Management 44:963-968.

Marston, M.A. 1942. Winter relations of bobcats to white-tailed deer in Maine. Journal of Wildlife Management 6:328-337.

Matlack, C.R., and A.J. Evans. 1992. Diet and condition of bobcats, *Lynx rufus,* in Nova Scotia during autumn and winter. Canadian Journal of Zoology 70:1114-1119.

Mautz, W.W., and P.J. Pekins. 1989. Metabolic rate of bobcats as influenced by seasonal temperatures. Journal of Wildlife Management 53:202-205.

McCord, C.M. 1974. Selection of winter habitat by bobcats on the Quabbin Reservation, Massachusetts. Journal of Mammalogy 55:428-437.

Nielsen, C.K., and A.. Woolf. 2002. Survival of unexploited bobcats in southern Illinois. Journal of Wildlife Management 66:833-838.

Palma, L., P. Beja, and M. Rodrigues. 1999. The use of sighting data to analyze Iberian lynx habitat and distribution. Journal of Applied Ecology 36: 812-824.

Petraborg, W.H., and V.E. Gunvalson. 1962. Observations on bobcat mortality and predation on deer. Journal of Mammalogy 43:430-431.

Rollings, C.T., 1945. Habits, foods and parasites of the bobcat in Minnesota. Journal of Wildlife Management 9:131-145.

Seton, E.T., 1925. Lives of Game Animals, Volume 1, Cats, Wolves, and Foxes. Doubleday, Garden City, New York.

Siegler, H.R., 1971. The status of wildcats in New Hampshire. Pages 46-53 *in* S.E.Jorgensen, and L.D. Mech, Editors. Proceedings of a Symposium on the Native Cats of North America, Their Status and Management. USDI, Fish and Wildlife Service, Twin Cities, Minnesota, USA.

Silver, H., 1974. A history of New Hampshire game and furbearers (2nd edition). Survey Report No. 6, New Hampshire Fish and Game Department, Concord, New Hampshire.

Smith, D.S. 1984. Habitat use, home range and movements of bobcats in western Washington. M.S. Thesis, University of Montana, Missoula, Montana, USA.

Sperduto, D.D., and W.F. Nichols. 2004. Natural communities of New Hampshire. The New Hampshire Natural Heritage Bureau and The Nature Conservancy, Concord, New Hampshire, USA.

Tabachnick, B.G., and L.S. Fidell. 2001. Using multivariate statistics. Harper Collins College Publishers, New York.

Thorne, S., and D. Sunquist. 2001. New Hampshire's Vanishing Forest: Conversion, Fragmentation, and Parcelization of Forests in the Granite State. Society for the Protection of New Hampshire Forests, Concord, New Hampshire.

Witmer, G.W., and D.S. deCalesta. 1986. Resource use by unexploited sympatric bobcats and coyotes in Oregon. Canadian Journal of Zoology 64:2333-2338.

Woolf, A., C. K. Nielson, T. Weber, and T.J.Gibbs-Kieninger. 2002. Statewide modeling of bobcat, *Lynx rufus*, habitat in Illinois, USA. Biological Conservation 104:191-198.

Zar, J., 1999. Biostatistical analysis. Fourth edition.

Prentice Hall, Upper Saddle River, New Jersey.

Zielinski, W.J., and T.E. Kucera. 1995. Introduction to detection and survey methods. Pages 1-15 in: Zielinski, W.J.; Kucera, T.E., eds., American Marten, Fisher, Lynx, and Wolverine: Survey Methods for Their Detection. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station; Gen. Tech. Rep. PSW-GTR-157.

Zielinski, W.J., R.L. Truex, L.A. Campbell, C.R. Carroll, and F.V. Schlexer. 2000. Systematic surveys as a basis for the conservation of carnivores in California forests. Unpublished report, USDA Forest Service, Pacific Southwest Research Station, Redwood Sciences Laboratory, Arcata, California.

Element 6: List of Figures

FIGURE 1. Distribution of bobcat harvests by township in New Hampshire from 1931 to 1965.

FIGURE 2. Locations of incidental captures, direct observations, and vehicle-killed bobcats (total = 90) during 1990 – 2004. The region to the west of the dashed line represents 49% of the state and it contained 74% of the >9,000 bobcats between 1931 and 1965. Seventy-two percent of the recent observations occurred in this area.

FIGURE 3. Modeled bobcat habitats where suitabilities were based on threshold values of elevation, minimum area of forest or wetland not fragmented by class I or class II roads, and annual snowfall.

FIGURE 4. Distribution of recent (1990 – 2004) incidental captures and observations in Ecological Sections of New Hampshire.

SPECIES PROFILE

Eastern Pipistrelle

Pipistrellus subflavus

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S1N,SUB
Authors: Jacques P Veilleux, Franklin Pierce College; Scott Reynolds, St. Paul's School

Element 1: Distribution and Habitat

1.1 Habitat Description

Eastern pipistrelles hibernate in caves or mines, although they occasionally use other structures. For successful hibernation, eastern pipistrelles require habitat with low levels of human disturbance and a proper microclimate (e.g., temperature stability). Although eastern pipistrelles hibernate singly or in groups of two or three, individual hibernacula can have large populations of eastern pipistrelles, including over 750 individuals from a single mine in New York (Hicks 2003). Therefore, the protection of hibernacula is an important conservation concern.

No available data describe the summer habitat requirements of eastern pipistrelles in New Hampshire. The few available data on summer habitat use and life history come from the Midwest (Veilleux et al. 2003, Veilleux et al. 2004, Veilleux and Veilleux 2004). After leaving hibernacula, female eastern pipistrelles form maternity colonies in live or dead foliage of deciduous trees (Veilleux et al. 2003), although individuals in New Brunswick have roosted in Old Man's Beard (*Climatis vitalba*; H. Broders, personal communication) and individuals from the southeastern United States have roosted in Spanish moss (*Tillandsia useoides*; Davis and Mumford 1962). The birth and weaning of young occur within these foliage roosts. Some data indicate that females prefer to roost in oak (*Quercus alba* and *Q. rubra*) and maple (*Acer saccharum*) trees (Veilleux et al. 2003). Although eastern pipistrelles are a foliage-roosting species, individuals occasionally roost in man-made structures (Whitaker 1998).

1.2 Justification

Populations of eastern pipistrelles, like many other bat species, are believed to be decreasing. The likely reasons for the possible declines are the destruction or degradation of winter habitat (hibernacula) and summer habitat (roosting and foraging areas). Like other bat species, the eastern pipistrelle's life history is different from the typical life history of small mammals. Individuals are relatively long-lived and have a low reproductive rate. Eastern pipistrelles give birth to two young per year (Fujita and Kunz 1984), although only one may survive to reproductive age. The slow reproductive rate would, in turn, lead to a slow population recovery time. Since eastern pipistrelles are found in cave/mine habitats that are relatively rare and at risk, this species is at risk of population decline if such habitats are lost or degraded. Eastern pipistrelles are of conservation concern in New Hampshire for the above reasons and because of the lack of knowledge about the species' population status in New Hampshire (see section 1.4).

3.3 Protection and Regulatory Status

No specific ESA or RSA 212 regulations govern the take, transport, or use of this species. Scientific collecting or research involving the capture of individuals requires a permit through NHFG. Possession of live bats requires a permit under NHFG FIS 800. (?)

1.4 Population and Habitat Distribution

Data on the current and historic range of eastern

pipistrelles in New Hampshire are too few to allow a regional population comparison. The winter distribution data of eastern pipistrelles are limited to three mine localities with as many as five individuals in Mascot Lead Mine, three individuals in Mt. Kearsarge Lead Mine (Merrimack County), and one individual in Red Mine (Grafton County). One individual was also collected at Ruggle's Mine in Grafton (Grafton County), which is a potential but unsurveyed hibernaculum. Five definite summer records are known from New Hampshire. One individual is known from Canaan (Grafton County) and Chenger (2005) reported single individuals captured in the towns of Bartlett (Carroll County), Bean's Purchase (Coos County), Wentworth (Grafton County) and Warren (Grafton County). Possible echolocation call sequences have been recorded from Albany (Carroll County), Bartlett (Carroll County), New Boston (Hillsborough County), and possibly Nottingham (Rockingham County). These data indicate a potentially broad summer distribution of eastern pipistrelles in New Hampshire.

1.5 Town Distribution Map

1.6 Habitat Map

1.7 Sources of Information

Town data on the eastern pipistrelle's winter distribution were compiled from New Hampshire Natural Heritage Inventory – Bat Hibernaculum Record data sheets museum specimens, and college/university teaching collections. Summer distribution was determined from the published and gray literature of bat research in New Hampshire, as well as from specimen collections.

1.8 Extent and Quality of Data

Data on the distribution of eastern pipistrelles in New Hampshire are extremely limited (see section 1.4) but of high quality because qualified bat biologists identified the animals. The major knowledge gap is the paucity of occurrence records and research into distribution patterns.

1.9 Distribution Research

Priority research on the winter distribution of eastern pipistrelles should include surveys of potential hibernacula. Research on the summer distribution should include long-term mistnetting surveys accompanied by echolocation surveys (using Anabat acoustic survey methods). Mistnetting surveys should incorporate banding into the capture protocol and record all banding records in the Northeast Banding Database developed by the Northeast Working Group on Bats (NEWGB). An intensive banding program using state-issued wing bands would yield data on the summer distribution of all bat species in New Hampshire and may provide insight into overwintering areas.

Element 2: Species/Habitat Condition

2.1 Scale

Due to the small number of mines in New Hampshire that provide or potentially provide habitat for this species, each mine has been treated as a conservation planning unit under the habitat profile.

2.2 Relative Health of Populations

See section 1.4. The sparse data on winter or summer occurrences of eastern pipistrelles in New Hampshire prevent an analysis of the trends and viability of winter or summer populations. Priority conservation actions include winter surveys at New Hampshire mines that have not been surveyed

2.3 Population Management Status

No population management efforts are directed at the conservation of eastern pipistrelles.

2.4 Relative Quality of Habitat Patches

NHNHB has ranked both Mt. Kearsarge and Mascot Lead Mine as "B/C", indicating "fair to good quality and prospects for long-term conservation". Red Mine was ranked "B", indicating "good quality and prospects for long-term conservation". Ruggle's Mine has not been ranked by NHNHB. Although each mine with known wintering bats has been assessed for long-term conservation prospects, no research has

determined the microclimate quality.

2.5 Habitat Patch Protection Status

Red Mine and Ruggle's Mine are located on private land, while the DRED manages the Mascot Lead Mine and the Mt. Kearsarge Mine hibernacula.

2.6 Habitat Management Status

The only ongoing habitat management action occurring in New Hampshire is the bat gate at the Mascot Lead Mine (see Caves and Mines habitat profile). A census prior to gate installation (in 1992) found no eastern pipistrelles, and two were documented in the winter following installation. The 2004 winter survey documented five eastern pipistrelles.

2.7 Sources of Information

The winter distribution of eastern pipistrelles at known hibernacula was determined from New Hampshire Natural Heritage Survey – Hibernacula Survey Data Sheets. Scott Reynolds and Heather Durham conducted 1999 and 2000 winter surveys (Durham 2000). To determine habitat patch protection status, each potential and known hibernaculum was mapped on the Conservation Lands GIS data layer (GRANIT – 2003 data).

2.8 Extent and Quality of Data

The quality and extent of data varied between mines. For example, there have been four winter surveys at the Mascot Lead Mine since 1987; two were conducted since the installation of the bat gate in 1992. Since 1986, the Red Mine has been surveyed four times and the Mt. Kearsarge Lead Mine has been surveyed five times. With the exception of data collected in 1999 and 2000 at Red Mine and Mt. Kearsarge Lead Mine (Durham 2000), no microclimate data have been collected at any of these sites. Ruggle's Mine has not been surveyed.

2.9 Condition Assessment Research

The research priority for overwintering eastern pipistrelles is to obtain microclimate data (primarily temperature) at each hibernaculum. These data can then be used to assess microclimates at potential hibernacula. The research priorities for eastern pipistrelles during the summer include a statewide mistnetting survey, telemetry studies to determine roosting and foraging habitats, life history studies, and diet analysis.

Element 3: Species and Habitat Threat Assessment

3.1.1 Recreation

See Caves and Mines habitat profile

3.1.2 Development (Habitat Loss and Conversion), Unsustainable Harvest (Forestry Operations and Management)

(A) Exposure Pathway
As land in New Hampshire is deforested, eastern pipistrelles may experience summer habitat loss and degradation. Bats (particularly non-volant young) may also be killed if deforestation occurs during the parturition/lactation period (late May through mid-July). The additive results of habitat loss, degradation, and possible direct mortality could lead to a reduction in population size.

(B) Evidence
Recent data on colonial bat species indicate that bats occupy individual roost trees within a forest on a year-to-year basis (Barclay and Brigham 2001) and that individual bats return to the same roosting area each summer (Veilleux and Veilleux 2004). Bat biologists hypothesize that strong fidelity to roost areas (and possibly roost trees) allows individuals to relocate colony mates after emerging from hibernation. The removal of roost trees and forest habitat may disrupt the process of colony formation, with a corresponding reduction in individual fitness and population recruitment.

3.2 Sources of Information

Sources of information on threats to eastern pipistrelles include peer-reviewed scientific articles, gray literature, and expert review by John O. Whitaker, Jr. of Indiana State University.

3.3 Extent and Quality of Data

Fidelity of bats to specific roost areas (elements 3.1.3 and 3.1.4) is fairly well documented, but data on the effects of removing roost areas on colony dynamics are not available. Additional data on roost areas and roost trees are needed.

3.4 Threat Assessment Research

The final assessment effort for elements 3.1.3 and 3.1.4 would be to document roost areas in New Hampshire with relatively high numbers of eastern pipistrelles during the summer. Radiotelemetry studies would allow managers to determine the location of a roost area for a small population of eastern pipistrelles. Several years of capture and telemetry data at the roost areas would determine whether individual bats return to the same roost area. Such data would allow managers to assess the impact of removing forested habitat where eastern pipistrelles are known to occur.

Element 4: Conservation Actions

4.1.1 Gating, Habitat Protection

S*ee cave/mine habitat profile.*

4.1.2 Delineate habitat for conservation planning, Habitat Protection

(A) Removal of summer roosting habitat due to development, removal of summer roosting habitat due to logging.

(B) Justification

1) Sparse data on summer distribution patterns and population demographics of eastern pipistrelles limit the ability to determine whether documenting roosting habits (i.e. inter-annual fidelity to roost areas) will result in a measurable ecological response of population in the state. Since eastern pipistrelles breed in New Hampshire during the summer, it is important to understand their breeding habitat requirements and use this information to assess the potential impacts of habitat modification.
3) Veilleux and Veilleux (2004) reported that females return to very small summer roost areas each year. Minimum roost areas containing roost trees used by the same bats during two consecutive years ranged in size from 0.6 to 2.3 ha. Since development and logging can disrupt forested habitat at these small scales, it may be appropriate to limit or mitigate small-scale development or logging to protect eastern pipistrelles.

(C) Conservation Performance Objective
Integrate critical roosting habitats into a wildlife database. By protecting an entire habitat area, the smaller scale habitat needed by eastern pipistrelles (e.g., the preferred species of roost tree) will likely be protected as well.

(D) Performance Monitoring
To determine whether limiting or mitigating development and/or logging can maintain summer populations of eastern pipistrelles at specific habitat sites, managers can monitor whether eastern pipistrelles continue to use the habitat area over a long period (10 years).

(E) Ecological Response Objective
The habitat protection response objective is to maintain the current number of eastern pipistrelles roosting during summer within New Hampshire's forested habitats. Since data are too few to allow a valid estimate of the current eastern pipistrelle population status at summer roost areas, the minimal ecological response should be to maintain the initial populations located by biologists.

(F) Response Monitoring
To determine whether eastern pipistrelle summer populations are being maintained, known habitat areas should be monitored every three years. Such monitoring efforts will provide detailed data on whether eastern pipistrelles remain faithful to specific roost areas during the summer. These data will in turn allow managers to make informed decisions about eastern pipistrelle populations in areas threatened by high levels of development or logging.

(G) Implementation
Data on summer bat locations must be gathered. After summer habitat areas are identified, the state should initiate an intensive radio-telemetry study (1 to 2 years) to determine specific patterns of habitat use by individuals bats, and establish a long term

(10-year) monitoring program to determine if eastern pipistrelles remain faithful to small summer roost areas.

(H) Feasibility
The technical abilities are available in the region to determine both summer habitat areas (through mistnetting) and roosting habits (through radiotelemetry). The overall feasibility of conducting this research is limited by the availability of funding.

4.2 Conservation Action Research

Element 5: References

5.1 Literature

Barclay, R.M.R., and R.M. Brigham. 2001. Year-to-year reuse of tree-roosts by California bats (*Myotis californicus*) in southern British Columbia. American Midland Naturalist 146:80-85.

Chenger, J. 2005. 2004 Woodland bat survey in the White Mountain National Forest. Report prepared for the U.S. Department of Agriculture.

Currie, R.R. 2002. Response to gates at hibernacula. Pages 86-99 *in* A. Kurta and J. Kennedy, eds. The Indiana Bat: Biology and Management of an Endangered Species. Conservation International, Austin, Texas, USA.

Davis, W.H., and R.E. Mumford. 1962. Ecological notes on the bat *Pipistrellus subflavus*. American Midland Naturalist 68:394-398.

deVries, E. 2004. 150,000 MW by 2012! Renewable Energy World. June 2004:60-70.

Durham, H.C. 2000. Microclimate and roost selection in four New Hampshire bat hibernacula. Thesis, Antioch New England Graduate School, Keene, NH, USA.

Fujita, M.S.. and T.H. Kunz. 1984. *Pipistrellus subflavus*. Mammalian Species No. 228. American Society of Mammalogists.

Hicks, A. 2003. Indiana bat (*Myotis sodalis*) protection and management in New York State: Fiscal Year April 01, 2002 - April 01, 2003 Annual Report (Project W-166-E).

Johnson, S.A., V. Brack, and R.K. Dunlap. 2002. Management of hibernacula in the state of Indiana. Pages 100-109 *in* A. Kurta and J. Kennedy, eds. The Indiana Bat: Biology and Management of an Endangered Species. Bat Conservation International, Austin, Texas, USA.

Kerlinger, P.A. and J. Kerns. 2004. A study of bird and bat collision fatalities at the Mountaineer Wind Energy Center, Tucker County, West Virginia: Annual Report for 2003.

Krusic, R.A., M. Yamasaki, C.D. Neefus, and P.J. Pekins. 1996. Bat habitat use in White Mountain National Forest. Journal of Wildlife Management 60:625-631.

Kurta, A., D. King, J.A. Teramino, J.M. Stribley, and K.J. Williams. 1993. Summer roosting ecology of the endangered Indiana bat (*Myotis sodalis*) on the northern edge of its range. American Midland Naturalist 129:132-138.

Kurta, A. and J.A. Teramino 1994. A novel hibernaculum and noteworthy records of the Indiana bat and Eastern Pipistrelle (Chiroptera: Vespertilionidae). American Midland Naturalist 132: 410-413.

LaGory, K.E., D.S. Reynolds, and J.A. Kuiper. 2002. A survey of the bats of New Boston Air Force Station, New Hampshire. Unpublished Report to the U.S. Department of the Air Force.

McLeish, T. 2002. Wind power. Natural New England 11: 60-65.

Nicholson, C. 2003. Buffalo Mountain Windfarm: Bird and Bat Mortality Monitoring Report, 15pp.

Pierson, E., W.E. Rainey, and W.M. Koontz. 1991. Bats and mines: experimental manipulation for Townsend's big-eared bat at the McLaughlin Mine in California. Proceedings of the Thorne Ecological Institute: 31-42.

Reynolds, D.S. 1999. The distribution of New Hampshire bat species through remote acoustic monitoring. Unpublished report to the United States Fish and Wildlife Service (New England Field Office). 40 pp.

Speakman, J.R., P.I. Webb, and P.A. Racey. 1991. Effects of disturbance on the energy expenditure of hibernating bats. Journal of Applied Ecology 28: 1087-1104.

Thomas, D.W. 1995. Hibernating bats are sensitive to nontactile human disturbance. Journal of Mammalogy 76:940-946.

Thomas, D.W., M. Dorais, and J. Bergeron. 1990. Winter energy budgets and cost of arousals for hibernating little brown bats, *Myotis lucifugus*. Journal of Mammalogy 71:475-479.

Tuttle, M.D. 1976. Gating as a means of protecting

cave-dwelling bats. Pages 77-82 *in* Proceedings of the National Cave Management Symposium. Speleobooks, Albuquerque, New Mexico, USA.

Veilleux, J.P., J.O. Whitaker, and S. Veilleux. 2003. Tree-roosting ecology of reproductive female eastern pipistrelles, *Pipistrellus subflavus*, in Indiana. Journal of Mammalogy 84:1068-1075.

Veilleux, J.P. and S.L. Veilleux. 2004. Colonies and reproductive patterns of tree-roosting female eastern pipistrelle bats in Indiana. Proceedings of the Indiana Academy of Science 113:60-65.

Veilleux, J.P., J.O. Whitaker, Jr. and S.L. Veilleux. 2004. Reproductive stage influences roost use by tree roosting female eastern pipistrelles, *Pipistrellus subflavus*. Ecoscience 11:249-256.

Walsh, G. 2003. Is this the future of power generation in the Northeast? Natural New England 14: 62-71.

Whitaker, J.O. 1998. Life history and roost switching in six summer colonies of eastern pipistrelles in buildings. Journal of Mammalogy 79:651-659.

SPECIES PROFILE

Eastern Red Bat

Lasiurus borealis

Federal Listing: Not listed
State Listing: Not listed
Global Rank: Not ranked
State Rank: Not ranked
Authors: Jacques P Veilleux, Franklin Pierce College; Scott Reynolds, St. Paul's School

Element 1: Distribution and Habitat

1.1 Habitat Description

Eastern red bats inhabit New Hampshire during the summer. Individuals migrate to southern states in the fall and return to New Hampshire and other northern states in the spring (Cryan and Veilleux *in press*). No available data describe the summer habitat requirements of eastern red bats in New Hampshire. During the summer, eastern red bats roost in tree foliage (Shump and Shump 1982, Whitaker and Hamilton 1998). Adult males and non-reproductive females roost singly; reproductive females are colonial and roost with their young (Mumford 1973, Shump and Shump 1982, Hutchinson and Lacki 2000). Females give birth and wean their young within foliage roosts.

Studies have found that red bats roost in a variety of deciduous tree species, in the largest trees, often high off the ground near the outer canopy edge. Hutchinson and Lacki (2001) suggest that eastern red bats roosting at such locations are sheltered from high temperatures caused by direct solar insolation and benefit from the cooling effects of wind caused by evaporative/convective heat loss. Eastern red bats roosting in fragmented habitats, such as urban areas and farmland, may roost nearer the ground. This behavior may reflect the lower height of tree canopies in such areas, as well as benefits from the cooling effects of wind.

Roost trees are typically located close to permanent water sources (Hutchinson and Lacki 2000). Menzel et al. (1998) reported the mean roost area (the area containing all roost trees) at 2.6 ha, while Mager and Nelson (2001) reported a mean roost area of 90 ha. Veilleux and Veilleux (2004) reported individual female eastern pipistrelles, another foliage roost species, return to very small summer roost areas across years.

1.2 Justification

Like other bat species, the eastern red bat's life history is different from the typical life history of small mammals. Individuals are relatively long-lived and have a low reproductive rate with a mean litter size of three young per year (Shump and Shump 1982). Habitat loss and degradation may lead to population declines, which, when coupled with their slow reproductive rate, could lead to a slow population recovery time.

Eastern red bats are of conservation concern in New Hampshire for the above reasons and because of the lack of knowledge about the species' population status in New Hampshire. Only 11 individuals have been captured in New Hampshire. Sasse and Pekins (1996) reported 2 individuals captured in Livermore (Grafton County) and Bartlett (Carroll County). Chenger (2005) captured seven in the White Mountain National Forest, including two from Gorham (Coos County), three from Bean's Purchase (Coos County) and one from both Bartlett (Carroll County) and Piermont (Grafton County). LaGory et al. (2002) captured two at the New Boston Air Force Base in New Boston (Hillsborough County).

Based on echolocation calls, Krusic et al. (1996) reported the presence of eastern red bats in Bartlett (Carroll County). Reynolds (1999) reported echolocation calls recorded at three sites: Giles State Park in Springfield (Sullivan County), MacDowell Lake-

Woodcock in Peterborough (Hillsborough County), and Pawtuckaway State Park in Nottingham (Rockingham County). Chenger (2005) reported echolocation calls from Albany (Carroll County). The above data indicate that eastern red bats may have a wide summer distribution in New Hampshire. The current lack of detailed data on the distribution, habitat use, and life history of eastern red bats in New Hampshire is largely due to a lack of research.

1.3 Protection and Regulatory Status

No specific ESA or RSA 212 regulations govern the take, transport, or use of this species. Scientific collecting or research involving the capture of individuals requires a permit through NHFG. Possession of live bats requires a permit under NHFG FIS 800.

1.4 Population and Habitat Distribution

Data on the current and historical ranges of eastern red bats in New Hampshire are too few to allow a regional population comparison. Available data indicate that eastern red bats may have a wide summer distribution in New Hampshire.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

1.7 Sources of Information

Town data on the eastern red bat's summer distribution were compiled from museum specimens, college and university teaching collections, and the published and gray literature of bat research in New Hampshire.

1.8 Extent and Quality of Data

Data on the distribution of eastern red bats in New Hampshire are extremely limited, but the quality of existing data is believed to be good because eastern red bats are morphologically unique and easy to identify. The major knowledge gap is the paucity of occurrence records and research into distribution patterns.

1.9 Distribution Research

Priority research to determine the summer distribution of eastern red bats should include a long-term mistnetting survey of New Hampshire accompanied by echolocation surveys (using Anabat acoustic survey methods). A statewide mistnetting survey would also yield data on the summer distribution of New Hampshire's other six bat species of conservation concern.

Element 2: Species/Habitat Condition

2.1 Scale

Scale for an appropriate conservation planning unit has not been resolved by the upland forest habitat mapper (Steve Fuller, NHFG).

2.2 Relative Health of Populations

The paucity of data on summer occurrences in New Hampshire prevents an analysis of the population trends and viability of eastern red bats.

2.3 Population Management Status

Eastern red bats are not currently managed in New Hampshire. Lack of data on the distribution of eastern red bats in New Hampshire prohibits the identification of conservation opportunities.

2.4 Relative Quality of Habitat Patches

See section 2.1

2.5 Habitat Patch Protection Status

See section 2.1

2.6 Habitat Management Status

See section 2.1

2.7 Sources of Information

See section 2.1

2.8 Extent and Quality of Data

See section 2.1

2.9 Condition Assessment Research

The research priorities for eastern red bats include a statewide mist-netting to better understand distribution, telemetry studies to determine habitat use, life history studies, and diet analyses.

Element 3: Species and Habitat Threat Assessment

3.1.1 Development (Habitat Loss and Conversion)

(A) Exposure Pathway
As land in New Hampshire is deforested, eastern red bats will experience summer habitat loss and degradation. Bats (particularly non-volant young) may also be killed if deforestation occurs during the parturition/lactation period (late May through mid-July). The cumulative effects of habitat loss, degradation, and possible direct mortality could reduce population size.

(B) Evidence
Recent data indicate that bats occupy individual roost trees within a forest on a year-to-year basis (Barclay and Brigham 2001) and that individual bats return to the same, small roosting area each summer (Veilleux and Veilleux 2004). These data are for colonial bat species, but may also apply to solitary species (C. Willis, personal communication). Bat biologists hypothesize that strong fidelity to roost areas indicates that these sites are high quality breeding sites. The removal of roost trees and loss of forested habitat may reduce the quality of the habitat patch and a corresponding reduction in individual fitness and population recruitment.

3.1.2 Energy and Communication Infrastructure

See Cave and Mine Habitat Profile

Element 4: Conservation Actions

4.1.1 Documenting roosting habits, Habita Protection

(A) Removal of summer roosting habitat due to development, removal of summer roosting habitat due to logging.

(B) Justification
1) Identifying summer roost areas for eastern red bats and determining whether individual bats return to specific roost areas will allow managers to better assess the impact of development and logging.
2) Limited data exist on the spatial scale of the summer roosting habitat used by eastern red bats. Since development and logging can disrupt forested habitat, it may be appropriate to limit or mitigate small-scale development or logging in critical habitat.

(C) Conservation Performance Objective
Critical roosting habitats should be entered into a wildlife database. The summer habitat requirements for populations of eastern red bats will enable managers to assess how development or logging might impact eastern red bat populations. By protecting an entire habitat area, the smaller scale habitat needed by eastern red bats (e.g. the preferred species of roost tree) will likely be protected as well.

(D) Performance Monitoring
To determine whether limiting or mitigating development or logging can maintain summer populations of eastern red bats at specific habitat sites, managers can monitor whether eastern red bats continue to use the habitat area over a long period (e.g., 10 years).

(E) Ecological Response Objective
The habitat protection response objective is to maintain the current number of eastern red bats roosting within New Hampshire's forested habitats. Since the data are too few to allow a valid estimate of the current eastern red bat population, the minimal ecological response should be to maintain the initial populations located by biologists.

(F) Response Monitoring
To determine whether eastern red bat populations are being maintained, known habitat areas should be monitored every three years. These data will in turn allow managers to make better decisions about eastern red bat populations in areas threatened by high levels of development or logging.

(G) Implementation
To document the summer roosting habits of eastern

red bats, preliminary data on summer locations must be gathered. After summer habitat areas are identified, the state should coordinate an intensive short-term (1-2 year) radiotelemetry study to determine the specific patterns of habitat use by individuals, and a long-term (10 year) monitoring program with periodic 3-year monitoring to determine if eastern red bats remain faithful to small summer roost areas.

(H) Feasibility
The technical abilities are available to determine both summer habitat areas (through mistnetting) and roosting habits (through radiotelemetry). The overall feasibility of conducting this research is limited by the availability of funding.

4.1.2 Site-Selection and Pre-Construction Regulations, Regulation and Policy

See Cave/Mine Habitat profile

4.2 Conservation Action Research

Element 5: References

5.1 Literature

Barclay, R.M.R., and R.M. Brigham. 2001. Year-to-year reuse of tree-roosts by California bats (*Myotis californicus*) in southern British Columbia. American Midland Naturalist 146:80-85.

Chenger, J. 2005. 2004 Woodland bat survey in the White Mountain National Forest report prepared for the United States Department of Agriculture.

Cryan, P.M., and J.P. Veilleux. *in press*. Migration and the use of autumn, winter, and spring roosts by forest bats. Proceedings of the 2nd Bats and Forests Symposium, Hot Springs, Arkansas, USA.

deVries, E. 2004. 150,000 MW by 2012! Renewable Energy World. June 2004:60-70.

Hutchinson, J.T., and M.J. Lacki. 2000. Selection of day roosts by red bats in mixed mesophytic forests. Journal of Wildlife Management 64:87-94.

Hutchinson, J.T. and M.J. Lacki. 2001. Possible microclimate benefits of roost site selection in the red bat, *Lasiurus borealis*, in mixed mesophytic forests of Kentucky. Canadian Field-Naturalist 115:205-209.

Nicholson, C. 2003. Buffalo Mountain Windfarm: Bird and Bat Mortality Monitoring Report, 15pp.

Kerlinger, P.A. and J. Kerns. 2004. A study of bird and bat collision fatalities at the Mountaineer Wind Energy Center, Tucker County, West Virginia: Annual Report for 2003.

Krusic, R.A., M. Yamasaki, C.D. Neefus, and P.J. Pekins. 1996. Bat habitat use in White Mountain National Forest. Journal of Wildlife Management 60:625-631.

LaGory, K.E., D.S. Reynolds, and J.A. Kuiper. 2002. A survey of the bats of New Boston Air Force Station, New Hampshire. Unpublished Report to the U.S. Department of the Air Force.

Mager, K.J., and T.A. Nelson. 2001. Roost-site selection by eastern red bats (*Lasiurus borealis*. American Midland Naturalist 145:120-126.

McLeish, T. 2002. Wind power. Natural New England 11:60-65.

Menzel, M.A., T.C. Carter, B.R. Chapman, and J. Laerm. 1998. Quantitative comparison of tree roosts used by red bats (*Lasiurus borealis*) and seminole bats (*L. seminolus*). Canadian Journal of Zoology 76:630-634.

Mumford, R.E. 1973. Natural history of the red bat (*Lasiurus borealis*) in Indiana. Periodical Biology 75:155-158.

Reynolds, D.S. 1999. The distribution of New Hampshire bat species through remote acoustic monitoring. Unpublished report to the United States Fish and Wildlife Service (New England Field Office), Concord, New Hampshire, USA.

Sasse, D.B., and P.J. Pekins. 1996. Summer roosting ecology of northern long-eared bats (*Myotis septentrionalis*) in the White Mountain National Forest. Pages 91-101 *in* R.M.R. Barclay and R.M. Brigham, editors. Bats and Forests Symposium, October 19-21, 1995, Victoria, British Columbia, Canada. Research Branch, British Columbia Ministry of Forests, Victoria, B.C. Working Paper. 23/1996.

Shump, K.A., Jr., and A.U. Shump. 1982. *Lasiurus borealis*. Mammalian Species No. 183. American Society of Mammalogists.

Veilleux, J.P., and S.L. Veilleux. 2004. Intra-annual and interannual fidelity to summer roost areas by female eastern pipistrelles,_*Pipistrellus subflavus*. American Midland Naturalist 152:196-200.

Walsh, G. 2003. Is this the future of power generation in the Northeast? Natural New England 14:

62-71.
Whitaker, J.O., Jr., and W.J. Hamilton. 1998. Mammals of the Eastern United States. Cornell University Press, Ithaca, New York, USA.

SPECIES PROFILE

Eastern Timber Wolf

Canis lupus lycaon

Federal Listing: TN
State Listing: N/A
Affected Species: N/A
Global Rank: G4TNR
State Rank: SX
Author: Matthew Carpenter, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Historically, wolves lived in a wide variety of habitats throughout the northern hemisphere, from mountain forests to open prairie (Mech 1970). The main requirement for a wolf population is a source of large prey, such as deer, moose, or bison. Modern populations of wolves are limited by habitat fragmentation and direct or indirect human caused mortality (Musiani and Paquet 2004). Road density has been used in the Midwest as an indicator for suitable wolf habitat (Mladenoff et al. 1995). As populations expand in Minnesota, Wisconsin, and Michigan, wolves are adapting to semi-wild areas that were previously considered unsuitable (Mech 1995). The amount of residential or commercial development that wolves can learn to tolerate on a landscape is unclear.

1.2 Justification

Few species are loved and hated as passionately as the wolf. To some the wolf is an abstract symbol of a disappearing wilderness. To others the wolf is a vile murderer of livestock and deer. The wolf, from an ecological perspective, is part of a natural system. It has coevolved with the organisms of the northern forest over thousands of years. By preying on and shifting the distribution of herbivores such as deer, moose, and beaver, wolves indirectly influence plant species composition which in turn influences the very nature of the forest (Laundre et al. 2001). Since the extirpation of the wolf in the early 1800's New Hampshire has been missing the balancing influence of this top predator.

1.3 Protection and Regulatory Status

Gray wolves are currently listed under the federal endangered species act. In 2003, the USFWS divided gray wolf populations into three regions: western, southwestern, and eastern. New Hampshire was part of the Eastern Distinct Population Segment, which included the upper Midwest and the Northeast. In 2004, the USFWS proposed delisting the wolf in the Eastern Distinct Population Segment because populations had met recovery goals in the states of Minnesota, Wisconsin, and Michigan. A ruling in January of 2005 by the U.S. District Court in Oregon invalidated the USFWS population segments and returned the wolf to its status prior to 2003 (USFWS 2005). Therefore the wolf is currently classified as endangered in all eastern states except Minnesota, where it was reclassified as threatened in 1978.

The New Hampshire legislature passed a law (HB 240) in 1999 that bans the reintroduction of wolves into the state. The law does not restrict a natural recolonization by wolves.

1.4 Population and Habitat Distribution

Populations of gray wolves exist throughout northern North America, Europe, Russia, and Asia. A history of wolf persecution in Europe and the continental U.S. has extirpated the wolf from much of its former range (Mech 1970). Wolves were extirpated from New Hampshire in the early 1800's. The nearest population of wolves exists in Quebec, north of the St. Lawrence River. Wolves from this population have

been referred to as eastern timber wolves, considered a subspecies of gray wolves (USFWS 1992). Recent mitochondrial DNA evidence suggests that the eastern timber wolves, found in southeastern Canada, may be more closely related to red wolves (*Canis rufus*) and coyotes (*Canis latrans*) than to gray wolves (Wilson et al. 2000). The authors suggest that these wolves should be treated as a separate species, *Canis lycaon*. The issue remains unresolved.

In January of 2002, a wolf was snared near the town of Sainte-Marguerite-de-Lingwick, Quebec, approximately 32 km from the New Hampshire border (Villemure and Jolicoeur 2003). The trapper claimed to have seen other wolves in the area. This report is evidence that wolves are capable of crossing the St. Lawrence River, which is considered a major barrier to wolf dispersal (Wydeven et al. 1998, Harrison and Chapin 1998). It is the first confirmed wolf captured south of the St. Lawrence River, in Quebec, in over 100 years (Villemure and Jolicoeur 2003). Two wolves have been killed in Maine since 1993, although one of the individuals was behaving suspiciously like a released captive animal (Maine Department of Natural Resources [MDNR] 2004). Despite these reports, most studies suggest that a natural wolf recolonization of northern New England from populations in eastern Canada is unlikely (Wydeven et al. 1998, Carrol 2003). However, wolves tend to disperse over long distances, often crossing obstacles such as 4 lane highways (Merril 2000). The recent expansion of wolf populations in Europe and the midwestern states suggests that the potential for a natural recolonization of wolves in New Hampshire should be taken seriously.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

Refer to Mladenoff and Sickley (1998) for a map of potential wolf habitat in the northeast.

1.7 Sources of Information

Literature reviews and communications with New Hampshire Fish and Game biologists.

1.8 Extent and Quality of Data

New Hampshire Fish and Game biologists investigate credible wolf sightings, but have yet to confirm the presence of wolves in the state (Will Statts and Eric Orff, personal communications, NHFGD).

1.9 Distribution Research

Peggy Struhsacker of the National Wildlife Federation, through their northeast office in Montpelier, Vermont, has conducted winter track searches for wolves in New Hampshire and Maine since 2003. None have been detected to date (Eric Orff, personal communication, NHFG). Confirming the presence of wolves in the northeast is made difficult by the eastern coyote, which resembles the wolf in appearance. DNA evidence suggests that wolves in southeastern Canada occasionally hybridize with coyotes, which further complicates the issue (Lehman et al. 1991).

Recent advances in fecal DNA analysis offer an alternative method for confirming the presence of wolves. Fecal DNA sampling was used in France and Switzerland to monitor the recolonization of wolves in the western Alps over ten years (Valiere et al. 2003). NHFGD should adopt a standard procedure for collecting, storing, and shipping out possible wolf scat samples for DNA analysis.

Element 2: Species/Habitat Condition

2.1 Scale

N/A

2.2 Relative Health of Populations

Wolf populations are currently considered stable in Quebec (Lariviere et al. 2000). An increase in protection or a decrease in hunting/trapping pressure on wolves in Quebec would likely lead to an increase in wolf numbers, and ultimately to an increase in dispersal rates (Wydeven et al. 1998). Any increase in wolf dispersal would increase the likelihood of a natural wolf recolonization of the northeastern U.S. A wolf population that establishes in Maine would be likely to expand into northern New Hampshire.

2.3 Population Management Status

New Hampshire would constitute only a small portion of potential wolf range in the northeast, which would be expected to include areas of Maine, New Hampshire, Vermont, and New York. New Hampshire currently has no management plan that addresses the potential return of wolves to the state. Minnesota, Wisconsin, and Michigan are examples of states that have recently dealt with the issue of a naturally recovering wolf population. New Hampshire should look to these states for guidance in the preparation of a strategy for dealing with the potential return of wolves. A key component of this strategy would be to support public education that dispels myths about wolves and focuses on the actual benefits and problems of living with a wolf population. The strategy should also differentiate between short term and long-term management goals. In general, recovering wolf populations require protection in the short term, but expanding populations will need a more flexible management policy to address the inevitable increase in wolf/human conflicts, such as the killing of livestock or pets (Mech 1995). Minnesota has been successful with a strategy that allows for increased harvest in agricultural and suburban areas while maintaining protection in areas of core wolf habitat (Mech 1995).

2.4 Relative Quality of Habitat Patches

Mladenoff and Sickley (1998) identify most of northern New Hampshire as suitable wolf habitat based on its relatively low human population and road density and its abundant moose and deer populations.

2.5 Habitat Patch Protection Status

A portion of northern New Hampshire was recently protected from development with a 171,000-acre (692 km^2) conservation easement in the headwaters of the Connecticut Lakes. However, most of the large, unfragmented blocks of forest in the region are not protected.

2.6 Habitat Management Status

The majority of land in northern New Hampshire is managed for forestry products. Forestry operations actually benefit wolves by creating more browse for deer and moose. Future development could fragment the landscape, which would restrict the movements of a potential wolf population (Carrol 2003).

2.7 Sources of Information

Literature Review

2.8 Extent and Quality of Data

The status of wolves in Quebec is based on hunter survey reports (Lariviere et al. 2000). The potential for natural recolonization of the northeast has been addressed by a number of authors (Harrison and Chapin 1998, Wydeven et al. 1998, Carrol 2003).

2.9 Condition Assessment Research

Future research on the potential for recolonization should include studies of wolf/coyote interactions, a more detailed assessment of the St. Lawrence River as a barrier, and surveys to assess public attitudes toward wolves. Wolf recovery ultimately depends on support from the public. If public opinion toward wolves is unfavorable then any attempts to restore wolves will likely be unsustainable (Mech 1995). The Coalition to Restore the Eastern Wolf (CREW) is a group of organizations working to increase public awareness and influence policy decisions that will facilitate the return of wolves to the northeastern U.S. CREW is a valuable resource for monitoring public opinion toward wolves.

The potential for natural wolf recolonization may currently be limited by the year round open season on coyotes in New Hampshire. Closer monitoring of coyotes harvested in the state would increase the likelihood of intercepting wolves that cross the border. For example, the Maine Department of Natural Resources encourages trappers to report any canid longer than 4.5 ft from nose to tail (MDNR 2004).

Element 5: References

5.1 Literature Cited

Carrol, C. 2003. Impacts of landscape change on wolf viability in the northeastern U.S. and southern Canada: Implications for wolf recovery. Wildlands Project, Special Paper No. 5. 30 pp.

Harrison, D. J. and T. G. Chapin. 1998. Extent and connectivity of habitat for wolves in eastern North America. *Wildlife Society Bulletin* 20: 42-55

Laundre, J.W., L. Hernandez, and K.B. Altendorf. 2001. Wolves, elk, and bison: Reestablishing the "landscape of fear" in Yellowstone National Park, USA, *Canadian Journal of Zoology* 79(8):1401-1409

Lariviere, S., H. Jolicoeur, and M. Crete. 2000. Status and conservation of the gray wolf (Canis lupus) in wildlife reserves of Quebec. *Biological Conservation* 94:143-151

Lehman, N., A. Eisenhawer, K. Hansen, L. D. Mech, R. O. Peterson, P. J. P. Gogan, and R. K. Wayne. 1991. Introgression of coyote mitochondrial DNA into sympatric North America gray wolf populations. *Evolution* 45(1):104-119

Merril, M. B. 2000. Details of extensive movements by Minnesota wolves (Canis lupus). *American Midland Naturalist*. 144(2):428-433

Mladenoff, D. J. and T. A. Sickley. 1998. Assessing potential gray wolf restoration in the northeastern United States: A spatial prediction of favorable habitat and potential population levels. *Journal of Wildlife Management* 62(1):1-10

Mladenoff, D.J., T.A. Sickley, R.G. Haight, and A.P. Wydeven. 1995. A regional landscape analysis and prediction of favorable gray wolf habitat in the Northern Great Lakes Region. Conservation Biology 9:279-294

Mech, L. D. 1970. The Wolf: The Ecology and Behavior of an Endangered Species. University of Minnesota Press, Minneapolis. 384 pages

Mech, L. D. 1995. The challenge and opportunity of recovering wolf populations. *Conservation Biology* 9(2):1-9

Musiani, M. and P. C. Paquet. 2004. The practices of wolf persecution, protection, and restoration in Canada and the United States. *Bioscience* 54(1): 50-60

U.S. Fish and Wildlife Service [USFWS]. 1992. Recovery Plan for Eastern Timber Wolf. Twin Cities, MN. 73 pp.

U.S. Fish and Wildlife Service [USFWS] (Internet). 2005. Oregon District Court rules against gray wolf reclassification. Available: http://www.fws.gov/midwest/wolf/esa-status/or-court-rule-fws.htm. (Accessed July 2005)

Valiere, N., L. Fumagalli, L. Gielly, C. Miquel, B. Lequette, M-L. Poulle, J-M. Weber, R. Arlettaz, and P. Taberlet. 2003. Long-distance wolf recolonization of France and Switzerland inferred from non-invasive genetic sampling over a period of 10 years. *Animal Conservation* 6: 83-92

Villemure, M. and H. Jolicoeur. 2003. First confirmed occurrence of a wolf, Canis lupus, south of the St. Lawrence River in over 100 years. Unpublished report.

Wilson, P. J., S. Grewal, I. D. Lawford, J. N. M. Heal, A. G. Granacki, D. Pennock, J. B. Theberge, D. R. Voigt, W. Waddell, R. E. Chambers, P. C. Paquet, G. Goulet, D. Cluff, and B. N. White. 2000. DNA profiles of the eastern Canadian wolf and the red wolf provide evidence for a common evolutionary history independent of the gray wolf. *Canadian Journal of Zoology* 78: 2156-2166

Wydeven, A. P., T. K. Fuller, W. Weber, and K. MacDonald. 1998. The potential for wolf recovery in the northeastern United States via dispersal from southeastern Canada. *Wildlife Society Bulletin*. 26(4): 776-784.

SPECIES PROFILE

Hoary Bat

Lasiurus cinereus

Federal Listing: Not listed
State Listing: Not listed
Global Rank: Not ranked
State Rank: Not ranked
Authors: Jacques P Veilleux, Franklin Pierce College; Scott Reynolds, St. Paul's School

Element 1: Distribution and Habitat

1.1 Habitat Description

Hoary bats leave New Hampshire in the autumn to spend winter months in the South. During spring, they return north to their summer habitat (Cryan and Veilleux in press). No data describe the summer habitat of hoary bats in New Hampshire, though elsewhere they roost in tree foliage or even in woodpecker holes and squirrel nests (Shump and Shump 1982, Whitaker and Hamilton 1998).

Bats are not colonial, but roost singly during all times of the year (except for reproductive females, who birth and wean their young within the roost) (Shump and Shump 1982). Limited research suggests that hoary bats almost exclusively prefer the foliage of white spruce (*Picea glauca*) for their summer roosting (Willis and Brigham 2005). A study by Willis and Brigham (2005) demonstrated that, on average, hoary bats roosted 2 m from the tree trunk and in branches located 12.7 m from the ground. Roosts were oriented to the southeast (mean angle = 158.6). Roosts are typically sheltered by dense, overhanging foliage that forms an umbrella shape above the bats. The southeast exposure, lower canopy closure, and relative roost height may increase exposure of bats to sunlight, thereby providing warmer roost temperatures (Willis and Brigham 2005). Koehler and Barclay (2000) reported hoary bats from Manitoba, Canada, roosting at heights of 8-18 m in the foliage, and occasionally on the bark of trees. Trees bordered clearings or rose above nearby trees in the forest. Willis and Brigham (2005) observed reduced forest density on the roosting side of roost trees, possibly providing a open 'flyway' for bats returning to and leaving the roost. Hoary bats also roost at lower elevations, possibly due to lower wind levels and the abundance white spruce.

1.2 Justification

Hoary bats are relatively long lived and have a low reproductive rate, typically giving birth to 2 young per year (Koehler and Barclay 2000; Shump and Shump 1982). Habitat loss and degradation may lead to population declines, which are compounded by slow reproductive rates.

Only 6 individuals have been captured in New Hampshire, including 1 female in the WMNF (Krusic et al. 1996) and 1 juvenile female and 1 adult female in Livermore, Grafton Country (D.B. Sasse, Arkansas Game and Fish Commission, personal communication). LaGory et al. (2002) captured an adult female and adult male at the New Boston Air Force Base in New Boston, Hillsborough County, and a single hoary bat was collected in Conway, Carroll County. Based on echolocation calls, Reynolds (1999) reported the presence of hoary bats at Gile State Park, Springfield, Sullivan County and Pawtuckaway State Park, Nottingham, Rockingham County. Chenger (2005) reported echolocation calls from Gorham (Coos County) and Albany (Carroll County).

These data indicate that hoary bats may have a wide summer distribution in New Hampshire. The current lack of detailed data on the distribution, habitat use, and life history of hoary bats in New Hampshire is largely due to a lack of research.

1.3 Protection and Regulatory Status

No specific ESA or RSA 212 regulations govern take, transport, or use of this species. Scientific collection or research requiring capture of individuals requires a permit through NHFG. Possession of live bats requires a permit under NHFG FIS 800.

1.4 Population and Habitat Distribution

Data that describe the range of hoary bats in New Hampshire are too few to allow a regional comparison of hoary bat populations. See section 1.2.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

1.7 Sources of Information

Data on species distribution were compiled by searching for specimens deposited in museums and college/university teaching collections and by examining published and gray literature of research on bat populations in New Hampshire.

1.8 Extent and Quality of Data

There are limited data on the distribution of hoary bats in New Hampshire but data quality is believed to be good. Hoary bats are morphologically unique and identifications should be accurate.

1.9 Distribution Research

Research to determine summer distribution of hoary bats should include a long-term, statewide mist-netting survey, accompanied by echolocation surveys (e.g. use of Anabat acoustic survey methods when mistnetting).

Element 2: Species/Habitat Condition

2.1 Scale

Scale for an appropriate conservation planning unit has not been resolved by the Lowland Spruce-Fir Forest habitat mapper (Carol Foss, NHA).

2.2 Relative Health of Populations

Hoary bats have been captured at 3 localities in New Hampshire: WMNF (n = 3), Conway (n = 1) and New Boston (n = 2). Echolocation calls have been recorded in Albany, Gorham, Nottingham, and Springfield. Population trends and viability cannot be assessed with so little data.

2.3 Population Management Status

Hoary bats are not currently managed in New Hampshire.

2.4 Relative Quality of Habitat Patches

Scale for an appropriate conservation planning unit has not been resolved by the Lowland Spruce-Fir Forest habitat mapper, and therefore the data for determining the relative quality of such patches are unavailable.

2.5 Habitat Patch Protection Status

See 2.4.

2.6 Habitat Management Status

See 2.4.

2.7 Sources of Information

See 2.4.

2.8 Extent and Quality of Data

See 2.4.

2.9 Condition Assessment Research

Research of hoary bats during summer should include a statewide mist-netting survey to determine state distribution, telemetry studies to determine habitat use (roosting and foraging habitat), life history studies, and diet analyses.

Element 3: Species and Habitat Threat Assessment

3.1.1 Development (Habitat Loss and Conversion)

(A) Exposure Pathway

As land in New Hampshire is deforested, hoary bats will experience summer habitat loss and degradation. Bats (particularly non-volant young) may also be killed if deforestation occurs during the parturition/ lactation period (late May through mid-July)

(B) Evidence
Recent data indicate that individual roost trees are occupied by bats on a year-to-year basis (Barclay and Brigham 2001), and that individual bats return to the same, small summer roosting area each year (Veilleux and Veilleux 2004). These data are for colonial bat species, but may also apply to solitary species (C. Willis personal communication). Bat biologist hypothesize that strong fidelity to roost areas indicates that the habitat area offers a particularly high quality area for breeding; thus, deforestation may reduce the quality of the habitat patch. If the quality of the habitat patch is reduced, reduction in individual fitness and population recruitment may occur.

3.1.2 Energy and Communication Infrastructure

3.2 Sources of Information

Sources of information on threats to hoary bats included peer-reviewed scientific articles, gray literature, and expert review by John O. Whitaker, Jr. of Indiana State University.

3.3 Extent and Quality of Data

The threats described under element 3.1, and their potential impact on bat populations, are well documented. Data describing the long-term negative effect of habitat conversion (development and logging) is not well understood. Although fidelity to roost areas is well documented in other bats, it is not documented for hoary bats. Data on how hoary bats use roost areas and roost trees on a long-term basis are needed.

3.4 Threat Assessment Research

Areas in New Hampshire with high numbers of hoary bats during summer months should be documented. Radio-telemetry studies will allow managers to determine the location of a roost areas, and several years of capture and telemetry data would determine whether individual bats return to the same roost areas each year. Such data would also allow managers to assess the effects of deforestation on hoary bats.

Element 4: Conservation Actions

4.1.1 Documenting roosting habits, Habitat Protection

(A) Deforestation

(B) Justification

- Identifying summer roost areas and determining roost fidelity will allow managers to assess the effects of deforestation.
- No data on the spatial scale of summer roosting exist, though Veilleux and Veilleux (2004) reported individual female eastern pipistrelles, another foliage roosting species, returning to very small summer roost areas across years. Minimum roost areas containing roost trees used by the same bats during 2 consecutive years ranged between 0.6 and 2.3 ha. Since development can disrupt forested habitat at such small scales, it is appropriate to plan management accordingly.

(C) Conservation Performance Objective
Integrate critical roosting habitats into a wildlife database. Determining summer habitat requirements for populations of hoary bats is intended to allow managers to make good decisions about logging and development. By protecting a habitat area, the smaller scale attributes of a habitat (e.g. a preferred species of roost tree) will likely be protected as well (i.e., a coarse filter approach).

(D) Performance Monitoring
To determine whether limiting or mitigating deforestation results in the maintenance of summer populations of hoary bats, managers can monitor whether hoary bats continue to use a site over a long time period (periodic monitoring over a 10-year period).

(E) Ecological Response Objective
The habitat protection response objective is to maintain the current number of hoary bats roosting during summer within forested habitats. Since current data

are too few to allow an estimate of hoary bat population at summer roost areas, the minimal ecological response should be the maintenance of those populations initially located by biologists.

(F) Response Monitoring
Summer surveys at a known habitat area every three years will determine whether hoary bat populations are being maintained and whether bats remain faithful to specific roost areas during summer. These data will in turn allow managers to make better informed decision about the maintenance of hoary bat populations in areas threatened by high levels of development or logging.

(G) Implementation
Data on summer bat locations must be gathered. After summer habitat areas are identified, the state should initiate an intensive radio-telemetry study (1 to 2 years) to determine specific patterns of habitat use by individuals bats, and establish a long term (10-year) monitoring program to determine if hoary bats remain faithful to small summer roost areas.

(H) Feasibility
The technical competence to determine general summer habitat areas of hoary bats (mist-netting) and detailed patterns of their roosting habits (radio telemetry) is available. Research is limited by funding.

4.1.2 Site-Selection and Pre-Construction Regulations, Regulation and Policy

(A) Wind Resource Development

4.2 Conservation Action Research

Element 5: References

5.1 Literature

Barclay, R.M.R., and R.M. Brigham. 2001. Year-to-year reuse of tree-roosts by California bats (*Myotis californicus*) in southern British Columbia. American Midland Naturalist 146:80-85.

Chenger, J. 2005. 2004 Woodland bat survey in the White Mountain National Forest report prepared for the United States Department of Agriculture.

Cryan, P.M. and J.P. Veilleux. *in press*. Migration and the use of autumn, winter, and spring roosts by forest bats. Proceedings of the 2nd Bats and Forests Symposium, Hot Springs, AR.

deVries, E. 2004. 150,000 MW by 2012! Renewable Energy World. June 2004: 60-70.

Erickson, W.P., G.D. Johnson, D.P.Young, M.D. Strickland, R.E. Good, M. Bourassa, K. Bay, and K. Sernka. 2003. Synthesis and comparison of baseline avian and bat use, raptor nesting and mortality information from proposed and existing wind developments. Report prepared for the Bonneville Power Administration.

Koehler, C.E., and R.M.R. Barclay. 2000. Post-natal growth and breeding biology of the hoary bat, *Lasiurus cinereus*. Journal of Mammalogy 81:234-244.

Krusic, R.A., M. Yamasaki, C.D. Neefus, and P.J. Pekins. 1996. Bat habitat use in White Mountain National Forest. Journal of Wildlife Management 60:625-631.

LaGory, K.E., D.S. Reynolds, and J.A. Kuiper. 2002. A survey of the bats of New Boston Air Force Station, New Hampshire. Unpublished Report to the U.S. Department of the Air Force. 32 pp.

McLeish, T. 2002. Wind power. Natural New England 11:60-65.

Kerlinger, P.A., and J. Kerns. 2004. A study of bird and bat collision fatalities at the Mountaineer Wind Energy Center, Tucker County, West Virginia: Annual Report for 2003.

Koehler, C.E., and R.M.R. Barclay. 2000. Post-natal growth and breeding biology of the hoary bat, *Lasiurus cinereus*. Journal of Mammalogy. 81: 234-244.

Nicholson, C. 2003. Buffalo Mountain Windfarm: Bird and Bat Mortality Monitoring Report.

Sasse, D.B. and P.J. Pekins. 1996. Summer roosting ecology of northern long-eared bats (*Myotis septentrionalis*) in the White Mountain National Forest. Pp. 91-101 *In* Bats and Forests Symposium, October 19-21, 1995, Victoria, British Columbia, Canada. Research Branch, British Columbia Ministry of Forests, Victoria, B.C. Working Paper. R.M.R. Barclay and R.M. Brigham (ed.). 23/1996.

Shump, K.A. Jr., and A.U. Shump. 1982. *Lasiurus cinereus*. Mammalian Species No. 185. American Society of Mammalogists.

Veilleux, J.P. and S.L. Veilleux. 2004. Intra-annual and interannual fidelity to summer roost areas by female eastern pipistrelles,_*Pipistrellus subflavus*.

American Midland Naturalist 152:196-200.

Walsh, G. 2003. Is this the future of power generation in the Northeast? Natural New England 14: 62-71.

Whitaker, J.O., Jr., and W.J. Hamilton. 1998. Mammals of the Eastern United States. Cornell University Press.

Willis, C.K.R. and R.M. Brigham. 2005. Physiological and ecological aspects of roost selection by reproductive female hoary bats (*Lasiurus cinereus*). Journal of Mammalogy 86:85-94.

Young, D.P., W.P. Erickson, R.E. Good, M.D. Strickland, and G.D. Johnson. 2003. Avian and bat mortality associated with the initial phase of the Foote Creek Rim windpower project, Carbon County, Wyoming prepared for Pacificorp, Inc., SeaWest Windpower, Inc, and BLM.

SPECIES PROFILE

Indiana Bat

Myotis sodalis

Federal Listing: Endangered
State Listing: S1
Global Rank: G2
State Rank: SNA
Authors: Jacques P Veilleux, Franklin Pierce College; Scott Reynolds, St. Paul's School

Element 1: Distribution and Habitat

1.1 Habitat Description

During winter, Indiana bats require cave or mine habitat that provides adequate characteristics for successful hibernation. Such characteristics mainly include proper microclimate (i.e. temperature stability) and low levels of human disturbance. Within the hibernaculum, Indiana bats often form tight clusters (Griffin 1940). They prefer roost temperatures between 1°C - 10°C and relative humidity in excess of 75% (Menzel et al. 2001, Tuttle 2003). Indiana bats generally enter the hibernacula during late October and begin leaving in March, with over 50% of the hibernating population usually emerging by mid-April (Richter et al. 1993). Male Indiana bats are often found either using caves or mines during the summer months or are captured in adjacent habitat (Whitaker and Brack 2002).

The summer habitat requirements of Indiana bats in New Hampshire are unknown; in fact, there is only one summer record of an Indiana bat in New Hampshire (Krusic 1996). Elsewhere in the summer, Indiana bats roost in trees with exfoliating bark or, rarely, in cavities. This habitat provides females with a physical space for forming maternity colonies where young are reared. Ideal habitat includes a roost tree and proximity to food and water.

1.2 Justification

Indiana bats are listed as federally endangered due to severe population declines at major hibernacula in the Midwest. Indiana bats have experienced a range-wide decline of approximately 57% in the last 50 years (Clawson 2002). In the 1930s, Indiana bats were the most abundant wintering bat species in Vermont. Of the 24 historic hibernacula known in the Northeast, at least ten have not been used by Indiana bats since 1980 (Hicks and Novak 2002). Massive deforestation in the 1880s was the primary cause of their decline in the Northeast (Trombulak et al. 2001). Currently, most hibernating Indiana bats in the northeast are found in New York (Hicks and Novak 2002).

Bats have a unique life history compared with other small mammals. Individuals are relatively long-lived and have a low reproductive rate, usually giving birth to a single young (Thompson 1982). Their slow reproductive rate contributes to a slow recovery time following population losses. Indiana bats are found in relatively rare, at-risk habitats during winter (caves/mines) and are thus particularly vulnerable to habitat loss or degradation. Indiana bats are of conservation concern in New Hampshire for the above reasons and because so little is known about the species' population status. Indiana bats have not been found hibernating in any of the 7 known hibernacula in New Hampshire, although there may exist unsurveyed mines that serve as hibernacula.

One male Indiana bat was captured in Bartlett (Krusic 1996), indicating that the species occurs in New Hampshire. It is possible that additional Indiana bats reside in New Hampshire during the summer, but few surveys have been completed. Some females that hibernate in New York currently form maternal colonies in Vermont's Green Mountain National Forest, which is approximately 65 km from the New Hampshire border.

3.3 Protection and Regulatory Status

No additional laws, ordinances, or rules, beyond those outlined in the Endangered Species Act (ESA), regulate the take, transport, or use of this species in New Hampshire. Scientific collection or research requiring capture of individuals requires a permit through NHFG (NHFG). Possession of live bats requires a permit under NHFG FIS 800.

1.4 Population and Habitat Distribution

Too little is known about the historic or current distribution of Indiana bats to assess regional distribution in New Hampshire. There are no winter records of Indiana bats hibernating in New Hampshire, and only one adult male was collected in the summer. A single summer record (adult male) is known from Albany, Carroll County.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

1.7 Sources of Information

Distribution information was compiled by examining New Hampshire Natural Heritage Inventory – Bat Hibernaculum Record data sheets, and by examining the collection dates of specimens deposited in museum collections and university teaching collections, and from published and gray literature on bats in New Hampshire.

1.8 Extent and Quality of Data

Data on the distribution of the Indiana bat in New Hampshire are extremely limited and of limited quality. A University of New Hampshire Master's student identified the lone summer record, and since identification of Indiana bats is difficult and requires experience, the record should be considered tentative. More research should be aimed at determining distribution patterns for this species.

1.9 Distribution Research

Surveys of previously un-surveyed mines that may serve as bat hibernacula are needed to determine the winter distribution of Indiana bats in New Hampshire. A long-term, statewide mist-netting survey (with a protocol that meets the *de minimus* standards set out in the Indiana Bat Recovery Plan (USFWS 1999)), accompanied by echolocation surveys (e.g. use of Anabat acoustic survey methods when mist-netting), is needed to determine summer distribution. Initial mist-netting surveys should focus on bottomland forest and riparian corridor habitat in southwest New Hampshire. Mist-netting surveys should incorporate banding into the capture protocol and record all banding records in the Northeast Banding Database developed by the Northeast Working Group on Bats (NEWGB).

Element 2: Species/Habitat Condition

2.1 Scale

Due to the small number of mines in New Hampshire that may provide habitat for this species, each mine has been treated as a conservation planning unit under the habitat profile.

2.2 Relative Health of Populations

There is no known population of Indiana bats in New Hampshire. High priority conservation actions include the winter survey of the previously un-surveyed mines that may provide adequate winter habitat.

2.3 Population Management Status

Indiana bats are not currently managed in New Hampshire. Too little distribution data is available to develop conservation or management strategies.

2.4 Relative Quality of Habitat Patches

Indiana bat hibernacula in the Northeast tend to be large and thermally stable mines and caves with low ambient temperature, proximity to riparian habitat, and freedom from disturbance (Tuttle and Kennedy 2002, Tuttle 2003). Mascot Lead Mine is likely the only known hibernaculum that meets these characteristics. It is within 0.9 km of riparian habitat and located on land managed by the Department of Resources and Economic Development (DRED). Yuhas Mine

#2 in Alstead (Sullivan County) is within 0.8 km of riparian habitat, but total adit length could not be determined (Table 1). Because New Hampshire is in the northeastern periphery of the Indiana bat's range (Evans et al. 1998), it will be important to assess any potential hibernacula in Hillsborough, Merrimack, Cheshire, and Rockingham counties that meet these characteristics.

2.5 Habitat Patch Protection Status

2.6 Habitat Management Status

Bat gates have been installed at hibernacula for the last 35 years to reduce or eliminate disturbance to bats (Tuttle 1976). Bat gates are steel-welded structured installed in the entrance to a mine or cave to restrict human access while causing minimal impact on air flow and flight behavior of bats. Because many caves and mines are found in remote locations, bat gates have been described as "the only means available for protecting these [colonies of Indiana bats]" (Pierson et al. 1991: 31).

In New Hampshire, Mascot Lead Mine is the only known hibernaculum that is likely to have a microclimate conducive to Indiana bats, and it is the only hibernaculum where bat habitat is managed. This mine could potentially support Indiana bats, if the species were to overwinter in New Hampshire.

2.7 Sources of Information

To determine the winter distribution at known hibernacula, New Hampshire Natural Heritage Survey – Hibernacula Survey Data Sheets were examined. To determine habitat patch protection status, each hibernaculum, whether known or potential, was mapped on the Conservation Lands GIS data layer (GRANIT – 2003 data). Information about the summer habitat needs for Indiana bats is available from Menzel et al. 2001 and Clawson 2002.

2.8 Extent and Quality of Data

The data on known and potential hibernacula were collected in the summer of 2004 by Veilleux and Reynolds (2005).

2.9 Condition Assessment Research

Scientists need to determine the distribution and importance of mines that serve as winter roosts in New Hampshire. This requires establishing a monitoring program that will assess the physical attributes of potential hibernacula and document whether Indiana bats use any of these mines.

Research priorities for summering Indiana bats include the initiation of a state-wide mist-netting survey to document state-wide distribution, telemetry studies to determine habitat use (roosting and foraging habitat), life history studies to determine breeding status and reproductive patterns (e.g. timing of birth, weaning of young), and food habit analyses to determine prey preference.

Element 3: Species and Habitat Threat Assessment

3.1.1 Recreation

See Caves and Mines habitat profile.

3.1.2 Development (Habitat Loss and Conversion)

(A) Exposure Pathway

Industrial or residential development and forest cutting may affect Indiana bats and other species that rely on trees for summer roosting habitat. Individual bats may experience direct mortality (especially non-volant young) if the disturbance occurs during the parturition or lactation period (late May through mid-July: Thomson 1982). The cumulative results of habitat loss, degradation, and possibly direct mortality could lead to a corresponding reduction in population size.

(B) Evidence

Recent data indicate that Indiana bats rely on multiple roost trees (up to 18 trees by one colony) within a single season (Kurta and Whitaker 1998). Indiana bats appear to choose tree characteristics (such as tree width and roost height) rather than tree species (Kurta and Rice 2002, Miller et al. 2002, Lacki and Baker 2003). Radiotelemetry studies have shown that roost trees are usually clustered, with most trees within 1.0 km of each other (Kurta et al. 2002). Maternity colonies of Indiana bats show some degree of site fidelity

and often occupy the same roost trees for multiple seasons (Kurta et al. 2002). These data suggest that strong fidelity to roost trees and core roosting allows individuals to relocate colony mates after emerging from hibernation in the spring. The removal of roost trees below a critical density (estimated at 42 trees per hectare in bottomland forest and 67 trees per hectare in upland forests: Garner and Gardner 1992), or the loss of roost trees within the core roosting area, may disrupt colony formation. If individuals are unable to form a colony, it is likely that a corresponding reduction in individual fitness, and therefore population recruitment, will occur.

3.2 Sources of Information:

Much of the information on the biology of Indiana bats in caves and mines comes from the published literature and experts such as Alan Hicks of the New York Department of Environmental Conservation. Information on the biology of the summer foraging and roosting habitat of Indiana bats comes from the published literature.

3.3 Extent and Quality of Data

There are no data on the potential impact of wind resource development (Element 3.1.2) on Indiana bats. Habitat preference and fidelity of Indiana bats to specific roost areas (Element 3.1.3 and 3.1.4) is fairly well documented, but data on whether the removal of roost areas will negatively affect bats by disrupting colony dynamics is not available.

3.4 Threat Assessment Research

Element 4: Conservation Actions

4.1.1 Gating, Habitat Protection

See caves/mines habitat profile.

4.1.2 Site-Selection and Pre-Construction Regulations, Regulation and Policy

See caves/mines habitat profile.

4.1.3 Documenting roosting habits, Habitat Protection

(A) Removal of summer roosting habitat due to development, removal of summer roosting habitat due to logging.

(B) Justification

1) Identifying summer roost habitat for Indiana bats and determining whether individual bats return to specific roost areas each year will allow managers to better assess the impact of habitat disturbance.

2) The lack of data on the summer distribution and population demographics of Indiana bats in New Hampshire prevents informed management decisions on the impact of development and forest cutting on this species.

3) Research on Indiana bats in other states suggests that the core roosting habitat of a maternity colony encompasses up to 150 ha (Miller et al. 2002) and that the foraging area is often substantially larger (Evans et al. 1988, Callahan et al 1997). Since development activity, and especially logging, can disrupt forested habitat at similar scales, it is appropriate to plan management actions at this scale. By focusing on smaller scales, key habitat features such as preferred roost trees are more likely to be identified and protected.

4) As new information is gathered that refines our understanding of summer habitat use by Indiana bats, managers can inform development or logging interests about conservation action that may be required.

(C) Conservation Performance Objective

Integrate critical roosting habitats into a wildlife database. Better summer range data of Indiana bats may allow managers to make informed decisions about the limiting or mitigating development and logging activities within critical habitat.

(D) Performance Monitoring

Managers can monitor habitat use by Indiana bats over long periods (perhaps periodic monitoring over a 10-year period) to determine whether modified development and logging activities result in the maintenance of summer populations at specific sites.

(E) Ecological Response Objective: Maintain popu-

lations in delineated areas
The habitat protection response objective is to maintain the current number of Indiana bats roosting during summer within their core roosting habitat. Since there are virtually no data on the current Indiana bat population within the state, the minimal ecological response should be to maintain any populations located by biologists.

(F) Response Monitoring: Identify more specific monitoring parameters
If populations are identified, critical habitats will need to be surveyed (for example, every three years). Monitoring should provide data on whether Indiana bats show roost or habitat fidelity during the summer. These data will allow managers to make better-informed decision about the maintenance of Indiana bat populations in areas threatened by development or logging.

(G) Implementation
Preliminary data on the location of Indiana bats must be gathered. If summer habitat areas are identified, the state could consider more intensive population and habitat studies.

(H) Feasibility
The technical competence to determine general summer habitat areas of Indiana bats (mist-netting), as well as the detailed methods of evaluating their roosting habits (radio-telemetry), are available in the region.

4.2 Conservation Action Research

The conservation action research objective for Indiana bats is to document their existence within the state and protect critical habitats and resources. Documentation of Indiana bats' distribution and abundance will require extensive research at both the landscape level (for example, summer surveys within riparian and bottomland forest habitat) and habitat level (roost tree surveys within these habitats). If Indiana bats are found, research should move toward radio-telemetry in order to document core foraging and roosting habitat. Additional effort should then be concentrated on conserving and managing these critical resources.

Element 5: References

5.1 Literature

Callahan, E.V., R.D. Drobney, and L. Clawson. 1997. Selection of summer roosting sites by Indiana bats (*Myotis sodalis*) in Missouri. Journal of Mammalogy 78:818-825.

Clawson, R.L. 2002. Trends in population size and current status Pages 2-8 *in* A. Kurta and J. Kennedy, eds. The Indiana Bat: Biology and Management of an Endangered Species.

deVries, E. 2004. 150,000 MW by 2012! Renewable Energy World. June 2004: 60-70.

Durham, H.C. 2000. Microclimate and roost selection in four New Hampshire bat hibernacula. Thesis, Antioch New England Graduate School, Keene, NH, USA.

Evans, D.E., W.A. Mitchell, and R.A. Fischer. 1998. Species profile: Indiana bat (*Myotis sodalis*) on military installations in the southeastern United States USACE Technical Report SERDP-98-3.

Garner, J.D. and J.E. Gardner. 1992. Determination of summer distribution and habitat utilization of the Indiana bat (*Myotis sodalis*) in Illinois. Final Project Report E-3. Illinois Department of Conservation, Division of Natural Heritage and Illinois Natural History Survey, Center for Biogeographic Information.

Griffin, D., 1940. Notes on the life histories of New England cave bats. Journal of Mammalogy 21: 181-187.

Hicks, A. and P. Novak. 2002. History, status, and behavior of hibernating populations in the Northeast Pages 35-47 *in* A. Kurta and J. Kennedy, eds. The Indiana Bat: Biology and Management of an Endangered Species.

Johnson, S.A. V. Brack, and R.E. Rolley. 1998. Overwinter weight loss of Indiana bats (*Myotis sodalis*) from hibernacula subject to human visitation. American Midland Naturalist 139: 255-261.

Krusic, R.A., M. Yamasaki, C.D. Neefus, and P.J. Pekins. 1996. Bat habitat use in White Mountain National Forest. Journal of Wildlife Management. 60:625-631.

Kurta, A., and J.O. Whitaker. 1998. Diet of the endangered Indiana bat (*Myotis sodalis*) on the northern edge of its range. American Midland Naturalist 140: 280-286.

Kurta, A., and H. Rice 2002. Ecology and management of the Indiana bat in Michigan. Michigan Academician 34:175-190.

Kurta, A., S.W. Murray, and D.H. Miller. 2002. Roost selection and movements across the summer landscape Pages 118-129 *in* A. Kurta and J. Kennedy, eds. The Indiana Bat: Biology and Management of an Endangered Species.

Lacki, M. and M.D. Baker. 2003. A prospective power analysis and review of habitat characteristics used in studies of tree-roosting bats. Acta Chiropterologica 5:199-208.

McLeish, T. 2002. Wind power. Natural New England 11: 60-65.

Menzel, M.A., J.M. Menzel, T.C. Carter, W.M. Ford, and J.W. Edwards. 2001. Review of the forest habitat relationships of the Indiana bat (*Myotis sodalis*). General Technical Report NE-284; US Department of Agriculture.

Miller, N.E., R.D. Drobney, R.L. Clawson, and E.V. Callahan. 2002. Summer habitat in northern Missouri Pages 165-171 *in* A. Kurta and J. Kennedy, eds. The Indiana Bat: Biology and Management of an Endangered Species.

Richter, A. 1993. Modified cave entrances: thermal effect on body mass and resulting decline of endangered Indiana bats (*Myotis sodalis*). Conservation Biology 7: 407-415.

Speakman, J.R., P.I. Webb, and P.A. Racey 1991. Effects of disturbance on the energy expenditure of hibernating bats. Journal of Applied Ecology 28: 1087-1104.

Thomas, D.W. 1995. Hibernating bats are sensitive to nontactile human disturbance. Journal of Mammalogy 76: 940-946.

Thomson, C.E. 1982. *Myotis sodalis*. Mammalian Species 163: 1-5.

Trombulak, S., P.E. Higuera, and M. DesMeules. 2001. Population trends of wintering bats in Vermont. Northeastern Naturalist 8:51-62.

Tuttle, M.D. and J. Kennedy 2002. Thermal requirements during hibernation Pages 68-78 *In* A. Kurta and J. Kennedy, eds. The Indiana Bat: Biology and Management of an Endangered Species.

Tuttle, M.D. 2003. Estimating population sizes of hibernating bats in caves and mines. Pages 31-39 *in* T.J. O'Shea and M.A. Bogan, eds. Monitoring trends in bat populations of the United States and Territories: Problems and Prospects. USGS/BRD/ITR-2003-0003.

Veilleux, J.P. and S.D. Reynolds. 2005. Survey of known and potential mine habitat in New Hampshire. Unpublished report to New Hampshire Fish and Game Department.

Walsh, G. 2003. Is this the future of power generation in the Northeast? Natural New England 14: 62-71.

Whitaker, J.O. and V. Brack. 2002. Distribution and summer ecology in Indiana. Pages 48-54 *in* A. Kurta and J. Kennedy, eds. The Indiana Bat: Biology and Management of an Endangered Species.

SPECIES PROFILE

Canada Lynx

Lynx canadensis

Federal Listing: Threatened
State Listing: Endangered
Global Rank: G5
State Rank: S1
Authors: John A. Litvaitis and Jeffery P. Tash, University of New Hampshire

Element 1: Distribution and Habitat

1.1 Habitat Description

Lynx occupy various habitats in the boreal forests and their southern extensions (Anderson and Lovallo 2003). In eastern forests, dominant vegetation includes spruce (*Picea* spp.) and balsam fir (*Abies balsamea*). Snowshoe hare (*Lepus americanus*) are important prey for lynx, and young or subalpine stands may be preferred because they contain more hare than do mature stands (Anderson and Lovallo 2003). Though data on competition and predation are equivocal, lynx may avoid bobcat (*Lynx rufus*) and coyote (*Canis latrans*) by seeking deep snow, to which lynx are morphologically adapted (long legs and large feet, Parker et al. 1983).

1.2 Justification

Lynx have been listed as endangered in New Hampshire since 1980. The United States Fish and Wildlife Service (USFWS) listed all lynx populations in the lower 48 states as threatened in 2000.

1.3 Protection and Regulatory Status

Lynx trapping and hunting seasons in New Hampshire have been closed since 1971. Lynx are also protected under federal endangered species legislation (USFWS 2000).

1.4 Population and Habitat Distribution

Although there are no records of lynx reproducing in New Hampshire (McKelvey et al. 2000), lynx were frequently encountered in Coos and northern Carroll and Grafton counties (Siegler 1971, Silver 1974, Hoving et al. 2003). Lynx are more common toward the north, particularly in Quebec and New Brunswick. Large-scale timber harvests for agriculture and suburban developments north of the St. Lawrence Seaway combined with intensive lynx harvests and land clearing south of the Seaway may have resulted in isolation of lynx in northern New England (Litvaitis et al. 1991). Recent evidence indicates that core lynx populations in the Gaspé Peninsula may be the source for satellite populations in northwestern Maine and northern New Hampshire (Carroll 2005). Few lynx have been captured or killed in New Hampshire in recent years. In 1966 and 1992, adult lynx were killed after collisions with vehicles in Lee and west of Concord on Interstate 89, respectively (Litvaitis 1994).

1.5 Town Distribution Map

Recent observations are quite limited (figure 1). No conclusions can be drawn from this limited dataset.

1.6 Habitat Map

We relied extensively on the recent habitat modeling efforts by Hoving et al. (2005). Initial estimates of lynx habitat were obtained from the model developed by Hoving et al. (2005) in conjunction with information on land cover obtained from the New Hampshire Land Cover Assessment 2001 database from Complex Systems Research Center of the University of New Hampshire (Justice et al. 2002). This digital raster dataset was classified from 1990-1999 Landsat

Figure 1. Location of incidental observations of lynx during 1990-2004 (from NHDRED).

Thematic Mapper imagery into 23 classes with a cell size of 30 meters. Overall classification accuracy at this level was assessed at 82.2%. Mean annual snowfall from 1971 to 2000 was obtained from Spatial Climate Analysis Service at Oregon State University. This dataset uses the PRISM modeling system to estimate annual snowfall for each 2 x 2 km pixel based on data from over 7,000 weather stations nationwide and digital elevation models. Suitable lynx habitat in New Hampshire was estimated combining all cells that had a probability of occurrence of > 0.5.

Because lynx are dependent on snowshoe hares (Quinn and Parker 1987, Anderson and Lovallo 2003), a layer was added that included habitats known to support abundant hare populations. Specifically added were high elevation spruce (*Picea* spp.), fir (*Abies balsamea*) stands, and recent clearcuts that were in areas where annual snowfall was >250 mm [estimated snowfall threshold that limits bobcats in New Hampshire (Litvaitis et al. 2005)]. Both of these habitats are characterized by dense understory vegetation and contain an abundance of snowshoe hare. Information on high elevation spruce-fir stands was provided by New Hampshire Fish and Game (J. Oehler, personal communication). The clearcut dataset was provided by Complex Systems at UNH. Cuts had a minimum size of 1.2 ha, residual basal area of < 2 m^2/ha, and were harvested within 10-15 years (D. Justice, personal communication). Overall accuracy of the clearcut layer was 92%. Supporting this addition, Fuller and Harrison (2005) found that lynx showed a strong selection for mid-successional spruce-fir stands (~3.3 – 4.3 m tall) that were 11-22 years old in northwestern Maine. Hoving et al. (2004) also reported an association of lynx with regenerating stands.

Model Results

The total area estimated to be suitable for lynx [>50% probability of occurrence according to model developed by Hoving et al. (2005)] was 5,187 km^2 (figure 2). Because land cover and snowfall information were different from the sources used by Hoving et al. (2005), mapped habitats for this study are slightly different. Regional predicted habitat from Hoving et al. (2005) is shown in Figure 3.

According to Hoving (2001), the 2 variables in the habitat model probably do not directly influence lynx distributions. Annual snowfall is likely functioning as a surrogate variable for mean snow depth. This feature may influence foraging success and affect the distribution of possible competitors of lynx. The negative relationship with lynx presence and the abundance of deciduous forests is less obvious. In comparison to conifer stands, deciduous forests may represent habitats that support fewer snowshoe hares (e.g., Litvaitis et al. 1985) and red squirrels (*Tamiasciurus hudsonicus*) (Obbard 1987), an important secondary prey of lynx (O'Donoghue et al. 1998*b*). As a result, lynx may not be able to meet prey needs in areas dominated by deciduous forests.

Although this model performed well on a regional scale [correctly classified 94% of a reserved dataset (Hoving et al. 2005)], it is not certain that that it adequately described habitats on a more restricted basis (e.g., northern New Hampshire). As indicated, neither of the 2 variables directly affects carrying ca-

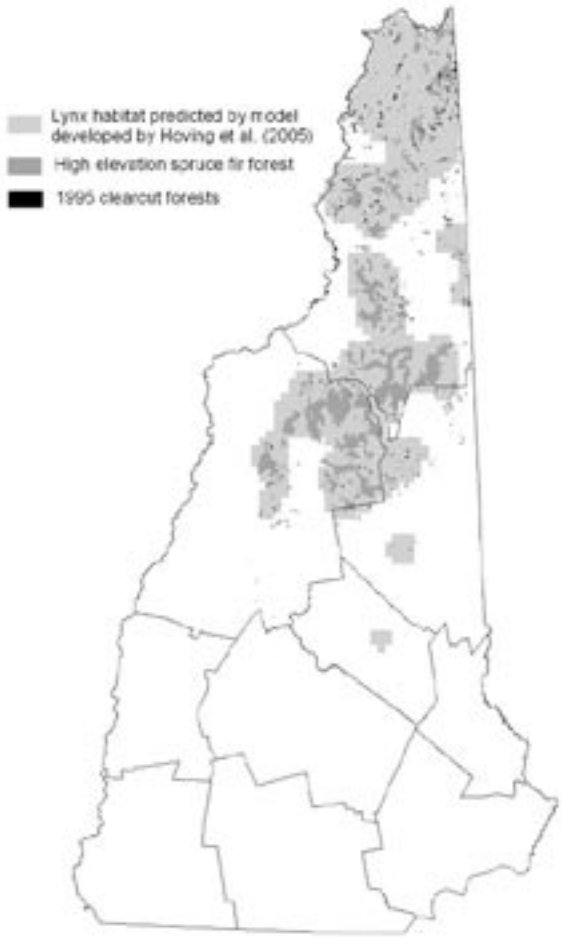


Figure 2. Lynx habitat in New northern New Hampshire predicted by the model developed by Hoving et al. (2005). High elevation spruce-fir stands and recent clearcuts also are included because these habitats support dense populations of snowshoe hares. Clearcuts (› 1.2 ha with ‹ 2 m^2 residual basal area) were only included if they had an average annual snowfall of › 250 mm.

Figure 3. Regional lynx habitat predicted by Hoving et al. (2005).

pacity or suitability at a landscape scale. To increase understanding of lynx requirements at landscape and stand scales, a modeling effort by Steury and Murray (2004) was used to examine the prey requirements of translocated lynx. If dispersing lynx that colonize habitats in New Hampshire are assumed to have prey requirements that are comparable to translocated individuals, this study may provide additional insight.

Populations of snowshoe hare in northern New Hampshire are not cyclic (Murray 2000). Under such circumstances, Stuery and Murray (2004) indicated that 1.5 hares/ha are needed for positive population growth among translocated lynx. Litvaitis et al. (1985) found that habitats capable of supporting that density of hare are characterized by very dense understory vegetation [>50,000 stem cover units/ ha. Such vegetation is found in regenerating clearcuts, high elevation conifer stands, and some shrub-dominated wetlands. Therefore, the inclusion of recent clearcuts and high elevation spruce-fir stands may provide a more realistic representation of important habitats for lynx, albeit a minimum estimate. Combined, these enriched prey habitats represent only 888 km^2 [17% of the total lynx habitat predicted by the Hoving et al. (2005) model]. Although northern populations of lynx are known to exploit alternative prey (especially red squirrels) when cyclic populations of hare crash (e.g., O'Donoghue et al. 1998*b*), lynx demography is directly dependent on snowshoe hare abundance (Brand and Keith 1979, O'Donoghue et al. 1997). Therefore, the modest abundance of high-density hare habitat supports the notion that New Hampshire does not contain sufficient habitat to support a viable, stand-alone population of lynx. Long-term persistence of lynx in New Hampshire is probably dependent on immigrants (Litvaitis et al. 1991, Carroll 2005), and the State likely represents the southern limit of lynx in eastern North America.

1.7 Sources of Information

Published investigations, summary papers (Quinn and Parker 1987, Anderson and Lovallo 2003), and unpublished reports (e.g., Carroll 2005, Fuller and Harrison 2005) were used.

1.8 Extent and Quality of Data

Although no information exists on the habitat needs of lynx in New Hampshire, substantial interest in this species has resulted in a number of investigations in regions with comparable habitat.

1.9 Distribution Research

1. Developing protocols to provide a comprehensive monitoring of lynx populations should be considered. However, based on the limited habitat for lynx in New Hampshire, such a protocol should be developed to address multiple species (e.g., forest carnivores).
2. Any effort to understand the demography of lynx in New Hampshire should be placed in a regional context that considers lynx populations in Maine, New Brunswick, and Quebec.

Element 2: Species Habitat Condition

2.1 Scale

Based on the large home range of lynx (circa 100 km^2), it may be most appropriate to group suitable habitats using the ecological sections defined by Sperduto and Nichols (2004). Over 95% of the lynx habitat estimated by the model proposed by Hoving et al. (2005) was in the White Mountain Ecosection and 99% of suitable clearcuts and high elevation spruce-fir stands occur in this ecosection.

2.2 Relative Health of Populations

There is no evidence that a population of lynx currently resides in New Hampshire.

2.3 Population Management Status

Other than protected status, there are no efforts under way to manage lynx in New Hampshire. The status of lynx in New Hampshire will largely be determined by the ability of lynx emigrating from northern source populations to reach the State. Specifically, habitat continuity along the suspected dispersal corridor (figure 4) should be maintained.

2.4 Relative Quality of Habitat Patches

It is suspected that the highest quality lynx habitat is associated with high elevation spruce-fir stands (figure 3).

2.5 Habitat Patch Protection Status

Approximately 89% of high elevation spruce-fir stands occur on public lands.

2.6 Habitat Management Status

Management options within the State are restricted to providing quality habitat for snowshoe hare. However, given the reduction in even-aged timber management in recent decades and increased tendency for modifications in silviculture practices [e.g., use of pre-commercial thinning; see Homyack (2003)], it is likely that the abundance of habitats that support high density populations of snowshoe hare will decline.

In 2000, the USFWS and USFS developed a lynx conservation agreement that requires the USFS to promote the conservation of lynx habitat on national forests within the historic range of lynx (USFS Agreement 00-MU-11015600-013). Application of even-aged timber management on the White Mountain National Forest could enhance prey abundance for lynx. However, all management alternatives considered in the revised White Mountain National Forest Plan do not include an increase in the amount of forest that will be under even-aged management. In fact, the most liberal application of even-aged management that is being considered would not replace the hare habitat that is being lost to succession.

2.7 Sources of Information

Historical data on abundance of lynx were obtained from Silver (1974). Recent observations were obtained from the Natural Heritage Bureau Element Occurrence database.

2.8 Extent and Quality of Data

As indicated previously, there is no information on stand or patch-specific features that affect habitat use and fitness of lynx in New Hampshire.

2.9 Condition Assessment Research

An inventory and monitoring protocol would provide information on lynx demographics and habitat (including patch-level) preferences. Potentially, this inventory could be associated with USFS National Forest Inventory and could link habitat and land-use changes to changes in lynx demographics (Zielinski et al. 2000). An inventory and monitoring program could be designed using a variety of platforms (e.g., snow tracks, scooted panels, or remotely-triggered cameras) and gather information on a number of mesocarnivores (e.g., bobcats, fishers, and pine marten), making it cost attractive (Zielinski and Kucera 1995).

Element 3: Species and Habitat Threat Assessment

3.1.1 Unsustainable Forestry Operations

(A) Exposure Pathway
Timber harvest programs are moving away from even-aged management and thus are reducing local populations of snowshoe hare.

(B) Evidence
A recent shift in New England from conifer clear cutting to pre-commercial thinning will enhance growth of young trees but will reduce carrying capacity of a young stand for snowshoe hares (Homyack 2003).

3.1.2 Scarcity (Hybridization)

(A) Exposure Pathway:
Lynx colonizing New Hampshire will likely encounter low-density bobcat populations in northern counties (Litvaitis et al. 2005). Under these conditions, hybridization is possible because neither species may encounter conspecifics.
(B) Evidence:
Hybridization between bobcats and lynx has been detected in northern Minnesota where both species are at relatively low densities (Schwartz et al. 2004).

3.1.4 Unregulated Take

(A) Exposure Pathway
Leghold traps can capture lynx

(B) Evidence
No direct evidence; speculation.

3.2 Sources of Information

Published papers, as well as summary reports by Ruediger et al. (2000) and Carroll (2005) were used.

3.3 Extent and Quality of Data

Recent research efforts have increased our understanding of factors limiting the density of lynx populations.

3.4 Threat Assessment Research

It is difficult to conduct research in New Hampshire because lynx may be extirpated.

Element 4: Conservation Actions

Any effort seems tenuous based on the current abundance of lynx (extirpated)

Element 5: References

Anderson, E.M., and M.J. Lovallo. 2003. Bobcat and lynx. Pages 758-782 *in* G.A. Feldhammer, B.C. Thompson, and J.A. Chapman, editors. Wild mammals of North America: biology, management, and conservation (2nd edition*).* John Hopkins Press, Baltimore, Maryland, USA.

Brand, C.J., and L.B. Keith. 1979. Lynx demography during a snowshoe hare decline in Alberta. Journal of Wildlife Management 43:827-849.

Buskirk, S.W., L.F. Ruggiero, and C.J. Krebs. 2000. Habitat fragmentation and interspecific competition: implications for lynx conservation. Pages 83-100 *in* L.F. Ruggiero, K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey, and J.R. Squires, editors. Ecology and Conservation of lynx in the United States. University Press of Colorado, Boulder, Colorado, USA.

Carroll, C. 2005. Carnivore restoration in the northeastern U.S. and southeastern Canada. Report 2: marten and lynx viability analysis. Wildlands Project, Richmond, Vermont, USA.

Carroll, C., W.J. Zielinski, and R.F. Noss. 1999. Us-

ing presence/absence data to build and test spatial habitat models for the fisher in the Klamath region, USA. Conservation Biology 13:1344-1359.

Fuller, A.K., and D.J. Harrison. 2005. Influence of forest practices on stand-scale habitat selection by lynx in northern Maine: preliminary results (abstract). Page 13 *in* L.S. Kenefic and M.J. Twery, editors. Changing forests – challenging times. Proceedings of the New England Society of American Forests 85th Winter Meeting, General Technical Report NE-325, USDA Forest Service, Newtown Square, Pennsylvania, USA.

Homyack, J.A. 2003. Effects of precommercial thinning on snowshoe hares, small mammals, and forest structure in northern Maine. M.S. Thesis, University of Maine, Orono, ME.

Hoving, C. L. 2001. Historical occurrence and habitat ecology of Canada lynx (*Lynx canadensis*) in eastern North America. Thesis, University of Maine, Orono, Maine, USA.

Hoving, C.L., D. J. Harrison, W.B. Krohn, W.J. Jakubas, and M.A. McCollough. 2004. Canada lynx habitat and forest succession in northern Maine, United States. Wildlife Biology 10:285-294.

Hoving, C.L., D.J. Harrison, W.B. Krohn, R.A. Joseph, and M. O'Brien. 2005. Broad-scale predictors of Canada lynx occurrence in eastern North America. Journal of Wildlife Management: In press.

Hoving, C.L., R.A. Joseph, and W.B. Krohn. 2003. Recent and historical distributions of Canada lynx in Maine and the Northeast. Northeastern Naturalist 10:363–382. 529

Justice, D., A. Deely, and F. Rubin. 2002. New Hampshire land cover assessment: final report. Complex Systems Research Center, University of New Hampshire, Durham, New Hampshire.

Litvaitis, J.A. 1994. New Hampshire's wild felines. New Hampshire Wildlife Journal 6:4-7.

Litvaitis, J.A., D. Kingman Jr., J. Lanier, and E. Orff. 1991. Status of lynx in New Hampshire. Transactions of the Northeast Section of the Wildlife Society. 48:70– 75.

*Litvai*tis, J.A., J.A. Sherburne, and J.A. Bissonette. 1985. Influence of understory characteristics on snowshoe hare habitat use and density. Journal of Wildlife Management 49:866-873.

Litvaitis, J.A., J.P. Tash, and C.L. Stevens. 2005. The rise and fall of bobcats in New Hampshire: relevance of historical harvests to understanding current patterns of distribution and abundance. Biological Conservation: in review.

McKelvey, K.S., K.B. Aubry, and Y.K. Ortega. 2000. History and distribution of lynx in the contiguous United States. Pages 207–264 *in* L.F. Ruggiero, K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey, and J.R. Squires, editors. Ecology and Conservation of lynx in the United States. University Press of Colorado, Boulder, Colorado, USA.

Murray, D.L. 2000. A geographic analysis of snowshoe hare population demography. Canadian Journal of Zoology 78:1207-1217.

Murray, D.L. and S. Boutin. 1991. The influence of snow on lynx and coyote movements: does morphology affect behavior? Oecologia 88:463–469. 574.

Murray, D.L., S. Boutin, and M. O'Donoghue. 1994. Winter habitat selection by lynx and coyotes in relation to snowshoe hare abundance. Canadian Journal of Zoology 72: 1444-1451.

Obbard, M.E. 1987. Red squirrel. Pages 265-281 *in* M. Novak, J.A. Baker, M.E. Obbard, and B. Malloch, editors. Wild furbearer management and conservation in North America. Ontario Ministry of Natural Resources, Toronto, Ontario, Canada.

O'Donoghue, M., S. Boutin, C.J. Krebs, and E.J. Hofer. 1997. Numeric responses of coyotes and lynx to the snowshoe hare cycle. Oikos 80:150-162.

O'Donoghue, M., S. Boutin, C.J. Krebs, D.L. Murray, and E.J. Hofer. 1998*a*. Behavioral responses of coyotes and lynx to the snowshoe hare cycle. Oikos 82:169-183.

O'Donoghue, M., S. Boutin, C.J. Krebs, G. Zuleta, D.L. Murray, and E.J. Hofer. 1998*b*. Functional responses of coyotes and lynx to the snowshoe hare cycle. Ecology 79:1193-1208.

O'Donoghue, M., E. Hofer, and F.I. Doyle. 1995. Predator versus predator. Natural History 104: 6-9.

Parker, G.R., J. W. Maxwell, L.D. Morton, and G.E. J. Smith. 1983. The ecology of the lynx (*Lynx canadensis*) on Cape Breton Island. Canadian Journal of Zoology 61:770–786.

Quinn, N.W.S. and G. Parker. 1987. Lynx. Pages 682–694 *in* M. Novak, J. A. Baker, M.E. Obbard,

and B. Malloch, editors. Wild Furbearer Management and Conservation in North America. Ontario Ministry of Natural Resources, Toronto, Ontario, Canada.

Ruediger, B., J. Claar, S. Gniadek, B. Holt, L. Lewis, S. Mighton, B. Naney, G. Patton, T. Rinaldi, J. Trick. A. Vandehey, F. Wahl, N. Warren, D. Wenger, and A. Williamson. 2000. Canada lynx conservation assessment and strategy. USDA Forest Service, USDI Fish and Wildlife Service, USDI Bureau of Land Management, and USDI Park Service. Forest Service Publication R1-00-53, Missoula, Montana.

Schwartz, M.K., K.L. Pilgrim, K.S. McKelvey, E.L. Lindquist, J.J. Claar, S. Loch, and L. Ruggiero. 2004. Hybridization between Canada lynx and bobcats: genetic results and management implications. Conservation Genetics 5:349-355.

Siegler, H.R., 1971. The status of wildcats in New Hampshire. Pages 46-53 *in* S.E.Jorgensen, and L.D. Mech, editors. Proceedings of a Symposium on the Native Cats of North America, Their Status and Management. USDI, Fish and Wildlife Service, Twin Cities, Minnesota, USA.

Silver, H., 1974. A history of New Hampshire game and furbearers (2nd edition). Survey Report No. 6, New Hampshire Fish and Game Department, Concord, New Hampshire.

Sperduto, D.D., and W.F. Nichols. 2004. Natural communities of New Hampshire. The New Hampshire Natural Heritage Bureau and The Nature Conservancy, Concord, New Hampshire, USA.

Stuery, T.D., and D.L. Murray. 2004. Modeling the reintroduction of lynx to the southern portion of its range. Biological Conservation 117:127-141.

USFWS (U.S. Fish and Wildlife Service). 2000. Endangered and threatened wildlife and plants; determination of threatened status for the contiguous U.S. distinct population segment of the Canada lynx and related rule; final rule. Federal Register 65:16052–16086.

Zielinski, W.J., and T.E. Kucera. 1995. Introduction to detection and survey methods. Pages 1-15 in: Zielinski, W.J.; Kucera, T.E., eds.,American Marten, Fisher, Lynx, and Wolverine: Survey Methods for their Detection. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station; Gen. Tech. Rep. PSW-GTR-157.

Zielinski, W.J., R.L. Truex, L.A. Campbell, C.R. Carroll, and F.V. Schlexer. 2000. Systematic surveys as a basis for the conservation of carnivores in California forests. Unpublished report, USDA Forest Service, Pacific Southwest Research Station, Redwood Sciences Laboratory, Arcata, California.

Element 6 : List of Figures

Figure 1. Location of incidental observations of lynx during 1990-2004 (from NHDRED).

Figure 2. Lynx habitat in New northern New Hampshire predicted by the model developed by Hoving et al. (2005). High elevation spruce-fir stands and recent clearcuts also are included because these habitats support dense populations of snowshoe hares. Clearcuts (> 1.2 ha with < 2 m^2 residual basal area) were only included if they had an average annual snowfall of > 250 mm.

Figure 3. Regional lynx habitat predicted by Hoving et al. (2005).

SPECIES PROFILE

New England Cottontail

Sylvilagus transitionalis

Federal Listing: Under review for threatened/endangered status
State Listing: Management concern
Global Rank: G4
State Rank: S3
Authors: John A. Litvaitis and Jeffery P. Tash, University of New Hampshire

Element 1: Distribution and Habitat

1.1 Habitat Description

New England cottontails (hereafter referred to as 'NEC') occupy a variety of habitats including native shrublands and regenerating forests associated with small-scale disturbances that result from beavers (*Castor canadensis*), local windstorms, and human land uses. Less frequent but larger-scale disturbances (including hurricanes and wild fires) also provide early-successional habitats, especially near the Atlantic coast (Lorimer and White 2003). Habitats of NEC are described by vegetation structure (especially height and density) rather than specific plant communities (Eabry 1968).

The most consistent characteristic of NEC habitat is dense understory cover (Fay and Chandler 1955, Eabry 1968, Linkkila 1971). Coniferous stems provide NEC with approximately 3 times the visual obstruction of deciduous stems in winter (Litvaitis et al. 1985). NEC prefer sites with more than 50,000 stem-cover units/ha and are reluctant to venture more than 5 m from cover (Barbour and Litvaitis 1993). In regenerating stands or idle agricultural fields, NEC colonize after secondary succession has progressed and a woody understory is well developed (approximately 5 to 7 years). As the stand matures and young trees develop a closed canopy (approximately 20 to 25 years after disturbance), understory vegetation becomes sparse and the site is no longer suitable for NEC.

1.2 Justification

Since 1960, the distribution and abundance of NEC has declined substantially throughout New England (Johnston 1972, Jackson 1973, Litvaitis 1993). See section 1.4.

1.3 Protection and Regulatory Status

The species is currently being considered for threatened or endangered status by the USFWS (Federal Register: June 30, 2004; Volume 69, Number 125, Pages 39395-39400). The hunting season of NEC in New Hampshire was closed in September 2004.

1.4 Population and Habitat Distribution

Present-day populations of NEC span < 25% of their historic range (figure 1). A recent range-wide survey of the historic range of NEC (protocol described by Litvaitis et al. 2002) indicated that the distribution of NEC in New Hampshire has declined substantially. Only eastern cottontails and snowshoe hares were

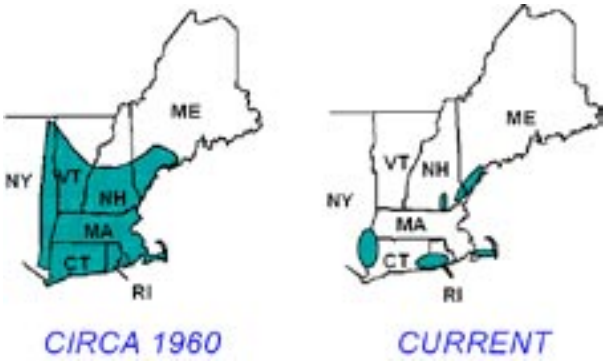


Figure 1. Historical and current distributions of New England cottontails. Historical distribution is a compilation of Hall and Kelson (1959), Johnston (1972), and Jackson (1973). Current distribution is based on a range-wide survey of suitable habitats (J. Tash et al., unpublished data).

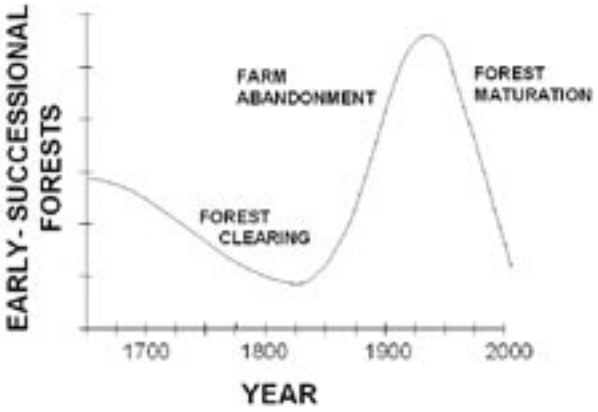


Figure 2. Successional wave that is passing through forests in the northeastern United States following land clearing for agriculture and subsequent abandonment of these lands. Modified from Litvaitis (1993).

found in the western portion of the state.

Probably the most important disturbance that influenced the abundance of NEC was the clearing of forests for agriculture by European settlers and subsequent abandonment of these lands (Ahn et al. 2002, Hall et al. 2002). Cleared lands were abruptly abandoned in the mid-1800s for more productive farms in the midwestern United States. Many of these tracts reverted to second-growth forests (Irland 1982), and NEC and other early-successional forest species reached unprecedented levels of abundance throughout the northeastern United States in the early 1900s (DeGraaf and Miller 1996, Foster et al. 2002, Litvaitis et al. 2005*b*). Litvaitis (1993) used information on the rate of farmland abandonment and developed a simple model of forest succession to estimate the approximate recruitment of early-successional habitats. Most of the abandoned lands matured into closed-canopy forests by 1960 and species dependent on these habitats quickly declined, including NEC (figure 2). Litvaitis (1993) summarized the approximate range retraction by NEC in New Hampshire (figure 3).

If populations of NEC stabilized at reduced densities reached in the 1960s, conservation actions probably would not be needed. However, early-successional habitats in the northeastern United States continue to decline (Brooks 2003) and remaining populations of NEC in New Hampshire and elsewhere are vulnerable to extinction (Litvaitis and Villafuerte 1996).

Figure 3. Range change of New England cottontail in New Hampshire from 1950 to present day. The 1950 delineation is based on a survey of conservation officers conducted by C.L. Stevens (unpublished map). Retraction by 1973 is based on livetrapping survey conducted by Jackson (1973). Locations of known populations of New England cottontails are indicated and were based on field surveys during 2002 and 2003.

1.5 Town Distribution Map

Remnant populations are restricted to southeastern and south-central New Hampshire.

1.6 Habitat Map

We used the results of the range-wide inventory that included NEC-occupied sites in Maine and New Hampshire to investigate landscape-scale environmental factors that affect their distribution. Seventeen habitat features, including class I and II road density, local road density, forest-open edge, and percent forest, were inventoried within 1-km around each NEC location and an equivalent number of patches known to be vacant within occupied quads. A 1-km radius (3.14 km^2) represents a reasonable approximation of dispersal distance of NEC (Litvaitis and Villafuerte

1996). We then used GIS to compare the inventoried information between the occupied and unoccupied sites to determine if any differences occurred.

Our data screening yielded 13 variables that differed between known NEC locations and vacant sites (appendix 2). Data analysis indicated that class I and II road density, local road density, forest-open edge, and percent forest were the most significant. Seventy-seven percent of known locations and ninety-one percent of vacant sites were correctly identified using these variables

1.7 Sources of Information

Information on current distribution of NEC came from a recent range-wide survey of the historic range of NEC (Litvaitis et al. 2002, Tash and Litvaitis, unpublished data). We also relied on other published investigations. Sources of information for the habitat map included USGS National Land Cover Characterization Project derived from early to mid-1990s Landsat Thematic Mapper satellite data (Vogelman et al. 2001), class I and II roads, rights-of-way (e.g., powerlines and pipelines) and railroad corridors from United States Census Bureau 2000 TIGER data, and snow coverage data from the Spatial Climate Analysis Service at Oregon State University.

1.8 Extent and Quality of Data

The habitat model does not identify habitats that will support NEC but describes areas that are similar to habitats that are currently occupied by NEC in New Hampshire and Maine. Most of the variables used in model development were obtained at a landscape scale (e.g., abundance of forest edges and class I + II roads), and do not provide a complete description of patch suitability. The most influential feature at the patch scale—understory density—could not be obtained from satellite imagery. Additionally, this model was based on habitats currently occupied by NEC and it does not represent the habitats that the species could potentially occupy but were not encountered during our survey. Based on the distribution of remaining NEC populations in New Hampshire (largely human-dominated landscapes), the features identified as important are probably only important in similar landscapes.

The remaining variables may have more obvious influences on habitat suitability. Local roads (class III and higher) had a negative influence probably because these roads lack the brushy corridor and fragment existing habitats. Forests also had a negative effect because NEC rely on dense understory vegetation that is usually sparse in closed-canopy forests. Finally, the abundance of forest-open area edges (positive influence) may index the abundance of brushy edges that are often found at the edge of forest stands.

The distribution of present-day populations of NEC is substantially affected by heterospecific interactions that were not included in our model. These include competition with expanding populations of eastern cottontails (*S. floridanus*) (Fay and Chandler 1955, Reynolds 1975) and interactions with snowshoe hares (*Lepus americanus*). The latter has not been studied in any detail.

1.9 Distribution Research

Develop a monitoring program to track changes in the abundance and distribution of NEC. This will

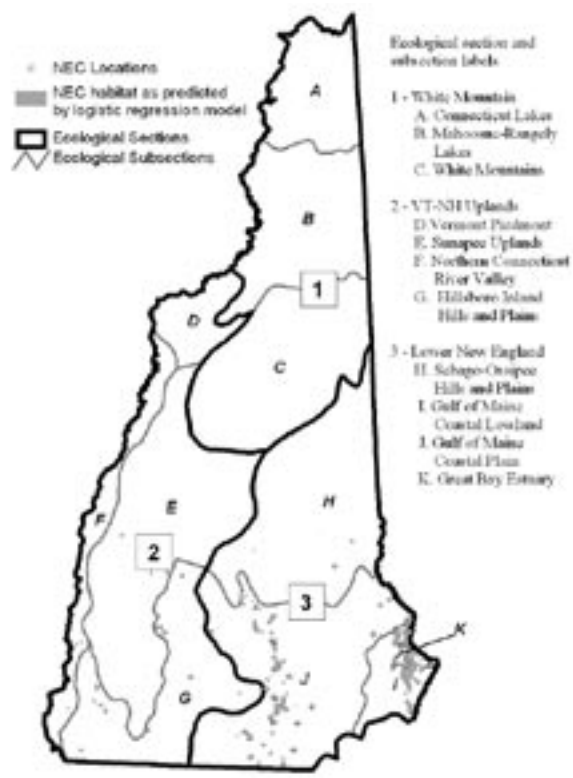


Figure 5. Modeled habitats of New England cottontails based on Class I and II road density, local road density, forest-open edge, and percent forest cover within 1 km. Habitats depicted had a >50% of being occupied.

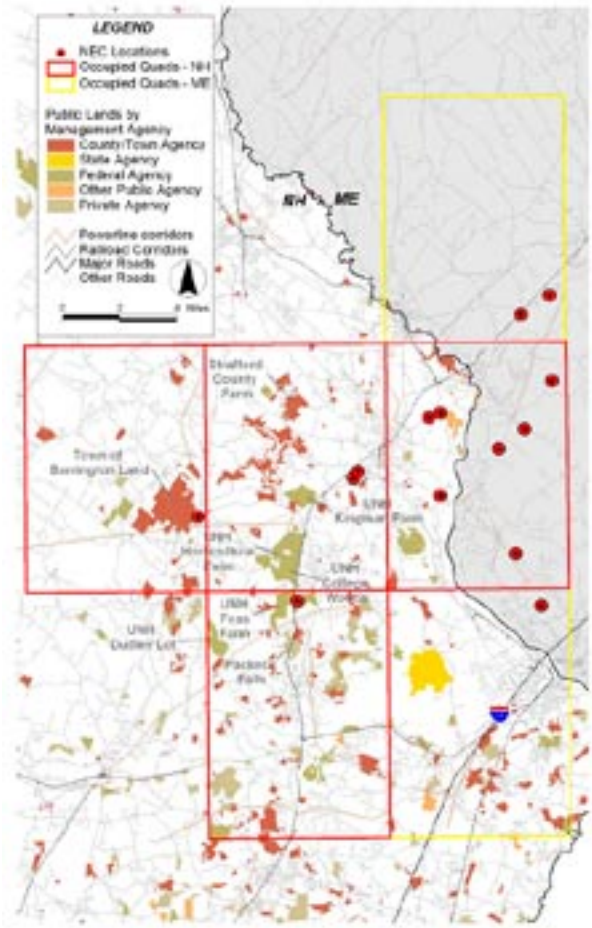


Figure 5. Distribution of public land in relation to habitats occupied by New England cottontails in southeastern New Hampshire.

Figure 6. Distribution of public land in relation to habitats occupied by New England cottontails in southcentral New Hampshire.

become increasingly important as management efforts are directed toward expanding remaining populations. A monitoring program that relied on fecal analysis would be cost effective (Kovach et al. 2003).

Element 2: Species Habitat Condition

2.1 Scale

Based on the ephemeral nature of habitats, and the restricted distribution of NEC, we believe ecological subsections (Sperduto and Nichols 2004) is an appropriate scale to develop habitat management plans (figure 4).

2.2 Relative Health of Populations

Remaining populations of NEC in New Hampshire span a modest portion of the region that was occupied historically, including the Seacoast (figure 5) and Merrimack River Valley (figure 6).

2.3 Population Management Status

There have not been any habitat-based management efforts directed toward NEC. The recent closing of hunting seasons on this species will have little influence on long-term patterns of abundance.

2.4 Relative Quality of Habitat Patches

Modeled habitats with a greater than 50% probability of NEC occurrence (according to the generated model) averaged 223 ha, and 65% of sites were greater than 5 ha. Again, a distinction must be made between model habitats and actually occupied habi-

tats. Litvaitis and Villafuerte (1996) reported that patches occupied in southeastern New Hampshire ranged from 0.2 to ~15 ha, and that populations of NEC in the region are functioning as induced metapopulations (Litvaitis and Villafuerte 1996). In such an arrangement, small patches (less than 3 to 5 ha) may represent the majority. Such patches are dependent on the colonization of surplus rabbits from larger patches of habitat (Litvaitis and Villafuerte 1996). Although large patches have been identified, the majority of these sites probably do not contain adequate patch-specific features (especially dense understory vegetation) to support NEC.

2.5 Habitat Patch Protection Status

Habitats with a greater than 0.5 probability of NEC occurrence (according to model predictions) totaled 34,061 ha. Approximately 21% (7,222 ha) occur on existing conservation lands or easements. Modeled habitats were most abundant in the Lower New England Ecosection (28,593 ha), especially in Gulf of Maine Coast Plain (13,454 ha) and Gulf of Maine Coast Lowland (14,523 ha) subsections.

2.6 Habitat Management Status

There is no NEC-specific habitat management.

2.7 Sources of Information

Land use and land cover data were obtained from the New Hampshire Land Cover Assessment 2001 database at the Complex Systems Research Center of UNH.

2.8 Extent and Quality of Data

There has been sufficient research on patch-specific habitat features. This information would be complemented by additional efforts to understand landscape elements that influence metapopulation survival (Litvaitis and Villafuerte 1996).

2.9 Condition Assessment Research

Substantial research has been conducted on the status and distribution of NEC and their habitat in New Hampshire.

Element 3: Species and Habitat Threat Assessment

3.1.1 Altered Natural Disturbance (Natural Succession)

(A) Exposure Pathway
NEC are obligate residents of habitats with dense understory vegetation. Forest succession and contemporary land uses have limited the generation of such habitats (Brooks 2003), and natural disturbance regimes in relatively young forests are not sufficient to provide adequate habitats (Litvaitis et al. 1999, Litvaitis 2003). Additionally, the current range occupied by NEC in New Hampshire (Figures 5 and 6) are embedded in rapidly developing landscapes (Sundquist and Stevens 1999).

(B) Evidence
Based on existing literature and recent survey of NEC habitats in New Hampshire.

3.1.2 Predation and Herbivory

(A) Exposure Pathway
Predation is the most common proximate mortality factor of NEC. Cottontails occupying small patches of habitat (les than 3 ha) are most vulnerable (Barbour and Litvaitis 1993, Brown and Litvaitis 1995, Villafuerte et al. 1997).

(B) Evidence
Extensive investigations of NEC in New Hampshire.

3.1.3 Scarcity (Competition)

(A) Exposure Pathway
NEC are sympatric with eastern cottontails and snowshoe hares in New Hampshire. Eastern cottontails are currently found along the Connecticut River Valley where NEC have apparently been extirpated. Allopatric populations of eastern cottontails also occur in the southern portion of the Merrimack River Valley and along the Atlantic coast to Great Bay in the southeastern portion of the State (Tash and Litvaitis, unpublished data). Stochastic events (e.g., winter with deep snow) also may benefit snowshoe hares.

(B) Evidence
Speculation based on literature review.

3.2 Sources of Information

Extensive research conducted in New Hampshire (reviewed by Litvaitis et al. 2005*a*).

3.3 Extent and Quality of Data

Substantial information on NEC status and conservation is available on New Hampshire populations.

3.4 Threat Assessment Research

The interactions between NEC and either eastern cottontails or snowshoe hares in contemporary landscapes, where human land uses are a dominant force creating early-successional habitats, warrant additional investigation.

Element 4: Conservation Actions

4.1. Development of early-successional habitat networks in landscapes currently occupied by NEC.

Based on the status of NEC populations in New Hampshire, habitat restoration and translocations are essential. If such efforts were undertaken, initial efforts would be most effective by expanding existing populations. The majority of NEC-occupied habitats occur on private lands, but several are near public land (figures 5 and 6). Indeed, cottontails for translocations may come from private lands that undergo development. Remaining populations also are associated with rapidly expanding human populations and associated developments (Sundquist and Stevens 1999). Additionally, remaining populations are associated with disturbance-generated habitats. As such, they have a finite period of suitability (figure 1). Unless active management programs develop, the long-term viability of these populations is unlikely. Habitats with a greater than 0.5 probability of NEC occurrence (according to model predictions) totaled 34,061 ha (figure 5). Approximately 21% (7,222 ha) occur on existing conservation lands or easements. Some of these lands may become suitable habitat with only modest intervention. Although modeled habitats do not reveal any information about the suitability of specific patches of habitat, the model does provide a landscape context within which suitable patches could be managed. Additionally, the habitat model provides insight into important landscape features that likely facilitate demographic exchanges among populations of NEC in human-dominated landscapes. For example, classes I and II roads were associated with NEC sites because the roads often have a brushy corridor associated with them. In southern Maine (included in model development), Litvaitis et al. (2003) encountered extensive stretches of Interstate 95 that had shrub-dominated margins more than 10 m wide. Additionally, rest areas and exit ramps had sufficient disturbance-generated habitats to support 1 to 2 cottontails (J. Litvaitis, personal observation). Although Interstate 95 poses a formidable barrier (up to 7 or 8 lanes of vehicle traffic) to east–west movement, the substantial habitat associated with this corridor may facilitate north–south movement.

In southern New Hampshire, one of the most expansive populations was associated with railroad corridors. Here, the strip of brushy vegetation also may be functioning as an important dispersal corridor. Management of habitats exclusively along the corridor of multi-lane highways, however, may create some unexpected problems. Specifically, enhancing habitats in these areas may benefit local NEC populations but create a potential "ecological trap" for wide-ranging predators of NEC by exposing them to elevated risks of vehicle collisions. A more prudent approach may be to rely on brushy edges of roads or utility rights-of-way as movement corridors but enhance habitats some distance (circa 0.5 km) from these corridors.

Predation is clearly the most common mortality factor among NEC in New Hampshire, especially by coyotes (*Canis latrans*) and foxes (*Vulpes vulpes*) (Barbour and Litvaitis 1993, Brown and Litvaitis 1995, Villafuerte et al. 1997). Populations of these carnivores have increased in southern New Hampshire as forest-dominated landscapes are converted into agricultural fields or suburban developments (Oehler and Litvaitis 1996). NEC occupied patches in southeastern New Hampshire ranged from 0.2 to greater than 15 ha, but very small patches (less than or equal to 2 ha) were inherently vulnerable because of intense predation (Barbour and Litvaitis 1993, Villafuerte et al. 1997). As a result, any effort to manage

habitats of NEC in human-dominated landscapes should be directed toward larger patches of habitat (Litvaitis 2001).

As populations of NEC respond to restoration, additional management should occur. In less developed landscapes, management activities may shift toward developing a network of patches that compliment native shrublands and land uses that provide early-successional forests or old-field habitats. In regions where the historic abundance of shrublands and barrens was limited, timber harvests will provide a practical approach to diversify stand age distributions. Here, a "sliding scale" approach would be appropriate in mid-successional forests where natural disturbances are rare (Litvaitis 2003). Initially, the size of timber harvests would be larger than natural disturbances to offset the shortfall in early-successional habitat that currently exists. Once established, some of these openings could be maintained by active management (e.g., cutting, mowing, or control fires). As forests mature, management efforts (especially timber harvests) could be patterned after canopy gaps (Runkle 1991) or modified to specific silviculture practices of a region (Seymour et al. 2002) if other forms of NEC-suitable habitats (e.g. native shrublands and beaver impoundments) are adequately represented. Such an approach may be most appropriate on public lands or industrial forests where road networks and elevated populations of generalist predators may not be a concern (Litvaitis et al. 2005).

Element 5: References

5.1 Literature

Ahn, S., W.B. Krohn, A.J. Plantinga, T.J. Dalton, and J.A. Hepinstall. 2002. Agricultural land changes in Maine: a compilation and brief analysis of census of agriculture data, 1850-1997. Maine Agricultural and Forest Experiment Station, Technical Bulletin 182, University of Maine, Orono, Maine, USA.

Barbour, M.S., and J.A. Litvaitis. 1993. Niche dimensions of New England cottontails in relation to habitat patch size. Oecologia 95:321-327.

Brooks, R.T. 2003. Abundance, distribution, trends, and ownership patterns of early successional forests in the northeastern United States. Forest Ecology and Management 185:65-74.

Brown, A.L., and J.A. Litvaitis. 1995. Habitat features associated with predation of New England cottontails: what scale is appropriate? Canadian Journal of Zoology 73:1005-1011.

Chapman, J.A., and J.A. Litvaitis. 2003. Eastern cottontails and their allies. Pages 101-125 *in* G.A. Feldhammer, B.C.Thompson, and J.A. Chapman, editors, Wild Mammals of North America: Biology, Management, and Conservation - 2nd edition. John Hopkins Press, Baltimore, MD.

Chapman, J.A., and R.P. Morgan. 1973. Systematic status of the cottontail complex in western Maryland and nearby West Virginia. Wildlife Monographs 36:1-54.

Dalke, P.D., and P.D. Sime. 1941. Food habits of the eastern and New England cottontails. Journal of Wildlife Management 5:216-228.

DeGraaf, R.M., and R.I. Miller. 1996. The importance of disturbance and land-use history in New England: implications for forested landscapes and wildlife conservation. Pages 3-25 *in* R.M. DeGraaf and R.I. Miller, editors. Conservation of faunal diversity in forested landscapes. Chapman and Hall, London.

Eabry, H.S. 1968. An ecological study of *Sylvilagus transitionalis* and *S. floridanus* of northeastern Connecticut. M. S. Thesis, University of Connecticut, Storrs.

Fay, F.H., and E.H. Chandler. 1955. The geographic and ecological distribution of cottontail rabbits in Massachusetts. Journal of Mammalogy 36:415-424.

Foster, D.R., G. Motzkin, D. Bernardos, and J. Cardoza. 2002. Wildlife dynamics in the changing New England landscape. Journal of Biogeography 29:1337-1358

Hall, B., G. Motzkin, D.R. Foster, M. Syfert, and J. Burk. 2002. Three hundred years of forest and land-use change in Massachusetts, USA. Journal of Biogeography 29:1319-1336.

Hall, E.R., and K.R. Kelson. 1959. The mammals of North America. Ronald Press Company. New York, NY.

Irland, L.C. 1982. Wildlands and woodlots – a story of New England's forests. University Press of New England, Hanover, New Hampshire.

Jackson, S.N. 1973. Distribution of cottontail rabbits (*Sylvilagus* spp.) in northern New England. M. S. Thesis, University of Connecticut, Storrs.

Johnston, J.E. 1972. Identification and distribution

of cottontail rabbits in southern New England. M. S. Thesis, University of Connecticut, Storrs.

Keith, L.B., and S.E.M. Bloomer. 1993. Differential mortality of sympatric snowshoe hares and cottontail rabbits in central Wisconsin. Canadian Journal of Zoology 71:1694-1697.

Kovach, A. I., M.K. Litvaitis, and J.A. Litvaitis. 2003. Evaluation of fecal DNA analysis as a method to determine the geographic range of a rare lagomorph. Wildlife Society Bulletin 31:1061-1065.

Linkkila, T. 1971. Influence of habitat upon changes within the interspecific Connecticut cottontail population. M.S. Thesis, University of Connecticut, Storrs.

Litvaitis, J.A. 1993. Response of early successional vertebrates to historic changes in land use. Conservation Biology 7:866-873.

Litvaitis, J.A. 2001. Importance of early-successional habitats to mammals in eastern forests. Wildlife Society Bulletin 29:466-473.

Litvaitis, J.A. 2003. Are pre-Columbian conditions relevant baselines in managed forests of the northeastern United States? Forest Ecology and Management 185:113-126.

Litvaitis, J.A., M.S. Barbour, A.L. Brown, A.I. Kovach, J.D. Oehler, B.L. Probert, D.F. Smith, J.P. Tash, R.Villafuerte, and M.K. Litvaitis. 2005*a*. Testing multiple hypotheses to identify the causes of the range-wide decline of New England cottontails. In review for forthcoming book, Biology of lagomorphs - evolution, ecology and conservation. P. Alves and K. Hackländer, editors.

Litvaitis, J.A., B. Johnson, W. Jakubas, and K. Morris. 2003. Distribution and habitat features associated with remnant populations of New England cottontails in Maine. Canadian Journal of Zoology 81:877-887.

Litvaitis, J.A., B. Johnson, A. Kovach, M.K. Litvaitis, and R. Jenkins. 2002. Manual of sampling protocols for a regional inventory of New England cottontails. Interim Report to U. S. Fish and Wildlife Service, Concord, New Hampshire.

Litvaitis, J.A., J.A. Sherburne, and J.A. Bissonette. 1985. Influence of understory characteristics on snowshoe hare habitat use and density. Journal of Wildlife Management, 49: 866-873

Litvaitis, J.A., J.P. Tash, and C.L. Stevens. 2005*b*. The rise and fall of bobcats in New Hampshire: relevance of historical harvests to understanding current patterns of distribution and abundance. Biological Conservation: In review.

Litvaitis, J.A., and R. Villafuerte. 1996. Factors affecting the persistence of New England cottontail metapopulations: the role of habitat management. Wildlife Society Bulletin 24:686-693.

Litvaitis, J.A., D.L. Wagner, J.L. Confer, M.D. Tarr, and E.J. Snyder. 1999. Early successional forests and shrub-dominated habitats: land-use artifact or critical community in the northeastern United States. Northeast Wildlife 54:101-118.

Lorimer, C.G., and A.S. White. 2003. Scale and frequency of natural disturbances in the northeastern United States: implications for early-successional forest habitat and regional age distributions. Forest Ecology and Management 185:41-64.

Nugent, R.F. 1968. Utilization of fall and winter habitat by the cottontail rabbits of northwestern Connecticut. M.S. Thesis, University of Connecticut, Storrs.

Oehler, J.D., and J.A. Litvaitis. 1996. The role of spatial scale in understanding responses by medium-sized carnivores to forest fragmentation. Canadian Journal of Zoology 74: 2070-2079.

Probert, B.L., and J.A. Litvaitis. 1996. Behavioral interactions between invading and endemic lagomorphs: implications for conserving a declining species. Biological Conservation 76:289-296.

Reynolds, K.M. 1975. Interspecific changes within sympatric cottontail populations of northwestern Connecticut. M.S. Thesis, University of Connecticut, Storrs.

Runkle, J.R. 1991. Gap dynamics of old-growth eastern forests: management implications. Natural Areas Journal 11:19-25.

Seymour, R.S., A.S. White, and P.G. deMaynadier. 2002. Natural disturbance regimes in northeastern North America—evaluating silvicultural systems using natural scale and frequencies. Forest Ecology and Management 155:357–367.

Silver, H. 1974. A history of New Hampshire game and furbearers (2nd edition). Survey Report Number 6, New Hampshire Fish and Game Department, Concord, New Hampshire.

Smith, D.F., and J.A. Litvaitis. 1999. Differences in eye size and predator-detection distances of New England and eastern cottontails. Northeast Wildlife 54:55-60.

Smith, D.F., and J.A. Litvaitis. 2000. Foraging strat-

egies of sympatric lagomorphs: implications for differential success in fragmented landscapes. Canadian Journal of Zoology 78:2134-2141.

Sperduto, D.D., and W.F. Nichols. 2004. Natural communities of New Hampshire. The New Hampshire Natural Heritage Bureau and The Nature Conservancy, Concord, New Hampshire, USA.

Sundquist, D., and M. Stevens. 1999. New Hampshire's changing landscape: population growth, land conversion and resource fragmentation in the Granite State. The Society for Protection of New Hampshire Forests, Concord, New Hampshire.

Tabachnick, B.G., and L.S. Fidell. 2001. Using multivariate statistics. Harper Collins College Publishers, New York.

Villafuerte R., J.A. Litvaitis, and D.F. Smith. 1997. Physiological responses by lagomorphs to resource limitations imposed by habitat fragmentation: implications to condition-sensitive predation. Canadian Journal of Zoology 75:148-151.

Vogelmann, J.E., S.M. Howard, L. Yang, C.R. Larson, B.K. Wylie, and J.N. Van Driel. 2001. Completion of the 1990's National Land Cover Data Set for the conterminous United States. Photogrammetric Engineering and Remote Sensing 67:650-662.

Yang, L., S.V. Stehman, J.H. Smith, and J.D. Wickham. 2001. Short Communication: Thematic accuracy of MRLC land-cover for the eastern United States. Remote Sensing of Environment 76:418-422.

Zar, J. 1999. Biostatistical analysis. Fourth edition. Prentice Hall, Upper Saddle River, New Jersey.

Element 6: List of Figures

Figure 1. Historical and current distributions of New England cottontails. Historical distribution is a compilation of Hall and Kelson (1959), Johnston (1972), and Jackson (1973). Current distribution is based on a range-wide survey of suitable habitats (J. Tash et al., unpublished data).

Figure 2. Successional wave that is passing through forests in the northeastern United States following land clearing for agriculture and subsequent abandonment of these lands. Modified from Litvaitis (1993).

Figure 3. Range change of New England cottontail in New Hampshire from 1950 to present day. The 1950 delineation is based on a survey of conservation officers conducted by C.L. Stevens (unpublished map). Retraction by 1973 is based on livetrapping survey conducted by Jackson (1973). Locations of known populations of New England cottontails are indicated and were based on field surveys during 2002 and 2003.

Figure 4. Modeled habitats of New England cottontails based on Class I and II road density, local road density, forest-open edge, and percent forest cover within 1 km. Habitats depicted had a >50% of being occupied.

Figure 5. Distribution of public land in relation to habitats occupied by New England cottontails in southeastern New Hampshire.

Figure 6. Distribution of public land in relation to habitats occupied by New England cottontails in southcentral New Hampshire.

SPECIES PROFILE

Northern Bog Lemming

Synaptomys borealis sphagnicola

Federal Listing: Not listed
State Listing: Not listed
Species Global Rank: G4T3Q
State Rank: SH
Author: Mariko Yamasaki and Angela Karedes, United States Department of Agriculture Forest Service

Element 1: Distribution and Habitat

1.1 Habitat Description

The northern bog lemming (hereafter called bog lemming) is found in northern New England, New York, and eastern Canada in higher elevation mossy spruce woods (1,300 to 4,500 feet), low elevation spruce-fir, hemlock and beech forests, sphagnum bogs, damp weedy meadows, and alpine sedge meadows (Clough and Albright 1987, DeGraaf and Yamasaki 2001, Banfield 1974, Saunders 1988). Special habitat requirements include moist loose soils or leaf mold (Banfield 1974, DeGraaf and Yamasaki 2001). Bog lemmings feed on grasses and sedges and are active year-round. Bog lemmings use tunnels several inches below ground and shallow runways on the ground surface (Banfield 1974). In the summer, bog lemmings construct spherical nests of dried grasses in burrows, and in winter, it nests on the ground (Banfield 1974).

1.2 Justification

Bog lemmings are probably the rarest mammal in New England and eastern Canada, making them vulnerable to local extirpation (Banfield 1974). Recent surveys in the White Mountains found one individual at one out of 108 sites (Yamasaki, unpublished data). Only two other sites in the region have yielded specimens over the last 100 years. Comprehensive surveys for bog lemmings have been not been conducted outside of the White Mountains; difficulty in properly identifying this species may contribute to its lack of detection. Considerable work is required to understand the habitat requirements of this rare mammal in northern New Hampshire, as it has been found in low numbers across a variety of northern forest, alpine, and sphagnum vegetative communities. Further surveys for bog lemmings in sphagnum-dominated vegetative communities might be productive as in Montana surveys (Reichel and Beckman 1993, Reichel and Beckman 1994, Reichel 1995, Reichel and Corn 1997).

1.3 Protection and Regulatory Status

The bog lemming is currently listed as having historical occurrences in the NHNHB database (2005).

1.4 Population and Habitat Distribution

Three specimens of bog lemmings have been recorded in New Hampshire in the past 100 years in the White Mountains region (Preble 1899, Clough and Albright 1987, Yamasaki, unpublished data). Northern New Hampshire represents the southernmost edge of the range of bog lemmings in northern New England and eastern Canada (DeGraaf and Yamasaki 2001, NatureServe 2004). There are insufficient data to determine any further spatial distribution patterns.

1.5 Town Distribution Map

Specimens of *S. borealis* have been reported from the towns of Carroll, Coos County, in 1898 (Preble 1899), Benton, Grafton County, in 1958 (Clough and Albright 1987), and Bean's Purchase, Coos County, in 1996 (M. Yamasaki, USDA Forest Service, unpublished data).

1.6 Habitat Map

It is difficult to delineate a habitat map for this species from three locations spanning 100 years with limited sampling effort. With the cooperation of the WMNF, Yamasaki conducted a 3-year systematic survey of small mammals between 1995 and 1997. This survey took place in potential habitats across three levels of vegetation management in the White Mountains region. Directed searches used snap trap grids and 10-bucket, Y-shaped, drift fence pitfall sets to target rock voles *(Microtus chrotorrhinus)*, long-tailed shrews *(Sorex dispar),* and northern bog lemmings. Out of the 108 study sites surveyed across managed, unmanaged, and remote locations in the forest, one managed site in a lowland spruce-fir stand yielded a bog lemming specimen (Yamasaki 1997). The positive identification was confirmed by the American Museum of Natural History where the specimen now resides.

While 10 years of small mammal sampling at the Bartlett Experimental Forest in Bartlett produced many specimens of small mammal species from the White Mountains region, including occasional specimens of southern bog lemmings, it produced no specimens of northern bog lemmings.

1.7 Sources of Information

Information on habitat, population distribution, and status was collected from unpublished data, scientific literature, and limited agency data.

1.8 Extent and Quality of Data

The bog lemming is probably the least understood mammal species in New Hampshire due to its rarity. Systematic searches in the White Mountains region from 1995 to 1997 located one individual at 1 of 108 sample sites (M. Yamasaki, USDA Forest Service, unpublished data).

1.9 Distribution Research

Directed, systematic, and long-term small mammal surveys and vegetation sampling in appropriate habitat types (e.g., sphagnum bogs, sub-alpine meadows, and upland forests with moist soils), especially north of the notches of the White Mountains, are needed to better describe the distribution and ecology of this species.

Element 2: Species/Habitat Condition

2.1 Scale

Lands north of the notches in the White Mountain section M212A appear to be the southerly extent of the range of the bog lemming. These lands include subsections M212Ad, M212Ae, and M212Af in Avers et al. (1994) and would likely be a component of a greater North Country conservation planning unit.

2.2 Relative Health of Populations

There are insufficient data to draw conclusions about the population health or distribution of bog lemmings.

2.3 Population Management Status

There are no management efforts for bog lemmings in New Hampshire.

2.4 Relative Quality of Habitat Patches

There are no data to with which to assess the relative quality of habitat patches for *S. borealis*.

2.5 Habitat Patch Protection Status

All documented specimens in New Hampshire are within the proclamation boundary of the White Mountain National Forest. The bog lemming is recognized as a "Region 9 Regional Forester Sensitive Species" whose special concerns are addressed in the planning or analysis phases of management programs.

2.6 Habitat Management Status

There are no habitat management efforts for bog lemmings.

2.7 Sources of Information

Information on habitat, population distribution, and status was collected from unpublished data, scientific literature, and limited agency data.

2.8 Extent and Quality of Data

The bog lemming is probably the least understood mammal species in New Hampshire due to its rarity. Systematic searches in appropriate habitats in the White Mountain National Forest located one occurrence out of 108 sample sites during a study from 1995 to 1997 (M. Yamasaki, USDA Forest Service, unpublished data).

2.9 Condition Ranking

There is no information with which to make this assessment.

2.10 Condition Assessment Research

Directed, systematic, and long-term small mammal surveys and vegetation sampling in appropriate habitat types (e.g., sphagnum bogs, sub-alpine meadows, and upland forests with moist soils), especially north of the notches of the White Mountains, are needed to better describe the habitat characteristics of bog lemmings (e.g., associated vegetative communities, habitat condition indicators, potential impacts of forest management and recreation).

Element 3: Species and Habitat Threat Assessment

3.1.1 Scarcity (Natural Rarity)

(A) Exposure Pathway
The most significant threat to the bog lemming is its rarity. The natural distribution may be that of isolated metapopulations with few individuals in each location. This pattern might inhibit dispersal and habitats may not repopulate easily if there are local extirpations (Clough and Albright 1987).

(B) Evidence
There are no data for this analysis. The work by Reichel and Corn (1997) in Montana may demonstrate a similar set of habitat conditions and distribution patterns for bog lemmings in the northern Rockies
.

3.2 Sources of Information

Information on the habitat, population distribution, and status was collected from unpublished data, scientific literature, expert review and consultation, and limited agency data.

3.3 Extent and Quality of Data

There are no data with which to conduct metapopulation analyses in New Hampshire.

3.4 Threat Assessment Research

There are no baseline data with which to test threat hypotheses.

Element 4: Conservation Actions

The first conservation action is to develop data on baseline occurrence, habitat use, and distribution.

4.1.1 Developing data on baseline occurrence, habitat and distribution, Restoration and Management

(A) Rarity

(B) Justification
- Surveys north of the notches of the White Mountains may provide more intensive population and habitat data for metapopulation analyses
- Surveys of the probable habitat can test the rarity hypothesis.
- Surveys north of the notches of the White Mountains should be followed by further investigation of sphagnum-dominated vegetative communities in the North Country of New Hampshire.
- Rarity is a low threat ranking, making this conservation action less urgent for NHFG. Unless there are imminent plans to modify sphagnum-dominated vegetative communities, the time frame for this work is not immediate.
- Further investigations that increase NHFG's knowledge of population dynamics and habitat availability for will help to better conserve and manage habitats for this species.

(C) Conservation Performance Objective

The objective of surveying for the presence of the bog lemming in potential habitats is to test the rarity hypothesis and to better understand the status of this poorly known species. Determining the basic ecological attributes of bog lemmings will help assess threats to its survival at the most southerly edge of its range in the northeastern United States and eastern Canada. Successful survey protocols will increase the likelihood of correctly identifying critical habitat.

(D) Performance Monitoring
There is no monitoring program for bog lemmings. Systematic searches of potential habitat would establish the distribution of this species in the North Country of New Hampshire before initiating other conservation actions.

(E) Ecological Response Objective
There are no data with which to formulate an ecological response objective.

(F) Response Monitoring
There are no data with which to formulate response monitoring.

(G) Implementation
There are opportunities to partner with the USDA Forest Service, USFWS, industrial forestry concerns, New Hampshire Division of Forest and Lands, and NHNHB to extend existing small mammal survey protocols used by USDA Forest Service to the greater North Country area.

(H) Feasibility
The USDA Forest Service conducted systematic surveys for bog lemmings during 1995 to 1997. Much cooperation and coordination would be required to accomplish a similar survey in the North Country, but it could be accomplished with adequate funding, personnel, and resources.

4.2 Conservation Action Research

Directed, systematic, and long-term small mammal surveys and vegetation sampling in appropriate habitat types (e.g., sphagnum bogs, sub-alpine meadows, and upland forests with moist soils), especially north of the notches of the White Mountains, are needed to describe habitat characteristics of bog lemmings (e.g., associated vegetative communities, habitat condition indicators, potential impacts of forest management and recreation).

Element 5: References

5.1 Literature

Avers, PE., D.T. Cleland, and W.H. McNab. 1994. National hierarchical framework of ecological units. Pages 48-61 *in* L.H. Foley, editor. Proceedings of the National Silviculture Workshop, November 1-4, 1993, Hendersonville, North Carolina. General Technical Report SE-88. U.S. Forest Service, Southeastern Forest Experiment Station. Asheville, North Carolina, USA.

Banfield, A.W.F. 1974. The mammals of Canada. University of Toronto, Toronto, Canada.

Clough, G.C., and J.J. Albright. 1987. Occurrence of the northern bog lemming, *Synaptomys borealis*, in the northeastern United States. Canadian Field-Naturalist 101(4): 611-613.

DeGraaf, R.M., and M. Yamasaki. 2001. New England Wildlife: habitat, natural history, and distribution. University Press of New England. Hanover, New Hampshire, USA.

Linzey, A.V. 1983. *Synaptomys cooperi*. Mammalian Species 210: 1-5. American Society of Mammalogists.

Preble, E.A. 1899. Description of a new lemming mouse from the White Mountains, New Hampshire. Proceedings of the Biological Society of Washington 13: 43-45.

Reichel, J.D. 1996. Northern Bog Lemming Survey: 1995. Unpublished Report, Montana Natural Heritage Program. Helena, Montana, USA.

Reichel, J.D., and S.G. Beckstrom. 1993. Northern Bog Lemming Survey: 1992. Unpublished Report, Montana Natural Heritage Program. Helena, Montana, USA.

Reichel, J.D., and S.G. Beckstrom. 1994. Northern Bog Lemming Survey: 1993. Unpublished Report, Montana Natural Heritage Program. Helena, Montana, USA.

Reichel, J.D., and J.G. Corn. 1997. Northern bog lemmings: survey, population parameters, and population analysis. Unpublished report to the Kootenai National Forest. Montana Natural Heritage Program. Helena, Montana, USA.

Saunders, D.A. 1988. Adirondack Mammals. State University of New York-College of Environmental Science and Forestry. Syracuse, New York.

Yamasaki, M. 1997. White Mountain National Forest Small Mammal Identification and Collection Report. Unpublished Report. Northeastern Forest Experimental Station RWU-4155, Durham, New Hampshire, USA.

5.2 Data Sources

NatureServe. 2004. NatureServe Explorer. An online encyclopedia of life. <http://www.natureserve.org/explorer/servlet/NatureServe>. Accessed 8 February 2005.

New Hampshire Fish and Game Department. no date. Endangered and Threatened Species List. <http://www.wildlife.state.nh.us/Wildlife/Nongame/endangered_list.htm>. Accessed 11 April 2005.

New Hampshire Natural Heritage Bureau. 2005. Animal Tracking List. <http://www.nhdfl.org/formgt/nhiweb/Documents/w_animal.pdf> Accessed 11 April 2005.

Nicholas, D. 2001. *Synaptomys borealis*. Online. Animal Diversity Web. <http://animaldiversity.ummz.umich.edu/site/accounts/information/synaptomys_borealis.html> Accessed 18 November 2004.

USDA Forest Service. 2000. Regional Forester Sensitive Animals List. <http://www.fs.fed.us/r9/wildlife/tes/docs/rfss_animals.pdf>. Accessed 11 April 2005.

USDA Forest Service. 2002. Sensitive species viability evaluation. Northern bog lemming. < http://www.fs.fed.us/r9/white/3_WM_fpr_Web/forest_plan/revision/viability/animals/northern_bog_lemming.pdf>. Accessed 11 April 2005.

USDI Fish and Wildlife Service. 1999. Endangered and Threatened Wildlife and Plants List. 50 CFR 17.11. <http://www.fws.gov/endangered/50cfr_animals.pdf>. Accessed 11 April 2005.

IUCN. 2004. *2004 IUCN Red List of Threatened Species.* <http://www.redlist.org/search/details.php?species=40018>. Downloaded 11 April 2005.

SPECIES PROFILE

Northern Myotis

Myotis septentrionalis

Federal Listing: Not listed
State Listing: Not listed
Global Rank: S4
State Rank: Not ranked
Authors: Jacques P Veilleux, Franklin Pierce College; Scott Reynolds, St. Paul's School

Element 1: Distribution and Habitat

1.1 Habitat Description

During winter, the northern myotis requires cave or mine habitat that provides adequate characteristics for successful hibernation. Such characteristics include proper microclimate (i.e. temperature stability) and a low level of human disturbance. During hibernation, the northern myotis often retreats into small holes, cracks, and crevices in the walls and ceiling (John Whitaker, Indiana State University, personal communication, Durham 2000), though they will also cling to the wall and ceiling surface. It is unknown whether the northern myotis prefers caves and mines with large numbers of small crevices for hibernation. Northern myotis is often found deep within mine shafts (Durham 2000). Northern myotis bats are known to use caves and mines year-round and often maintain some activity throughout the winter months (Whitaker & Rissler 1992).

In the White Mountain National Forest (WMNF), sixty-six percent of northern myotis roosted in snags (dead trees) and the remainder roosted in live trees (Sasse 1995), They will use a variety of deciduous species, and choice may be influenced by availability. Large, tall trees with intact bark and moderate levels of decay are commonly chosen, especially if they have hollows (Sasse 1995). Most roost trees used by northern myotis in West Virginia were located in 70-90 year-old intact forests that had not been logged in 10 to 15 years (Owen et al. 2003). However, some females have been observed roosting in actively managed industrial forests in West Virginia (Menzel et al. 2002).

1.2 Justification

Like other bats, northern myotis' life history is different from the typical life history of other small mammals. Individuals are relatively long lived and have a low reproductive rate, generally giving birth to a single young each year (Whitaker and Hamilton 1998). Since northern myotis is found in relatively rare, at-risk habitats during winter (caves/mines), they are at risk of population decline if such habitats are lost or degraded. Their slow reproductive rate would, in turn, lead to a slow population recovery time.

Northern myotis are of conservation concern in New Hampshire for the above reasons and because of the lack of knowledge about the species' population status in New Hampshire. Northern myotis represents approximately 12.5% of New Hampshire's overwintering bats and has been documented in each of New Hampshire's known hibernacula (table 1). Individuals have not been banded at these hibernacula, and therefore no data on population turnover are available.

The majority of data describing summer population status is limited to the region of the WMNF (Sasse 1995, Krusic 1996, Chenger 2005), with limited additional data from other regional surveys. No systematic surveys have confirmed its statewide distribution or provided population estimates. Because most bat species are experiencing population declines, it is important to establish such baseline data to monitor population trends.

1.3 Protection and Regulatory Status

No specific Endangered Species Act or RSA 212 regulations govern take, transport, or use of this species. Scientific collecting or research requiring capture of individuals requires a permit through New Hampshire Fish and Game Department (NHFG). Possession of live bats requires a permit under NHFG FIS 800.

1.4 Population and Habitat Distribution

Winter distribution of the northern myotis includes each of New Hampshire's seven hibernacula (figure 1). The concentration of northern myotis among the hibernacula ranges from fewer than 1% (Mascot Lead Mine) to 47% (Bristol Mine) of the total bat population. Northern myotis in New Hampshire tend to be less common (fewer than 1% of hibernating bats) in the large hibernacula such as Mascot Lead Mine, intermediate (less than 20%) at medium-sized mines such as Paddock Copper Mine and Mt. Kearsarge Lead Mine, and relatively abundant in small hibernacula such as Bristol Mine, Beebe River Mine, and the Red Mine (table 1). This pattern is consistent with hibernaculum surveys in Vermont (Trombulak 2001).

Summer records are known from Carroll, Coos, Cheshire, Grafton, and Hillsborough counties. Of 141 summer captures of the northern myotis in New Hampshire, 74.2% are from the White Mountain National Forest (Sasse 1995, Krusic 1996, Chenger 2005), 24.3% are from northern Cheshire County (Chenger 2002, J.P. Veilleux, unpublished data) and 3.5% are from Merrimack and Hillsborough County (LaGory et al. 2002, Reynolds, unpublished data). Any apparent geographical clustering may be an artifact of sampling effort.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

1.7 Sources of Information

Town data on species distribution during winter were compiled by examining New Hampshire Natural Heritage Inventory – Bat Hibernaculum Record data sheets. Summer distribution data were determined by examining published and gray literature of research on bat populations in New Hampshire, as well unpublished bat survey data (J. Veilleux).

1.8 Extent and Quality of Data

Data on the distribution of northern myotis in New Hampshire are mainly limited to the two regions described in element 1.4 (WMNF and northern Cheshire County). The quality of existing data, in relation to accuracy of identification of individuals and echolocation calls, is believed to be good. However, a Master's student with little experience identified bats in the WMNF. Although it may be confused with the little brown bat, the northern myotis is relatively easy to identify.

1.9 Distribution Research

Potential winter hibernacula in New Hampshire need to be surveyed. Likewise, statewide studies (using mist-netting and Anabat acoustic survey equipment) are needed to determine the summer distribution of northern myotis. Mist-netting surveys should incorporate banding into the capture protocol and should list all banding records in the Northeast Banding Database developed by the Northeast Working Group on Bats (NEWGB). An intensive banding program using state-issued wing bands would yield data on the summer distribution of all bat species in New Hampshire and might indicate where summer populations of bats in New Hampshire spends each winter.

Element 2: Species/Habitat Condition

2.1 Scale

Due to the relatively small number of viable mines in New Hampshire, each mine has been treated individually as a conservation planning unit in the habitat profile.

2.2 Relative Health of Populations

Northern myotis is known from each of the seven mine hibernacula in New Hampshire (table 1), and there has been decline in northern myotis within the two largest hibernacula over the last 15 years. Between 1993 and 2004, Mascot Mine had a 91% reduction in the northern myotis population (figure

1). Similarly, Paddock Copper Mine had a 53% reduction in the northern myotis population between 1991 and 1999. The data are too sparse to determine whether this decline represents an increase in mortality or a reduction in population recruitment.

2.3 Population Management Status

Northern myotis are not specifically managed in New Hampshire. The bat gate at Mascot Lead Mine is a conservation tool for hibernating bats collectively, but this mine has also seen the greatest reduction in northern myotis over the last 12 years. Lack of data on the summer distribution of northern myotis hinders effective management.

2.4 Relative Quality of Habitat Patches

The New Hampshire Natural Heritage Survey (NHNHS) has ranked all known northern myotis bat hibernacula according to habitat quality and prospects for long-term conservation. Carter's Mine (Grafton County), Paddock Copper Mine (Grafton County), and Bristol Mine (Grafton County) each received an 'A', indicating excellent quality and prospects for long-term conservation. Dodge Mine (Grafton County) was ranked 'B', indicating good quality and prospect for long-term conservation. Both Mt. Kearsarge Lead Mine and Mascot Lead Mine were ranked as 'B/C', indicating fair to good quality and prospects for long-term conservation. Beebe River Mine was ranked as 'C', indicating fair quality and/or prospects for long-term conservation. However, NHNHS ranking does not appear to reliably assess the value of northern myotis mine habitats, because the two hibernacula in serious decline received a 'B/C' (Mascot Lead Mine) and an 'A' (Paddock Copper Mine).

2.5 Habitat Patch Protection Status

Five of the seven known mines (Carter's Mine, Beebe River Mine, Bristol Mine, Paddock Copper Mine, Red Mine) are located on private land, and two (Mascot Lead Mine and Mt. Kearsarge Lead Mine) are managed by the DRED. Each mine identified as a potential habitat is located on private land. The exact location of one mine (Keyes Mine) could not be determined, and therefore its protection status is unknown.

2.6 Habitat Management Status

The only ongoing habitat management practice in New Hampshire is the bat gate at Mascot Lead Mine. Bat gates (see Caves and Mines habitat profile). Mascot Lead Mine, which was gated in 1992, had lost all but 11 individuals by 2004, despite having 67 northern myotis in 1992 and 127 in 1993. These results testify to the need for further study of northern myotis' management needs in New Hampshire.

2.7 Sources of Information

NHNHS – Hibernacula Survey Data Sheets were examined to determine the winter populations at known hibernacula. To determine habitat patch protection status, each hibernaculum (both known and potential) was mapped on the Conservation Lands GIS data layer (GRANIT – 2003 data). The physical attributes of four of the known bat hibernacula (Mt. Kearsarge Lead Mine, Paddock Copper Mine, Carter's Mine, and Red Mine) were recorded in 1999 and 2000 by Durham (2000). Data were used to generate mine maps and to examine species-specific thermal preferences.

2.8 Extent and Quality of Data

The quality and extent of data collected varies between the mines. For example, there have been four winter surveys at Mascot Lead Mine since 1987, two of which were conducted since installation of the bat gate in 1992. Red Mine has been surveyed four times since 1986, and the Mt. Kearsarge Lead Mine and Paddock Copper Mine have been surveyed five times since 1986. Carter's Mine (three surveys since 1989), Beebe River Mine (three surveys since 1988), and Bristol Mine (one survey in 1989), have generally been surveyed less frequently. With the exception of data collected in 1999 and 2000 at Red Mine, Paddock Copper Mine, Carter's Mine, and Mt. Kearsarge Lead Mine (Durham 2000), no microclimate data have been collected at any of these sites. Furthermore, there are no known bat surveys from Ruggle's Mine.

2.9 Condition Ranking

2.10 Condition Assessment Research

A research priority for overwintering northern myotis is to determine the cause of population decline in Mascot Lead Mine and Paddock Copper Mine. Once microclimate data (primarily temperature) have been obtained at each hibernaculum for an entire winter, the data can be used to assess microclimate at potential hibernacula throughout the state.

Research priorities for summering northern myotis include a statewide mist-netting survey, telemetry studies to determine roosting and foraging behavior, life history studies, and diet analysis.

Element 3: Species and Habitat Threat Assessment

3.1.1 Recreation

See Caves and Mines habitat profile.

(A) Exposure Pathway
Caves and abandoned mines are natural destinations for spelunkers. Though spelunkers may never come into contact with bats, noise and lights may rouse bats from hibernations, depleting bats' scarce energy reserves.

(B) Evidence
Northern myotis occur at hibernacula that may experience high levels of human disturbance (Beebe River Mine, Carter Mine, and Paddock Copper Mine). Carter Mine and Paddock Copper Mine are the two largest hibernacula for northern myotis, comprising over 50% of the known hibernating population of the species, and both of these mines are considered 'at risk'. Paddock Copper Mine and Beebe River Mine have seen the largest decline in hibernating northern myotis since 1986, whereas northern myotis populations within the gated hibernaculum (Mascot Lead Mine) remained stable during this same period.

3.1.2 Development (Habitat Loss and Conversion), Unsustainable Harvest (Forestry Operations and Management)

(A) Exposure Pathway
As New Hampshire land is deforested, northern myotis will experience summer roosting habitat loss and degradation. Individual bats (particularly non-volant young) may experience direct mortality if deforestation or disturbance occur during the parturition or lactation period. The cumulative result of habitat loss, degradation, and possibly direct mortality may lead to a reduction in population size.

(B) Evidence
Northern myotis generally relies on intact interior forests (Carroll et al. 2002, Owen et al. 2003, Patriquin and Barclay 2003) but will use forest edge habitat as well (Hogberg et al. 2002). Northern myotis relies on multiple roost trees per colony (Sasse and Pekins 1996), with a series of secondary roosts that are often clustered around a primary roost tree (Sasse 1995). Northern myotis uses a variety of trees as roosts (Sasse 1995, Owen et al. 2002) and relies more on living hardwoods and closed canopy habitat than do Indiana bats (Foster and Kurta 1998). These data suggest strong fidelity to core roosting areas within intact forest habitats. Although northern myotis is known to use human structures (Caceres and Barclay 2000), deforestation or fragmentation appears to be a substantial threat to this species. Logging, particularly at higher elevations such as the WMNF, also seems to pose a substantial threat.

3.1.3 Energy and Communication Infrastructure

Element 4: Conservation Actions

4.1.1 Gating, Habitat Protection

See Caves and Mines habitat profile.

4.1.2 Site-Selection and Pre-Construction Regulations, Regulation and Policy

4.1.3 Documenting roosting habits, Habitat Protection

(A) Removal of summer roosting habitat due to development, removal of summer roosting habitat due to logging.

(B) Justification

- Identifying summer roost areas of northern myotis and determining whether individual bats return to specific roost areas year-to-year will allow managers to better assess the effects of logging

and development.

- The data on summer demographics of northern myotis are limited to the northern part of the state. It is therefore unclear whether documentation of roosting habits (e.g., annual fidelity to roost areas) will be relevant to populations that occur in the southern half of the state, where development is intense.
- Data on the spatial scale of northern myotis' summer roosting is limited. However, the average home range of northern myotis in West Virginia is 65 ha, so it is reasonable to plan logging and development activity at such a scale (Owen et al. 2003).

(C) Conservation Performance Objective
Integrate critical roosting habitats into a wildlife database. Determining summer habitat requirements for northern myotis bats is intended to allow informed decisions about limiting or ameliorating development and logging in bat habitat. In addition, broad protection of habitat areas may also preserve smaller habitat attributes, such as preferred species of roost tree.

(D) Performance Monitoring
Observation of summer habitat use will allow managers to decide whether limiting or mitigating development and logging is successful. Observations should be long-term, perhaps including periodic monitoring over a 10-year period.

(E) Ecological Response Objective
Maintain populations in delineated areas. Since data are too few to allow a valid estimate of current northern myotis population at summer roost areas, the minimal ecological response should be the maintenance of those populations initially located by biologists.

(F) Response Monitoring
Long-term monitoring may include summer surveys in areas used by northern myotis every three years. These data may reveal whether northern myotis remains faithful to specific habitats and roost areas each summer. Managers, in turn, will make better decisions about the maintenance of northern myotis populations in areas threatened by development or logging.

(G) Implementation
After summer habitat is identified, the state should coordinate the following:

- An intensive short-term radio-telemetry study to determine specific patterns of habitat use by individual bats
- The establishment of a long term monitoring program to determine if northern myotis remain faithful to small summer roost areas

(H) Feasibility
The technical competence to determine general summer habitat areas of northern myotis (mist-netting and acoustic monitoring) and roosting habits (radio telemetry) is available. The overall feasibility of conducting this research is limited by funding.

4.2 Conservation Action Research

Element 5: References

5.1 Literature

Carroll, S.K., T.C. Carter, and G.A. Feldhamer. 2002. Placement of nets for bats: effects on perceived fauna. Southeastern Naturalist 1:193-198.

Caceres, M.C., and R.M.R. Barclay 2000. Myotis septentrionalis. Mammalian Species 634: 1-4.

Chenger, J. 2002. Bat inventory for project lands of the upper Connecticut River Basin. Unpublished report. U.S. Army Corps of Engineers, New England District.

Chenger, J. 2005. 2004 Woodland bat survey in the White Mountain National Forest report prepared for the U.S. Dept. of Agriculture.

Currie, R.R. 2002. Response to gates at hibernacula. Pages 86-99 in The Indiana Bat: Biology and Management of an Endangered Species, A. Kurta and J. Kennedy, editors. Bat Conservation International. Austin, Texas, USA.

deVries, E. 2004. 150,000 MW by 2012! Renewable Energy World. June 2004: 60-70.

Durham, H.C. 2000. Microclimate and roost selection in four New Hampshire bat hibernacula. Thesis, Antioch New England Graduate School, Keene, New Hampshire, USA.

Foster, R.W., and A. Kurta 1998. Roosting ecology of the northern bat (Myotis septentrionalis) and comparisons with the endangered Indiana bat (Myotis

sodalis). 80:659-672.

Hogberg, L., K.J. Patriquin, and R.M.R. Barclay. 2002. Use by bats of patches of residual trees in logged areas of the boreal forest. American Midland Naturalist 148: 282-288.

Johnson, S.A. V. Brack, and R.E. Rolley. 1998. Overwinter weight loss of Indiana bats (Myotis sodalis) from hibernacula subject to human visitation. American Midland Naturalist 139: 255-261.

Johnson, S.A., V. Brack, and R.K. Dunlap. 2002. Management of hibernacula in the state of Indiana. Pages 100-109 in The Indiana Bat: Biology and Management of an Endangered Species, A. Kurta and J. Kennedy, editors. Bat Conservation International. Austin, Texas, USA.

Kerlinger, P.A. and J. Kerns. 2004. A study of bird and bat collision fatalities at the Mountaineer Wind Energy Center, Tucker County, West Virginia: Annual Report for 2003.

Krusic, R.A., M. Yamasaki, C.D. Neefus, and P.J. Pekins. 1996. Bat habitat use in White Mountain National Forest. Journal of Wildlife Management 60:625-631.

LaGory, K.E., D.S. Reynolds, and J.A. Kuiper. 2002. A survey of the bats of New Boston Air Force Station, New Hampshire. Unpublished Report to the U.S. Department of the Air Force.

McLeish, T. 2002. Wind power. Natural New England 11:60-65.

Menzel, M.A., S.F. Owen, W.M. Ford, J.W. Edwards, P.B. Wood, B.R. Chapman, and K.V. Miller. 2002. Roost tree selection by northern long-eared bat (Myotis septentrionalis) maternity colonies in an industrial forest of the central Appalachian mountains. Forest Ecology and Management. 155:107-114.

Nicholson, C. 2003. Buffalo Mountain Windfarm: Bird and Bat Mortality Monitoring Report.

Owen, S.F., M.A. Menzel, W.M. Ford, J.W. Edwards, B.R. Chapman, K.V. Miller, and P.B. Wood. 2002. Roost tree selection by maternal colonies of northern long-eared Myotis in an intensively managed forest. GTR NE-292

Owen, S.F., M.A. Menzel, W.M. Ford, B.R. Chapman, K.V. Miller, J.W. Edwards, P.B. Wood. 2003. Home range size and habitat used by the northern myotis (Myotis septentrionalis). American Midland Naturalist. 150:352-359.

Patriquin, K.J.. and R.M.R. Barclay. 2003. Foraging by bats in cleared, thinned, and unharvested boreal forests. Journal of Applied Ecology 40: 646-657.

Pierson, E., W.E. Rainey, and W.M. Koontz. 1991. Bats and mines: experimental manipulation for Townsend's big-eared bat at the McLaughlin Mine in California. Proceedings of the Thorne Ecological Institute: 31-42.

Sasse, D.B. 1995. Summer roosting ecology of cavity-dwelling bats in the White Mountain National Forest. Thesis, University of New Hampshire, Durham, New Hampshire, USA.

Sasse, D.B., and P.J. Pekins. 1996. Summer roosting ecology of northern long-eared bats (Myotis septentrionalis) in the White Mountain National Forest. Pages 91-101 in Bats and Forests Symposium, October 19-21, 1995, Victoria, British Columbia, Canada. Research Branch, British Columbia Ministry of Forests, Victoria, B.C. Working Paper. R.M.R. Barclay and R.M. Brigham (ed.). 23/1996.

Speakman, J.R., P.I. Webb, and P.A. Racey. 1991. Effects of disturbance on the energy expenditure of hibernating bats. Journal of Applied Ecology 28: 1087-1104.

Thomas, D. W., M. Dorais, and J. Bergeron. 1990. Winter energy budgets and cost of arousals for hibernating little brown bats, Myotis lucifugus. Journal of Mammalogy 71:475-479.

Trombulak, S., P.E. Higuera, and M. DesMeules. 2001. Population trends of wintering bats in Vermont. Northeastern Naturalist 8:51-62.

Tuttle, M.D. 1976. Gating as a means of protecting cave-dwelling bats. Pages 77-82 in T. Ale and D. Rhodes, editors. Proceedings of the National Cave Management Symposium. Speleobooks, Albuquerque, New Mexico, USA.

Walsh, G. 2003. Is this the future of power generation in the Northeast? Natural New England 14: 62-71.

Whitaker, J.O., Jr., and W.J. Hamilton. 1998. Mammals of the Eastern United States. Cornell University Press, Ithaca, New York, USA.

Whitaker, J.O. and L. Rissler, 1992. Seasonal activity of bats at Copperhead Cave. Proceedings of the Indiana Academy of Sciences 101:127-134.

SPECIES PROFILE

Silver-Haired Bat

Lasionycteris noctivagans

Federal Listing: Not listed
State Listing: Not listed
Global Rank: Not ranked
State Rank: Not ranked
Authors: Jacques P Veilleux, Franklin Pierce College; Scott Reynolds, St. Paul's School

Element 1: Distribution and Habitat

1.1 Habitat Description

Silver-haired bats do not remain in New Hampshire during the winter (see Izor 1979 for discussion of silver-haired bats remaining in northern latitudes during winter). Individuals that inhabit New Hampshire during the summer migrate to southern states in autumn. During spring, individuals return to their summer habitat in New Hampshire (or, more generally, to northern states; Cryan and Veilleux *in press*).

The silver-haired bat is a tree roosting species that roosts in tree hollows (e.g. Vonhof 1996, Betts 1998a, Crampton and Barclay 1998). No data describe the summer roosting ecology of silver-haired bats in New Hampshire, but several studies have examined summer roosting in the northwestern United States and southwestern Canada (Campbell et al. 1996, Vonhof and Barclay 1996, Betts 1998a, Crampton and Barclay 1998). Though results of habitat studies varied, in general, silver-haired bats preferred to roost in large tall trees, often in early to moderate stages of decay, in deep cavities relatively high off the ground.

Betts (1998a) found most roosts used by silver-haired bats were in mature rather than young stands. Campbell et al. (1996) found roost sites located > 100 m from riparian areas, on slopes averaging 38%, and the slope aspect for 11 of 15 roosts within 70° of north. The maternity roost described by Parsons et al. (1986) was located within a mixed-wood stand dominated by sugar maple (*Acer saccharum*), eastern white cedar (*Thuja occidentalis*), and white birch (*Betula papyrifera*).

1.2 Justification

Like other bats, silver-haired bats have a life history different from the life history of other small mammals. Individuals are relatively long-lived and have a low reproductive rate, typically giving birth to two young per year (Kunz 1982). Habitat loss and degradation may lead to population decline, which would be aggravated by slow reproductive rates. Silver-haired bats are also of conservation concern in New Hampshire because little is known about their population status. The lack of detailed data on the distribution, habitat use, and life history of silver-haired bats in New Hampshire may be largely due to a lack of research.

1.3 Protection and Regulatory Status

No specific Endangered Species Act (ESA) or RSA 212 regulations govern take, transport, or use of this species. Scientific collection or research requiring capture of individuals requires a permit through NHFG. Possession of live bats requires a permit under NHFG FIS 800.

1.4 Population and Habitat Distribution

Data on the current and historic range of silver-haired bats in New Hampshire are too few to allow a regional comparison. Only one individual has been captured in New Hampshire—Sasse (1995) captured an adult male in the town of Bartlett (Carroll County; D.B. Sasse, Arkansas Game and Fish Commission, personal communication). Reynolds (1999) also recorded echolocation calls at 3 sites: McDowell-Woodcock

(Peterborough, Hillsborough County), Bear Brook State Park (Pembroke, Merrimack County), and Pawtuckaway State Park (Nottingham, Rockingham County) and Krusic (1996) reported an echolocation recording from Bartlett, Carroll County. Existing data indicate that silver-haired bats may have a wide summer distribution in New Hampshire.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

1.7 Sources of Information

Data on species distribution were compiled by searching for specimens deposited in museums and college/university teaching collections and by examining published and gray literature of research on bat populations in New Hampshire.

1.8 Extent and Quality of Data

Data on the distribution of silver-haired bats in New Hampshire are extremely limited, though existing data are believed to be good. Hoary bats are morphologically unique and identifications should be accurate. Echolocation sequences of silver-haired bats are difficult to distinguish from big brown bats (*Eptesicus fuscus*; Betts 1998b), and therefore, such data should be treated with caution.

1.9 Distribution Research

A long-term, statewide mist-netting survey, accompanied by echolocation data (e.g., use of Anabat acoustic survey methods when mist-netting), is needed to determine the summer distribution of silver bats in New Hampshire.

Element 2: Species/Habitat Condition

2.1 Scale

Scale for an appropriate conservation planning unit has not been resolved by the upland forest habitat mapper (Steve Fuller, NHFG).

2.2 Relative Health of Populations

Population trends and viability cannot be inferred from the limited data on summer occurrences in New Hampshire.

2.3 Population Management Status

Silver-haired bats are not currently managed in New Hampshire. Management will require better information on the distribution of silver-haired bats.

2.4 Relative Quality of Habitat Patches

Scale for an appropriate conservation planning unit has not been resolved by the upland forest habitat mapper. Regardless of scale, it will be difficult to determine the relative quality of habitat patches in New Hampshire without first defining how and when silver-haired bats use various habitats.

2.5 Habitat Patch Protection Status

Because a scale for an appropriate conservation planning unit has not been resolved by the upland forest habitat mapper, data on the protection status of upland forest habitat patches are not available.

2.6 Habitat Management Status

Because a scale for an appropriate conservation planning unit has not been resolved by the upland forest habitat mapper, data on the habitat management status of upland forest habitat patches are not available.

2.7 Sources of Information

Because a scale for an appropriate conservation planning unit has not been resolved by the upland forest habitat mapper, sources of information used in determining the scale for conservation planning units are not available.

2.8 Extent and Quality of Data

Scale for an appropriate conservation planning unit has not been resolved by the upland forest habitat mapper. Therefore, the extent and quality of information used in determining the scale for conservation

planning units is uncertain.

2.9 Condition Assessment Research

Research priorities for silver-haired bats include a state-wide mist-netting survey, telemetry studies to determine habitat use (roosting and foraging habitat), life history studies to determine breeding status and reproductive patterns, and food habit analyses to determine prey preference.

Element 3: Species Threat Assessment

3.1.1 Development (Habitat Loss and Conversion), Unsustainable Harvest (Forestry Operations and Management)

(A) Exposure Pathway
As forested land in New Hampshire is cleared, silver-haired bats will experience habitat loss and degradation. Bats, particularly non-volant young, may experience direct mortality if the conversion occurs during the parturition/lactation period (late May through mid July). The cumulative result of habitat loss, degradation, and possibly direct mortality will likely reduce the population size.

(B) Evidence
Data indicate that individual roost trees are occupied by bats on a year-to-year basis (Barclay and Brigham 2001) and that individual bats return to the same, small summer roosting area each year (Veilleux and Veilleux 2004). These data are for colonial bat species, and therefore, bat biologists hypothesize that strong fidelity to roost areas (and possibly roost trees) in the landscape allows individuals to relocate colony mates after emerging from hibernation in the spring, or, in the case of silver-haired bats, after their return migration. The removal of roost trees may disrupt the process of colony formation. If individuals are unable to form a colony, it is likely that a corresponding reduction in individual fitness, and therefore population recruitment, will occur.

3.1.2 Energy and Communication Infrastructure

(A) Exposure Pathway

(B) Evidence
Turbine-related bat mortalities at the Backbone Mountain site (Mountaineer Wind Energy) show that non-hibernating migratory bats such as the silver-haired bat are at greatest risk of turbine impact. Mortality rates of silver-haired bats are usually lower than other migratory tree bats, but they are more likely to die at some sites. For example, silver-haired bats represented 56% of the total bat mortality at a site in Washington state (Erickson et al. 2003) and 31% at a site in Minnesota (Osborn et al. 1996).

3.2 Sources of Information

Sources of information on threats to silver-haired bats include peer-reviewed scientific articles, gray literature, and expert review by John O. Whitaker, Jr. of Indiana State University.

3.3 Extent and Quality of Data

The threats described under element 3.1 are relatively well documented. Data describing the long-term negative effect of habitat conversion (development/logging) are not well understood. The fidelity of bats to specific roost areas is fairly well documented, but not for silver-haired bats. It has been assumed that silver-haired bats will behave in a similar fashion to other species. Additional data on how silver-haired bats use roost areas and roost trees on a long-term (interannual) basis are needed.

3.4 Threat Assessment Research

A primary assessment would document areas in New Hampshire with relatively high numbers of silver-haired bats (i.e. roost areas). Radio-telemetry studies would allow managers to determine location of roost areas. Several years of capture and telemetry data at the roost areas would determine whether individual bats are returning to the same roost areas year-to-year. Such data would allow managers to assess the impact of deforestation (due to development or logging) on silver-haired bats.

Element 4: Conservation Actions

4.1.1 Documenting roosting habits, Habitat Protection

(A) Development (Habitat Loss and Conversion), Unsustainable Harvest (Forestry Operations and Management)

(B) Justification

- Identifying summer roost areas of silver-haired bats and determining whether individual bats return to specific roost areas on a year-to-year basis will allow managers to better assess the impact of logging and development in silver-haired bat habitat.
- Although no data exist about the scale of the silver-haired bat's summer roosting habitat, Veilleux and Veilleux (2004) observed individual female eastern pipistrelles returning to very small summer roost areas across years; minimum roost areas used by the same bats of this species over two years ranged from 0.6 to 2.3 ha. Where silver-haired bats are found to roost, it is important to manage logging and development at a comparably small scale.

(C) Conservation Performance Objective
Integrate critical roosting habitats into a wildlife database. This will help managers limit and ameliorate activities that threaten silver-haired bat populations. By protecting entire habitat areas, the smaller scale attributes of habitat needs for silver-haired bats (e.g. preferred species of roost tree) will be preserved as well.

(D) Performance Monitoring
To determine whether limiting or mitigating development and logging is beneficial to silver-haired bat populations at specific sites, managers can monitor whether silver-haired bats continue to use the habitat area over a relatively long period (perhaps periodic monitoring over a ten-year period).

(E) Ecological Response Objective
Maintain populations in delineated habitats. Since current data are too few to allow a valid estimate of current silver-haired bat population status at summer roost areas, the minimal ecological response should be the maintenance of populations initially located by biologists.

(F) Response Monitoring
Identify more specific monitoring parameters. A summer survey at a known habitat area should be conducted every three years. This would provide data on silver-haired bats' fidelity to specific roost areas during summer and would allow managers to make better decisions about the maintenance of silver-haired bat populations in areas of logging and development.

(G) Implementation
After summer habitat is defined, the state should coordinate an intensive radio-telemetry study to determine habitat use by individual bats (perhaps six individuals), and establish a long-term monitoring program (ten years, with periodic monitoring every 3 years) to determine if silver-haired bats remain faithful to summer roost areas.

(H) Feasibility
The technical competence to determine general summer habitat areas of silver-haired bats (mist-netting) and the detailed patterns of their roosting habits (radiotelemetry) is available. The overall feasibility of conducting this research is limited by the availability of funding.

4.1.2 Site-Selection and Pre-Construction Regulations, Regulation and Policy

4.2 Conservation Action Research

Element 5: References

5.1 Literature

Barclay, R.M.R., and R.M. Brigham. 2001. Year-to-year reuse of tree-roosts by California bats (*Myotis californicus*) in southern British Columbia. American Midland Naturalist 146:80-85.

Betts, B.J. 1998a. Roosts used by maternity colonies of silver-haired bats in northeastern Oregon. Journal of Mammalogy. 79: 643-650.

Bett, B.J. 1998b. Effects of interindividual variation in echolocation calls on identification of big brown bats and silver-haired bats. Journal of Wildlife

Management 62:1003-1010.

Campbell, L.A., J.G. Hallet, and M.A. O'Connell. 1996. Conservation of bats in managed forests: use of roosts by *Lasionycteris noctivagans*. Journal of Mammalogy 77:976-984.

Crampton, L.H., and R.M.R. Barclay. 1998. Selection of roosting and foraging habitat by bats in different-aged aspen mixedwood stands. Conservation Biology 12:1347-1358.

Cryan, P.M., and J.P. Veilleux. *in press*. Migration and the use of autumn, winter, and spring roosts by forest bats. Proceedings of the 2nd Bats and Forests Symposium, Hot Springs, AR.

deVries, E. 2004. 150,000 MW by 2012! Renewable Energy World. June 2004: 60-70.

Erickson, W.P., K. Kronner, and B. Gritski 2003. Nine Canyon Wind Power Project Avian and Bat Monitoring Report -- prepared for the Nine Canyon Technical Advisory Committee and Energy Northwest.

Izor, R.J. 1979. Winter range of the silver-haired bat. Journal of Mammalogy 60:641-643.

Kerlinger, P.A., and J. Kerns. 2004. A study of bird and bat collision fatalities at the Mountaineer Wind Energy Center, Tucker County, West Virginia: Annual Report for 2003.

Kunz, T.H. 1982. *Lasionycteris noctivagans*. Mammalian Species No. 172. American Society of Mammalogists.

McLeish, T. 2002. Wind power. Natural New England 11: 60-65.

Nicholson, C. 2003. Buffalo Mountain Windfarm: Bird and Bat Mortality Monitoring Report, 15pp.

Osborn, R.G., K.F. Higgins, C. Dieter, and R.E. Usgaard. 1996. Bat collisions with wind turbines in southwestern Minnesota. Bat Research News 37: 105-108.

Veilleux, J.P., and S.L. Veilleux. 2004. Intra-annual and interannual fidelity to summer roost areas by female eastern pipistrelles,_*Pipistrellus subflavus*. American Midland Naturalist 152:196-200.

Vonhof, M.J. 1996. Roost site preferences of big brown bats (*Eptesicus fuscus*) and silver-haired bats (*Lasionycteris noctivagans*) in the Pend d'Oreille Valley in Southern British Columbia. Pages 62-80 *In* Bats and Forests Symposium, October 19-21, 1995, Victoria, British Columbia, Canada (R.M.R. Barclay and R.M. Brigham, ed.). Res. Br., B.C. Min. For., Victoria, B.C. Work. Pap. 23/1996.

Vonhof, M.J., and R.M.R. Barclay. 1996. Roost-site selection and roosting ecology of forest-dwelling bats in southern British Columbia. Canadian Journal of Zoology. 74:1797-1805.

Walsh, G. 2003. Is this the future of power generation in the Northeast? Natural New England 14: 62-71.

Young, D.P., W.P. Erickson, R.E. Good, M.D. Strickland, and G.D. Johnson. 2003. Avian and bat mortality associated with the initial phase of the Foote Creek Rim windpower project, Carbon County, Wyoming prepared for Pacificorp, Inc., SeaWest Windpower, Inc, and BLM.

SPECIES PROFILE

Eastern Small-Footed Bat

Myotis leibii

Federal Listing: Not listed
State Listing: Endangered
Global Rank: G3
State Rank: S1
Authors: Jacques P Veilleux, Franklin Pierce College; Scott Reynolds, St. Paul's School

Element 1: Distribution and Habitat

1.1 Habitat Description

In winter, eastern small-footed bats (*Myotis leibii*) require cave or mine habitat that provides adequate characteristics for successful hibernation. Such characteristics include low levels of human disturbance and a stable microclimate (i.e. temperature stability). Although their hibernation has not been extensively researched, they appear to arrive at hibernacula later than most other species and leave earlier in the spring (Thomas 1993, Best and Jennings 1997). They also prefer colder temperatures than do other *Myotis* bats (Best and Jennings 1997, Butchkoski 2003, Tuttle 2003). For example, they are often found in the coldest sections of a cave or mine, either utilizing short (less than 150 m in length) adits (Best and Jennings 1997) or choosing roost locations near the entrance of larger hibernacula (Tuttle 2003). It is also believed that they roost in narrow crevices (Best and Jennings 1997), although all of the individuals documented in New Hampshire were found on exposed surfaces (Reynolds, unpublished data).

Few data describe the summer habitat of eastern small-footed bats in New Hampshire. Most suggest that they roost in rock crevices (Whitaker and Hamilton 1998, Chenger 2003). Chenger (2003) captured 11 small-footed bats in Surry, Cheshire County, and radiotagged 3 individuals (2 adult females and 1 adult male). Data from radiotagged bats revealed several roost sites, each within rock crevices in outcrops near the base of the Surry Mountain Lake dam. Although no radiotagged individuals were reproductive females, it is likely that females give birth and wean young within similar rock crevice roosts. No data describe the rock crevices (crevice dimension, temperature profile, height from ground, etc.) that provided roost habitat for these animals.

1.2 Justification

Like other bats, eastern small-footed bats are relatively long lived and have a low reproductive rate, likely giving birth to a single young per year (Best and Jennings 1997). Tuttle and Heaney (1984) found possible evidence of some twinning. Since eastern small-footed bats are found in rare habitats during summer (rocky outcrops) and winter (caves and mines), they are at risk of population declines if such habitats are lost or degraded. Their slow reproductive rate would, in turn, lead to a slow population recovery time.

Eastern small-footed bats have been documented in only 1 of the 7 known hibernacula in New Hampshire (Mascot Lead Mine). Although winter surveys of eastern small-footed bats suggest a stable or even increasing population (Butchkoski 2003, Reynolds unpublished data), total numbers are still extremely low. In fact, eastern small-footed bats are rarer than Indiana bats in most northeastern states that have long-term monitoring data (Trombulak et al. 2001, Thomas, 1993).

During summer, small-footed bats have been captured at 3 locations in New Hampshire, including the White Mountain National Forest (Krusic et al. 1996, Chenger 2005), New Boston (Hillsborough County; LaGory et al. 2002), and Surry (Cheshire County; Chenger 2005). Beyond these few data, the species' status in New Hampshire remains almost entirely unknown.

1.3 Protection and Regulatory Status

No specific ESA regulation governs take, transport, or use of this species. Scientific collection or research requiring capture of individuals requires a permit through New Hampshire Fish and Game (NHFG). Possession of live bats requires a permit under NHFG FIS 800.

1.4 Population and Habitat Distribution

Data that describe the range of eastern small-footed bats in New Hampshire are too few to allow a regional comparison of New Hampshire populations or to indicate distribution patterns. Winter distribution data of eastern small-footed bats is limited to 9 individuals from one locality (figure 1), and summer records are known from only 5 localities: the White Mountain National Forest (Krusic et al. 1996; no specific locality available), Bartlett (Coos Carroll County; Chenger 2005), New Boston (Hillsborough County; Lagory et al. 2002), Peirmont (Grafton County; Chenger 2005), and Surry (Cheshire County; Chenger 2005). Only 1, 1, 2, 2, and 11 records from each locality exist, respectively.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

1.7 Sources of Information

Data on winter distribution were compiled by examining New Hampshire Natural Heritage Inventory – Bat Hibernaculum Record data sheets, and by examining the collection dates of specimens deposited in museum collections and college/university teaching collections. Summer distribution data were determined by examining specimen collections, published literature, and unpublished sources.

1.8 Extent and Quality of Data

Data on the distribution of eastern small-footed bats in New Hampshire are extremely limited (see discussions in elements 1.2 and 1.4). The quality of data is believed to be good, as qualified bat biologists made identifications. Occurrence records and research efforts aimed at determining distribution patterns in New Hampshire are few.

1.9 Distribution Research

Potential hibernacula should be surveyed to determine the winter distribution of eastern small-footed bats. To determine summer distribution, long-term, statewide mist-netting and echolocation surveys (use Anabat acoustic survey methods when mist-netting) should be completed. Initial mist-netting surveys might focus on locations near cliff faces and rock outcrops, and should record all banding records in the Northeast Banding Database developed by the Northeast Working Group on Bats (NEWGB). An intensive banding program using state-issued wing bands would yield data on the summer distribution of all bat species in New Hampshire and might provide insight into where summer populations overwinter.

Element 2: Species/Habitat Condition

2.1 Scale

Due to the small number of suitable mines in New Hampshire, each mine has been treated as a conservation planning unit under the habitat profile.

2.2 Relative Health of Populations

Eastern small-footed bats are known only from the Mascot Lead Mine (Coos County). The New Hampshire Natural Heritage Survey ranked Mascot Lead Mine as 'B/C', indicating 'fair to good quality and prospects for long-term conservation'. In 2004, 9 hibernating individuals were documented in this mine. Given the small number of surveys, there is not enough data to conduct an analysis of trends and viability of winter populations.

2.3 Population Management Status

There is no management aimed at the conservation of eastern small-footed bats, although the one known winter population is incidentally protected by the bat gat at Mascot Lead Mine. Lack of data on the distribution of eastern small-footed bats prohibits identification of conservation opportunities beyond the need to conduct additional habitat surveys.

2.4 Relative Quality of Habitat Patches

The known winter population of eastern small-footed bats is in the abandoned Mascot Lead Mine. This is a relatively stable mine with multiple levels and two openings, both of which are gated to prevent human disturbance. No microclimate data have been collected within Mascot Lead Mine.

Although several of the potential hibernacula are shallow, there are no winter microclimate data to determine whether they are cold and stable enough to maintain a hibernating population of eastern small-footed bats. Because most of the summer records of eastern small-footed bats occur in southern New Hampshire, it will be important to assess any potential hibernacula in Hillsborough, Merrimack, Cheshire, and Rockingham counties as they are discovered.

2.5 Habitat Patch Protection Status

The Department of Resources and Economic Development (DRED) manages Mascot Lead Mine. The Nature Conservancy (TNC) maintains the gates that restrict access to the mine. The New Hampshire Natural Heritage Survey has given all known bat hibernacula a conservation rank that indicates habitat quality and prospects for long-term conservation. Mascot Lead Mine was ranked as 'B/C', indicating a 'fair to good quality and prospects for long-term conservation'.

2.6 Habitat Management Status

The only ongoing habitat management action occurring in New Hampshire is the bat gate at Mascot Lead Mine. These gates, used over the last 35 years, are steel structures installed in mine or cave entrances to restrict human access without hindering air flow or bat flight. Because many caves and mines are found in remote locations, bat gates are "the only means available for protecting these [colonies]" (Pierson et al. 1991: 31). It is reasonable to assume these bat gates have been highly effective at minimizing human disturbance due to spelunking activities, though surveys in 1993 and 2004 did not indicate significant changes from 1992 populations

2.7 Sources of Information

To determine the winter distribution at known hibernacula, New Hampshire Natural Heritage Survey-Hibernacula Survey Data Sheets were examined. To determine habitat patch protection status of Mascot Lead mine, the site was mapped on the Conservation Lands GIS data layer (GRANIT – 2003 data).

2.8 Extent and Quality of Data

There have been 4 winter surveys at Mascot Lead Mine since 1987; 2 of these surveys were conducted since installation of the bat gate in 1992. Although these surveys were extensive, no microclimate data were collected. Future surveys should be conducted in late winter (December through February) to ensure eastern small-footed bats have begun hibernation (Thomas 1993). Furthermore, surveys should not be done during mild weather periods when eastern small-footed bats are known to temporarily leave hibernacula (Butchkoski 2003).

2.9 Condition Assessment Research

Microclimate data (primarily temperature) must be obtained at Mascot Lead Mine for an entire winter season. Data logging probes should be mounted on rock surfaces near eastern small-footed bat roosts to obtain roost-specific data. These data can then be used to assess microclimate environments at potential hibernacula throughout the state. Summer surveys should include statewide mist-netting to better understand distribution, telemetry studies to determine habitat use, life history studies, and diet analyses.

Element 3: Species Threat Assessment

3.1.1 Recreation

See Caves / Mines Habitat.

3.1.2 Nonpoint Source Pollution

(A) Exposure Pathway

The only known summer roosting site of eastern small-footed bats in New Hampshire is the Surry Mountain Lake Dam, where bats roost in man-made boulder crevices along the southern outflow of the Surry Mountain Reservoir. To limit the amount of

plant material (especially woody material) growing in the rock slope, USACE sprays the rock slope with herbicide. It is unknown whether the direct application of herbicide on the roost area of eastern small-footed bats reduces the quality of the roost area or causes mortality of adult and young bats.

(B) Evidence
Vegetation management is part of the regular maintenance at water reservoirs operated by the USACE. Because bats have a high metabolic rate and localized foraging area, they are likely to be sensitive to pesticides (Schmidt et al. 2002). Indeed, data support this (Luckens and Davis 1964) and suggest that most of the exposure risk comes from direct contact at the roost (Clark et al. 1978). However, these studies also suggest that herbicides are less toxic than insecticides (Sullivan 1990).

Many toxic effects of pesticides involve the accumulation of toxins within fat tissue. At high doses, exposure can result in death at the roost site. At lower doses, the toxins may be released during periods of negative energy balance such as hibernation or lactation (Kunz et al. 1977). In adults, the main effect of an accumulating toxin would be increasing over-winter mortality at the hibernaculum as toxins are released into the bloodstream during arousal. For juveniles, the main effect would be a reduction in population recruitment through increased mortality due to the transfer of toxins through milk. It has also been suggested that young bats are at more risk of contact exposures due to their highly vascularized skin and lack of pelage (Kunz et al. 1977).

3.2 Sources of Information

Much of the information on the biology of eastern small-footed bats in caves and mines comes from published literature and from experts such as M. Brock Fenton of York University, Canada. Information on the biology of the foraging habitat of eastern small-footed bats comes from the published literature.

3.3 Extent and Quality of Data

The eastern small-footed bat is the least known of northeastern bats (Thomas 1993). Therefore, most data on threats to this species are based on its morphological and ecological similarity to other hibernating *Myotis* spp. For example, the effect of disturbance on hibernating bats (element 3.1.1) is well documented. In contrast, there are no data on the effects of wind resource development (element 3.1.2) on small-footed bats. Similarly, the effect of herbicides on bats (element 3.1.3) has not been documented in the literature.

3.4 Threat Assessment Research

Surveys should document the prevalence of eastern small-footed bats within the state and should determine the nature of herbicides used near potential maternity roosts. Mist-netting and radio-telemetry studies help locate any core roost habitat for eastern small-footed bats. Several years of capture and telemetry data at roost areas would determine site fidelity and reproductive success.

Element 4: Conservation Actions

4.1.1 Gating, Habitat Protection
See Caves/Mines.

4.1.2 Site-Selection and Pre-Construction Regulations, Regulation and Policy

4.1.3 Herbicide Management, Habitat Protection

(A) Herbicide Exposure at Roost Sites

(B) Justification
- There are no data on the exact effects of herbicides on bats. However, reducing or eliminating exposure to herbicides should be easy and would cost little.
- If rock-roosting bats are being exposed to high levels of herbicides, and that exposure is poisoning bats, then reducing exposure will have an immediate effect on population recruitment through reduced juvenile mortality and increased over-winter survivorship
- Modifying or eliminating herbicide usage at each USACE site is the appropriate scale for action.
- Given that eastern small-footed bats are the least studied bats in the Northeast, and given that the actions suggested will cost little, immediate action is appropriate.
- The exact nature of herbicide use (type, volume,

and timing), and the appropriate responses to it, should be determined.

(C) Conservation Performance Objective
The objective is to regulate herbicide application practices (type, volume, and timing) to minimize exposure.

(D) Performance Monitoring
The conservation action would be conducted at a USACE facility that uses boulder-retaining dams. The most likely location would be the Surry Mountain Reservoir because there are existing eastern small-footed bats using rock roosts at this site (Chenger 2005). Additionally, a control site would need to be established, either using a USACE facility that suspends vegetation management or finding an eastern small-footed colony that is not at herbicide exposure risk. Relative exposure would be compared between populations during the reproductive season (June through August) and in coordination with USACE personnel.

(E) Ecological Response Objective
The desired ecological response to reducing herbicide exposure is an increase in population recruitment within the exposed population.

(F) Response Monitoring
The response indicators required by this action could be collected in conjunction with radio telemetry studies that are focusing on habitat usage patterns in eastern small-footed bats. Therefore, the response measures would be inexpensive and would generate results that could immediately inform management decisions.

(G) Implementation
This conservation action will require having both treatment and control populations of eastern small-footed bats in reasonable proximity. The survey would most likely be done in coordination with radiotelemetry research, and therefore would be concentrated within a two-week time in late June and early August. The researchers would establish a reliable and non-invasive method of collecting data on herbicide loads. Because this action involves a state-listed species on federal land, potential partners include the NHFG, the United States Fish and Wildlife Service, and the USACE. Additional partnerships could be established with local non-governmental organizations (NGOs).

(H) Feasibility
The most difficult component of the conservation action will be finding two populations of eastern small-footed bats in proximity. Because so little is known about their abundance and distribution within the state, it will require extensive landscape-level surveying to find populations, and intensive radio telemetry to adequately understand their core roosting and foraging habitat.

4.2 Conservation Action Research

The conservation action research goal for eastern small-footed bats is to document their existence within the state and protect critical habitats and resources. The primary research action is to survey existing and potential hibernacula. This will include winter surveys of known and potential hibernacula and microclimate measurements at each site. These actions will inform future management decisions about the use of bat gates (element 4.1.1).

Element 5: References

5.1 Literature

Best, T., and J.B. Jennings. 1997. Mammalian Species, 547:1-6.

Butchkoski, C. 2003. Indiana bat hibernacula surveys. Annual report submitted to the Pennsylvania Game Commission.

Chenger, J. 2003. Bat inventory for project lands of the upper Connecticut River Basin. Unpublished report. U.S. Army Corps of Engineers, New England District.

Chenger, J. 2005. 2004 Woodland bat survey in the White Mountain National Forest report prepared for the U.S. Dept. of Agriculture.

Clark, D.R., T.H. Kunz, and T.E. Kaiser. 1978. Insecticides applied to a nursery colony of little brown bats (*Myotis lucifugus*): lethal concentrations in brain tissues. Journal of Mammalogy 59:84-91.

deVries, E. 2004. 150,000 MW by 2012! Renewable Energy World. June 2004: 60-70.

Johnson, S.A., V. Brack, and R.K. Dunlap. 2002. Management of hibernacula in the state of Indiana.

Pages 100-109 *in* A. Kurta and J. Kennedy, eds. The Indiana Bat: Biology and Management of an Endangered Species.

Kerlinger, P.A. and J. Kerns. 2004. A study of bird and bat collision fatalities at the Mountaineer Wind Energy Center, Tucker County, West Virginia: Annual Report for 2003.

Kunz, T.H., E.L.P. Anthony, and W.T. Rumage. 1977. Mortality of little brown bats following multiple pesticide applications. Journal of Wildlife Management 41:476-483.

Krusic, R.A., M. Yamasaki, C.D. Neefus, and P.J. Pekins. 1996. Bat habitat use in White Mountain National Forest. Journal of Wildlife Management. 60:625-631.

LaGory, K.E., D.S. Reynolds, and J.A. Kuiper. 2002. A survey of the bats of New Boston Air Force Station, New Hampshire. Unpublished Report to the U.S. Department of the Air Force.

Luckens, M.M., and W.H. Davis. 1964. Bats: sensitivity to DDT. Science 146:948.

McLeish, T. 2002. Wind power. Natural New England 11:60-65.

McMurry S.T., R.L. Lochmiller, J.F. Boggs, D.M. Leslie, and D.M. Engle. 1996. Demography and condition of populations of white-footed mice (*Peromyscus leucopus*) in late and early successional habitats. Journal of Mammalogy 77:335-345.

Nicholson, C. 2003. Buffalo Mountain Windfarm: Bird and Bat Mortality Monitoring Report.

O'Shea, T., and D.R. Clark. 2002. An overview of contaminants and bats, with special reference to insecticides and the Indiana bat Pages 237-253 *in* A. Kurta and J. Kennedy (eds.) The Indiana Bat: Biology and Management of an Endangered Species.

Pierson, E., W.E. Rainey, and W.M. Koontz. 1991. Bats and mines: experimental manipulation for Townsend's big-eared bat at the McLaughlin Mine in California. Proceedings of the Thorne Ecological Institute: 31-42.

Schmidt, A., K. Tyrell, and T. Glueck. 2002. Environmental contaminants in bats collected from Missouri Pages 228-236 *in* A. Kurta and J. Kennedy, eds. The Indiana Bat: Biology and Management of an Endangered Species.

Speakman, J.R., P.I. Webb, and P.A. Racey. 1991. Effects of disturbance on the energy expenditure of hibernating bats. Journal of Applied Ecology 28: 1087-1104.

Sullivan, T.P. 1990. Demographic responses of small mammal populations to a herbicide application in coastal coniferous forest: population density and resiliency. Canadian Journal of Zoology 68:874-883.

Thomas, D.W., M. Dorais, and J. Bergeron. 1990. Winter energy budgets and cost of arousals for hibernating little brown bats, *Myotis lucifugus*. Journal of Mammalogy 71:475-479.

Thomas, D.W. 1993. Status of the eastern small-footed bat (*Myotis leibii*) in Vermont. Report prepared for the Vermont Fish & Wildlife Nongame and Natural Heritage Program CTHER: 92-01-21.

Thomas, D.W. 1995. Hibernating bats are sensitive to nontactile human disturbance. Journal of Mammalogy 76:940-946.

Trombulak, S., P.E. Higuera, and M. DesMeules. 2001. Population trends of wintering bats in Vermont. Northeastern Naturalist 8:51-62.

Tuttle, M.D. 1976. Gating as a means of protecting cave-dwelling bats. Pages 77-82 *in* Proceedings of the National Cave Management Symposium.

Tuttle, M.D. 2003. Estimating population sizes of hibernating bats in caves and mines. Pages 31-39 *in* T.J. O'Shea and M.A. Bogan, eds. Monitoring trends in bat populations of the United States and Territories: Problems and Prospects. USGS/BRD/ITR-2003-0003.

Tuttle, M.D., and L.R. Heaney. 1974. Maternity habits of *Myotis leibii* in South Dakota. Bulletin Southern California Academy of Sciences. 73: 80-83.

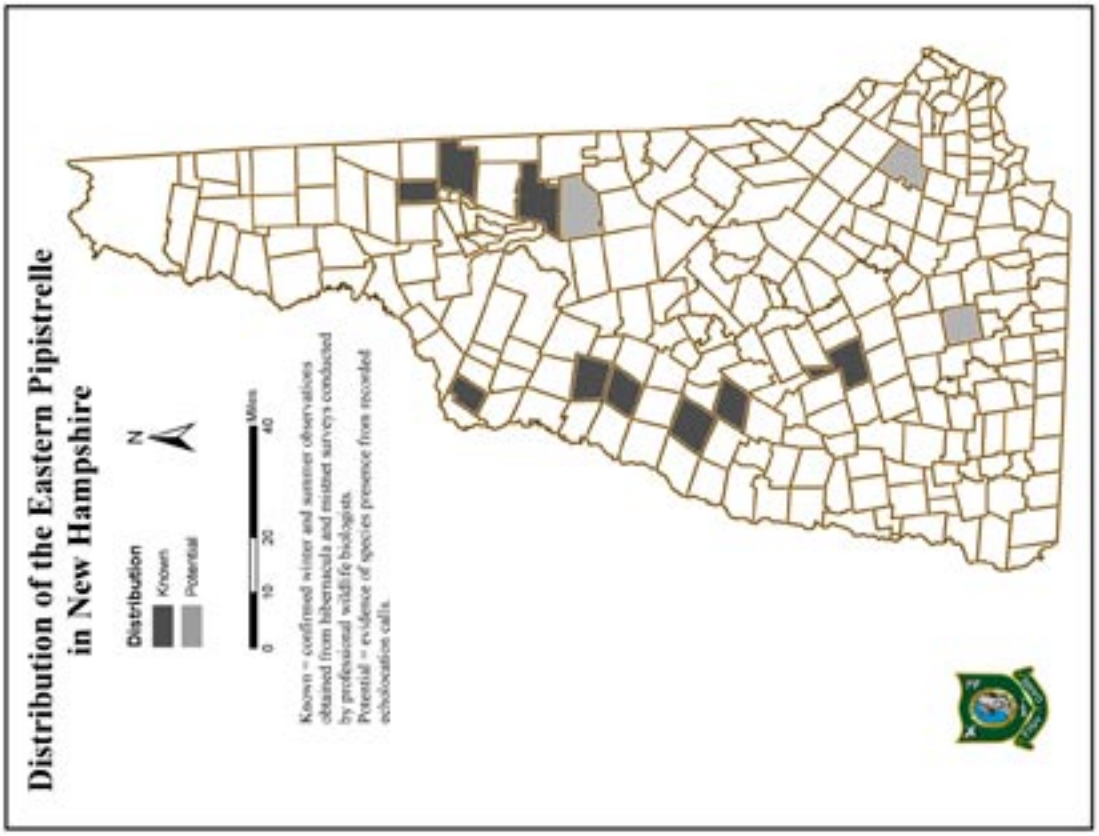
Walsh, G. 2003. Is this the future of power generation in the Northeast? Natural New England 14: 62-71.

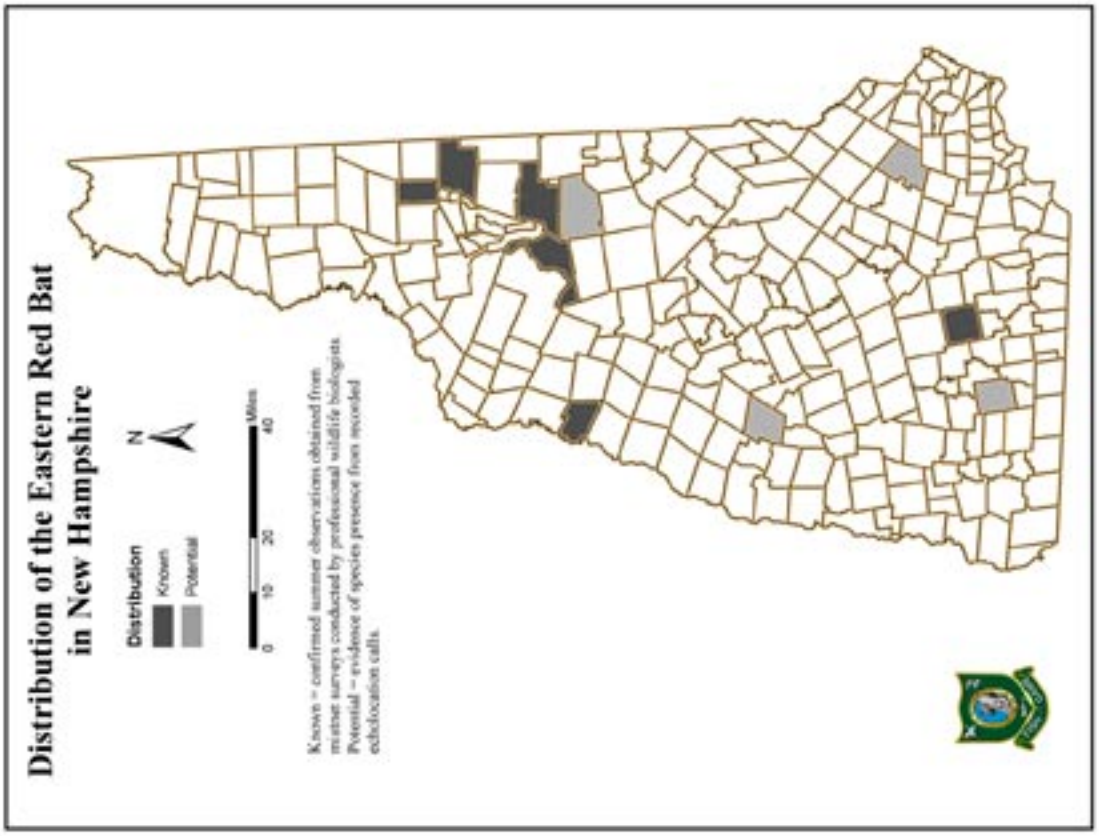
Whitaker, J.O., Jr., and W.J. Hamilton. 1998. Mammals of the Eastern United States. Cornell University Press

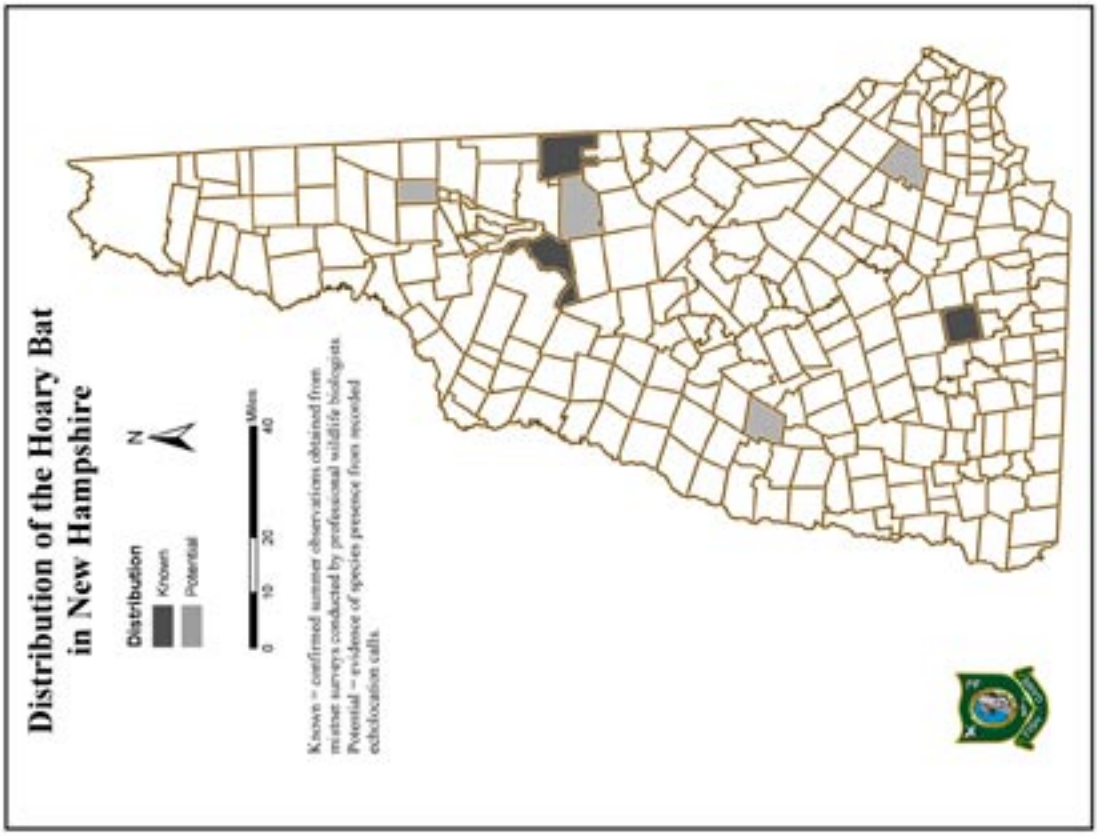
Mammal Maps

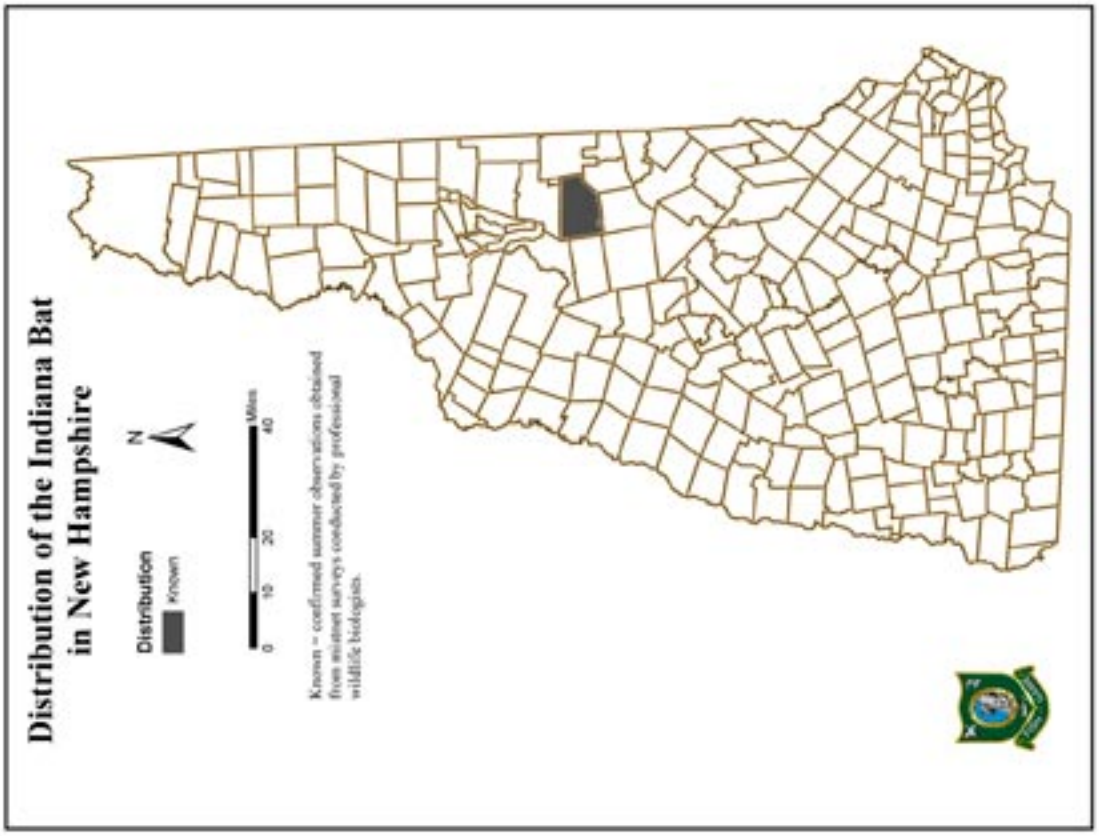
Distribution of Bobcat
in New Hampshire
Distribution
Known
N
0
10
20
40
Miles
Known = verified observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and obtained from trapper reports.

Distribution of American Marten
in New Hampshire
Distribution
Known
N
0
10
20
40
Miles
Known = confirmed observations from trapper reports and surveys conducted by the University of Massachusetts and NH Fish & Game Department.

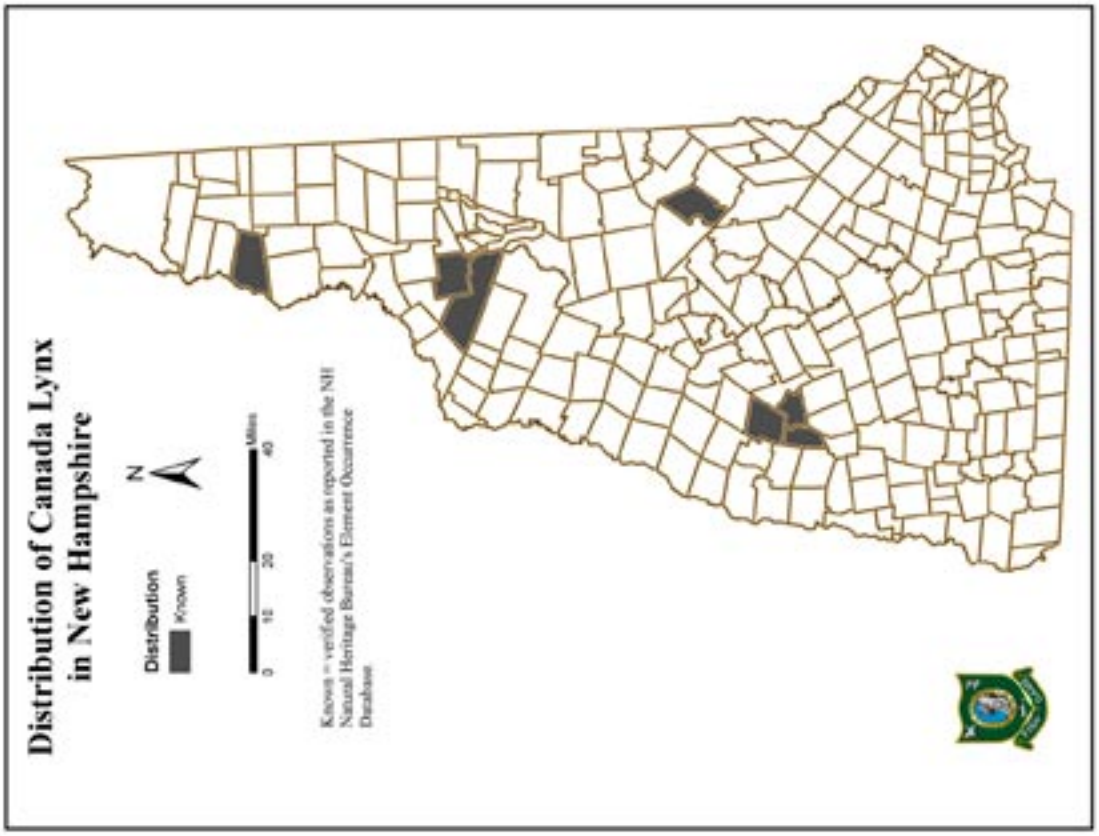

Distribution of the Eastern Pipistrelle in New Hampshire
Distribution
Known
Potential
N
0
10
20
40
Miles
Known = confirmed winter and summer observations obtained from hibernacula and mistnet surveys conducted by professional wildlife biologists.
Potential = evidence of species presence from recorded echolocation calls.

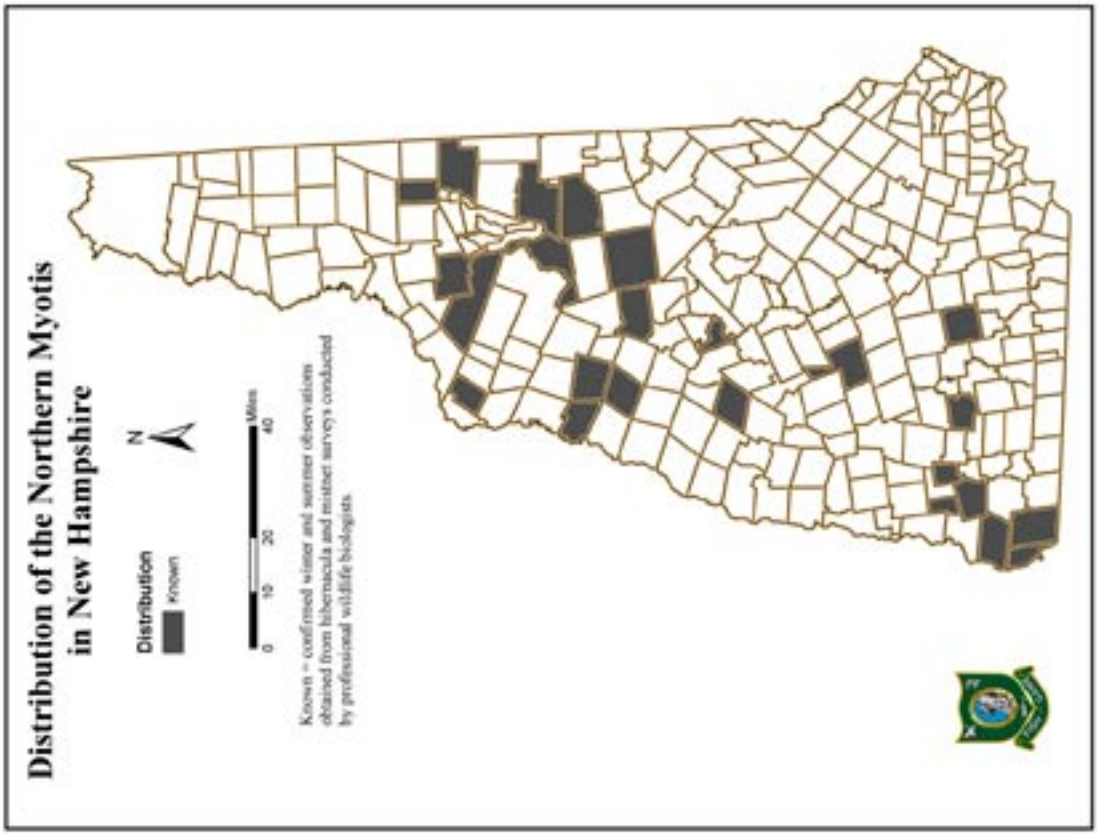

Distribution of the Eastern Red Bat in New Hampshire
Distribution
Known
Potential
N
0
10
20
40
Miles
Known = confirmed summer observations obtained from mistnet surveys conducted by professional wildlife biologists.
Potential = evidence of species presence from recorded echolocation calls.


Distribution of the Hoary Bat
in New Hampshire
Distribution
Known
Potential
N
0
10
20
40
Miles
Known = confirmed summer observations obtained from
mistnet surveys conducted by professional wildlife biologists.
Potential = evidence of species presence from recorded
echolocation calls.

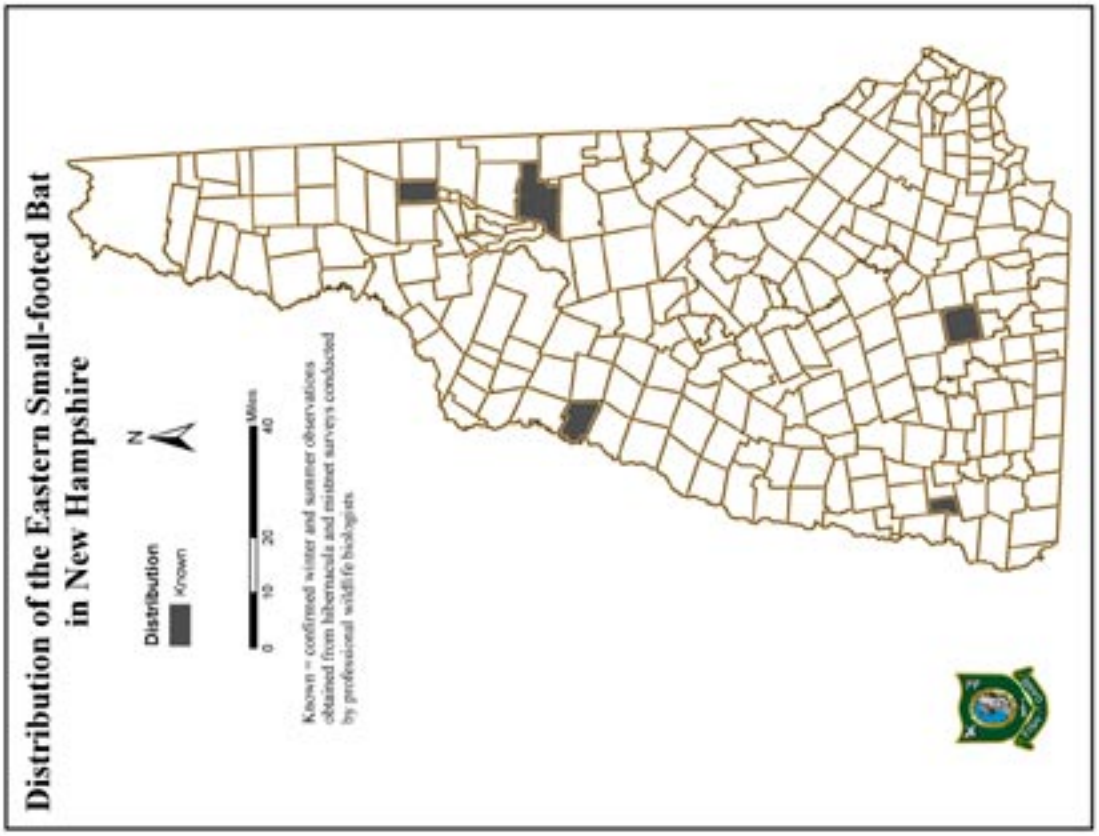

Distribution of the Indiana Bat
in New Hampshire
Distribution
Known
N
0
10
20
40
Miles
Known = confirmed summer observations obtained
from mistnet surveys conducted by professional
wildlife biologists.

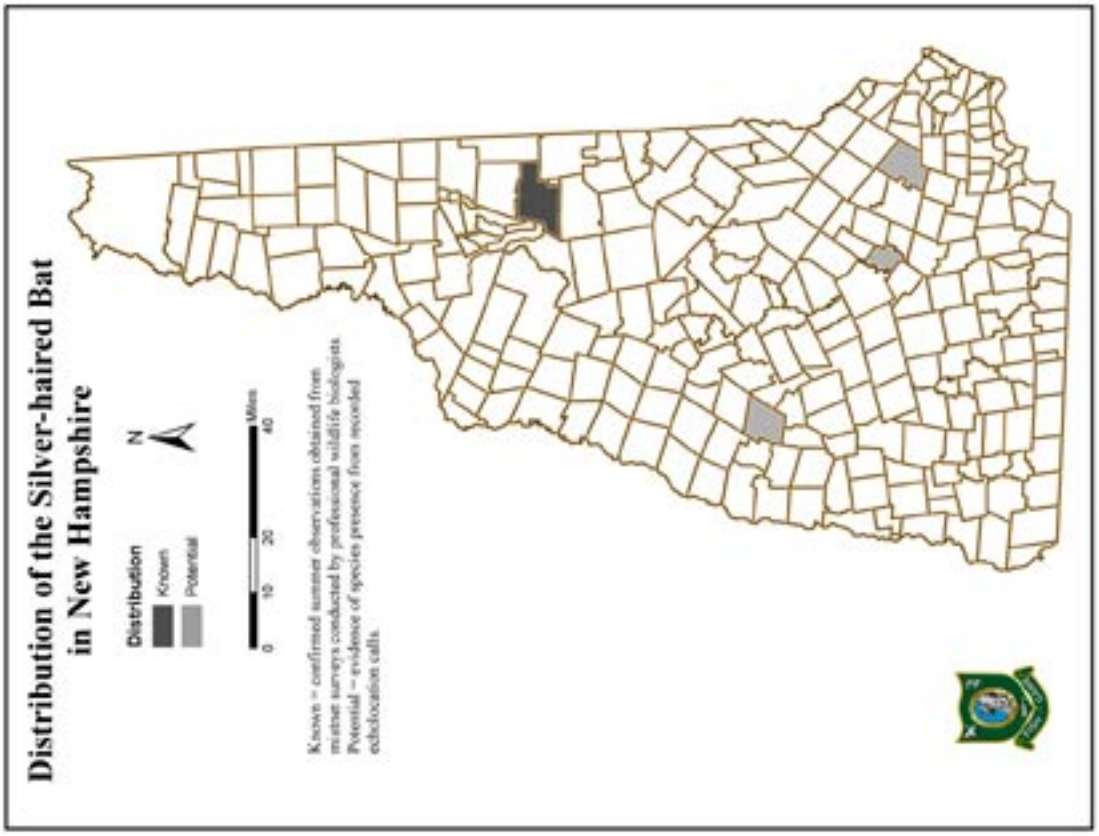
Distribution of New England Cottontail
in New Hampshire
Distribution
Known
N
0
10
20
40
Miles
Known = verified observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and obtained from University of New Hampshire surveys.


Distribution of Canada Lynx
in New Hampshire
Distribution
Known
N
0
10
20
40
Miles
Known = verified observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database.


Distribution of the Northern Myotis
in New Hampshire
Distribution
Known
N
0
10
20
40
Miles
Known = confirmed winter and summer observations
obtained from hibernacula and mistnet surveys conducted
by professional wildlife biologists.

Distribution of Northern Bog Lemming
in New Hampshire
Distribution
Known
Historic
N
0
10
20
40
Miles
Known = observation recorded during US Forest
Service survey.
Historic = observations greater than 20 years old.


Distribution of the Eastern Small-footed Bat in New Hampshire
Distribution
Known
N
0
10
20
40
Miles
Known = confirmed winter and summer observations obtained from hibernacula and mistnet surveys conducted by professional wildlife biologists.


Distribution of the Silver-haired Bat in New Hampshire
Distribution
Known
Potential
N
0
10
20
40
Miles
Known = confirmed summer observations obtained from mistnet surveys conducted by professional wildlife biologists
Potential = evidence of species presence from recorded echolocation calls.

APPENDIX A

Species Profiles

Part Three: Reptiles and Amphibians

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SPECIES PROFILE

Black Racer

Coluber constrictor constrictor

Associated Habitat: Shrublands
Federal Listing: None
State Listing: None
Affected Species: NA
Global Rank: G5
State Rank: S3
Author: Goulet, C. and M. N. Marchand
Affiliation: New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

The Northern black racer (Coluber constrictor constrictor) is a long, slender snake associated with a wide variety of early successional habitats, including: xeric and mesic forests; brushy areas; meadows; old fields; rocky ridges and ledges; and swamp and marsh edges (Hunter et al. 1999, Kjoss and Litvaitis 2000, Ernst and Ernst 2003). Additionally, wetlands may be important habitat components, as this species is extremely susceptible to dehydration (Ernst and Ernst 2003). Black racers appear to have a large (10-20 ha) but distinct home range, requiring fairly extensive patches of suitable habitat (Kjoss and Litvaitis 2000). Mammal burrows, rock crevices, rotting logs, and accumulated vegetation are required features within occupied patches, all of which serve as nest sites, retreats, and hibernacula (Ernst and Ernst 2003). High hibernacula site fidelity is common (Ernst and Ernst 2003). These sites are normally used communally, either in intra- or interspecific assemblages, during the months of September through May (Ernst and Ernst 2003). Juvenile prey consists primarily of insects whereas adult prey consists of frogs, toads, birds and their eggs, small mammals, and snakes, with mammals being the dominant food item (Ernst and Ernst 2003). Oviposition, which also may be communal, occurs during May or early June in loose soil, litter, or hollow logs (Ernst and Ernst 2003). Hatchlings emerge in August or September (Hunter et al. 1999).

1.2 Justification

Based on historic reports of large populations of black racers, substantial population declines have likely occurred in New Hampshire. In Maine, black racers are considered Endangered. Early successional and shrub-dominated habitats are rapidly declining throughout the northeastern United States, largely as a result of commercial and residential development and forest maturation (Kjoss and Litvaitis 2000). In New Hampshire, remaining patches of early-successional habitat are small and patchily distributed (Kjoss and Litvaitis 2000). Severe habitat loss, alteration, and fragmentation throughout the species' distribution is exacerbated by the species extensive habitat requirements (Kjoss and Litvaitis 2000).

1.3 Protection and Regulatory Status

There is currently no special protection for black racers in New Hampshire.

1.4 Population and Habitat Distribution

A total of 11 subspecies of black racers are recognized, all of which range north of Mexico (Ernst and Ernst 2003). The Northern black racer occurs from southern Maine and central New York, southwest to eastern Tennessee, northwestern Georgia, and northeastern Alabama (Ernst and Ernst 2003). In New Hampshire, this species is restricted to the southern half of the state, with the greatest number of verified records in the southeast. Within this region, black racers occur discontinuously, suggesting that populations may be confined to small pockets of optimal

habitat (Klemens 1993). The species distribution map associated with this profile is based on data synthesized at the time of its creation. Distribution maps are continually being updated as new reports are received.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

The University of New Hampshire (J. Taylor, Department of Zoology and S. Hale, Complex Systems Research Center) completed a potential habitat map for black racers within its New Hampshire range. These maps were primarily based on available GIS data layers including landcover, elevation, political boundaries, and element occurrences. Various query combinations can be performed to extract polygons matching user-defined criteria. An accuracy assessment has not been conducted on this model but maps should help prioritize areas to target for further surveys. Maps will need to be updated as new data layers become available.

1.7 Sources of Information

NatureServe (2005) provided status and ranking information. New Hampshire Reptile and Amphibian Reporting Program (RAARP) records and Taylor (1993) were the primary sources of locality records. Habitat and life history information was collected from scientific literature. Crother et al. (2000) was used for common and scientific names of reptiles and amphibians.

1.8 Extent and Quality of Data

The distribution, habitat use, and condition of black racer populations in New Hampshire are not well documented. This assessment was limited to those records included within the scientific literature or as high quality observations (photographs, specimens, or expert observer) in the RAARP database.

1.9 Distribution Research

Target RAARP volunteers to produce verified reports of black racer locations, especially in those areas where records are scarce. Systematic surveys and research are needed to provide more information regarding the condition and habitat requirements of populations. Black racers, and other rare reptiles and amphibians, should be incorporated into habitat inventories as well as management and restoration efforts. Specifically, the effects of disturbance-inducing management practices on both black racer abundance and overall early-successional herpetofaunal diversity should be evaluated (Greenberg et al. 1994), considering their association with a community type that is currently intensively managed for Lepidopteran conservation.

Element 2: Species/Habitat Condition

This species is widespread throughout southern New England, though little information is available to evaluate the condition of black racers in New Hampshire. In a historic report (1940-1950, specific date unknown), Donald Carle, professor of science at Keene Teachers College, noted that 112 black racers were found at one location in Keene. No observations of this magnitude are known more recently. Inventory and research are necessary to fully identify basic life-history info, habitat use, and condition of populations.

Element 3: Species and Habitat Threat Assessment

Habitat loss, fragmentation, road mortality, modification of ecological processes, as well as human exploitation are the primary factors threatening black racer populations in New Hampshire (Hunter et al. 1999, Kjoss and Litvaitis 2000). Refer to element 3 in the grassland and shrubland habitat profiles for a detailed discussion of threats.

Element 4: Conservation Strategies

In an urbanized setting, both habitat restoration and improved conductivity are essential to the long-term survival of black racers in the region (Kjoss and Litvaitis 2000). Early successional habitat is effectively restored using disturbance-inducing management treatments, including prescribed fire (Russell et al 1999). Maintaining clusters of early successional patches with minimal development is critical to the

far-ranging black racer (Kjoss and Litvaitis 2000). Refer to grassland and shrubland habitat profiles for further conservation strategies.

Element 5: References

5.1 Literature

Crother, B. I. Committee Chair, J. Boundy, J. A. Campbell, K. De Queiroz, D. R. Frost, R. Highton, J. B. Iverson, P. A. Meylan, T. W. Reeder, M. E. Seidel, J. W. Sites, Jr., T. W. Taggart, S. G. Tilley, and D. B. Wake. 2000. Scientific and standard English names of amphibians and reptiles of North America north of Mexico, with comments regarding confidence in our understanding. Society for the Study of Amphibians and Reptiles. Herpetological Circulars. 29

Ernst, C. H. and E. M. Ernst. 2003. Snakes of the United States and Canada. The Smithsonian Institution. Washington, D.C., USA and London, England.

Greenberg, C. H., D. G. Neary, and L. D. Harris. 1994. Effect of high-intensity wildfire and silvicultural treatments on reptile communities in sand-pine scrub. Conservation Biology 8(4): 1047-1057.

Hunter, M. L., A. J. Calhoun, and M. McCollough. 1999. Maine amphibians and reptiles. The University of Maine Press, Orono. 252pp.

Kjoss, V. A. and J. A. Litvaitis. 2000. Community structure of snakes in a human-dominated landscape. Biological Conservation 0: 1-8.

Klemens, M. W. 1993. Amphibians and reptiles of Connecticut and adjacent regions. State Geological and Natural History Survey of Connecticut. Bulletin No.112. Connecticut Department of Environmental Protection, Hartford, Connecticut, USA.

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. Available http: /www.natureserve.org/explorer. (Accessed: February 4, 2005).

Russel, K. R., D. H. Van Lear, and D. C. Guynn, Jr. 1999. Prescribed fire effects on herpetofauna: review and management implications. Wildlife Society Bulletin. 27:374-384.

Taylor, J. 1993. The Amphibians and Reptiles of New Hampshire. Nongame and Endangered Wildlife Program. New Hampshire Fish and Game Department. Concord, New Hampshire, USA.

5.2 Data Sources

New Hampshire Reptile and Amphibian Reporting Program (RAARP) database. Maintained by the New Hampshire Fish and Game Department, Nongame and Endangered Species Program, Concord New Hampshire (Accessed: February 14, 2005)

SPECIES PROFILE

Blanding's Turtle

Emydoidea blandingii

Federal Listing: Not listed
State Listing: Species of Special Concern
Affected Species: N/A
Global Rank: G4
State Rank: S3
Author: Michael N. Marchand, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Blanding's turtles require large habitats consisting of a diversity of wetland types and hydroperiods, sandy open areas for nesting, and limited human disturbance (Joyal 1996, Jenkins and Babbitt 2003). Aquatic habitats include marshes, ponds, forested and shrub swamps, fens, shallow slow-moving rivers, backwaters, oxbows, and vernal pools (Ernst et al. 1994, Fowle 2001). Additional habitats include buttonbush basin swamps, highbush blueberry-winterberry shrub thickets, and deep emergent marsh-aquatic beds (Sperduto 2004, Jenkins and Babbit 2003). Slow moving streams and rivers may be important for dispersal and travel between wetlands (Southwell 2002). Adults prefer clean shallow water with a soft organic bottom and abundant aquatic vegetation (Ross and Anderson 1990, Ernst et al. 1994). Duckweed (*Lemna*) is a common floating plant associated with Blanding's turtles (Ross and Lovich 1992).

Habitat use may shift seasonally and vary geographically. In some populations, vernal pools are used extensively in spring and summer (Joyal 1996), and when summer temperatures are high, Blanding's turtles may become relatively inactive. Turtles may estivate in vernal pools, shrub swamps, marshes, and ponds (Joyal 1996, Graham 1999, Fowle 2001).

Female turtles lay eggs in upland habitats, usually between late May and early July. Suitable nest sites include an open canopy with sand, loam, or gravelly substrate (Graham 1999). Human-altered sites (e.g, pastures, road edges, yards, cornfields, gravel pits, and power line right of ways) may be used (Linck et al. 1989, Joyal 1996, Jenkins and Babbitt 2003). Hatchlings may rest in moss, leaf litter, and grass tussocks prior to migrating from nesting areas to aquatic habitats (Butler and Graham 1995). Juveniles may use marsh edges and shrubby wetlands that provide refugia from predators (Pappas and Brecke 1992).

1.2 Justification

Like most turtles, Blanding's turtles are long-lived (up to 77 years in the wild; Brecke and Moriarty 1989) and are characterized by a late age of sexual maturity (14-20 years for female Blanding's turtles; Congdon and van Loben Sels 1993), relatively low fecundity (average 13 eggs per year, DePari et al. 1987, Congdon et al. 1983), and high rates of adult survival. Small increases in annual adult mortality (as little as 2-3%, Congdon et al. 1993, Gibbs and Shriver 2002), especially among females, can have catastrophic effects on populations. Blanding's turtles require large mosaics of wetland and upland habitats with relatively limited development.

Blanding's turtles occur patchily and at low densities throughout much of their range (Power et al. 1994) and are listed as endangered in Maine, threatened in Massachusetts and New York, and a Species of Special concern in New Hampshire. In New Hampshire, Blanding's turtle habitat overlaps with the highest human population densities. Therefore, turtles are extremely vulnerable to rapid development, especially where road density and traffic volume is high.

Blanding's turtles were listed as a candidate (candidate 2) for federal listing because of concerns over range-wide declines. Following a change in federal policy that eliminated federal candidate species listing,

the Northeast Endangered Species and Wildlife Diversity Technical Committee developed a list of species of regional concern. The Blanding's turtle was included in this list and was identified as a species that warrants federal or threatened species listing considerations as well as prelisting status reviews (Therres 1999).

1.3 Protection and Regulatory Status

See Marsh and Shrub Wetland Profile for regulations regarding wetland impacts.

- NHFG Rule FIS 803.02. Importation. Blanding's turtles shall not be imported to New Hampshire
- NHFG Rule FIS 804.02. Possession. Blanding's turtles shall not be possessed in New Hampshire.
- NHFG Rule FIS 811.01 Sale of Reptiles. No person shall sell Blanding's turtles in New Hampshire

1.4 Population and Habitat Distribution

Populations range from southern Ontario, south through Wisconsin, to Michigan, Minnesota, Ohio, Indiana, Illinois, Iowa, and Nebraska. Peripheral populations exist in Missouri and Pennsylvania and isolated populations of Blanding's turtles occur in Nova Scotia, New York, and New England (Ernst et al. 1994). In New England, Blanding's turtles are restricted to eastern Massachusetts, southeast and south-central New Hampshire, and south-coastal Maine.

In New Hampshire, the majority of known Blanding's turtle locations are in the southeast, where many towns have at least one record (See section 1.5). However, NHFG has received one verified record for the town of Moultonborough (photograph) and another record for Holderness (specimen verified by NHFG staff). A third record in adjacent Sandwich was made by the same observer who documented the Blanding's turtle in Moultonbough. These observations appear to be isolated from southern New Hampshire Blanding's turtle locations by the large lakes of central New Hampshire (i.e., Squam and Winnepesaukee lakes). Although these observations are northerly compared with other New Hampshire records, they are south of reported observations in western Maine (Graham 1999).

Specimens were also observed in Auburn and near Cohas brook, Manchester (Huse 1901), Milford (Babcock 1919), near Allenstown, and in Derry (Oliver and Bailey 1939). Of these towns, recent records have been received for Auburn, Milford, Allenstown, and Derry. Historic towns with no recent records include Manchester (1900), Nashua (1979), New Durham (1982), and Pembroke (1978).

1.5 Town Distribution Map

1.6 Habitat Map

Blanding's turtle records were buffered by 1 km (Inferred Extent, NatureServe Element Occurrence specifications), and overlapping buffers were merged. These areas were considered occupied. For each occupied area, the following variables were measured: size (ha), area of potentially suitable wetland habitat (ha), conservation land (ha, percent), road density, and amount of development (ha, percent).

1.7 Sources of Information

Distribution information came largely from the New Hampshire Reptile and Amphibian Reporting Program (RAARP). High quality records were submitted to NHNHB and were incorporated in the New Hampshire Rare Species Database. New Hampshire studies included an assessment conducted by D. Carroll along the Lamprey River and a study focused on the Great Bay and Concord areas (Jenkins and Babbitt 2003).

1.8 Extent and Quality of Data

Location records incorporated into the Rare Species Database included high quality photographs, specimens, and expert observations. Although most towns where Blanding's turtles currently occur probably have been reported, several towns in the center and periphery of the New Hampshire Blanding's turtle distribution have not verified the species presence to date.

1.9 Distribution Research

RAARP volunteers should report observations in towns where historic observations have been recorded (Manchester, Nashua, New Durham, Pembroke), in towns where gaps exist in the known distribution (e.g., Bedford), and in towns at the edge of the spe-

cies' New Hampshire range (e.g., Brookline, Henniker, Warner) where occurrence is likely. The NHB rare species database should be updated with recent reports, including a photo-verified report that was received for Hooksett but has not yet been incorporated into the Rare Species Database.

Where the species is likely to occur, visual and trapping surveys should be conducted. The NHFG should coordinate this effort and should involve other state and federal agencies, universities, non-government organizations, and expert observers.

Element 2: Species/Habitat Condition

2.1 Scale

Initially, potential Blanding's turtle habitat was mapped throughout the distribution of the species in New Hampshire. However, because of the large area mapped as potential habitat, habitat quality was assessed based on known occupied sites (1 km buffer around locations; see element 1.6).

2.2 Relative Health of Populations

There is little information on the condition of Blanding's turtle populations in New Hampshire. Among 100 records (Element Occurrences) in the Rare Species Database maintained by the NHNHB (as of 30 March 2005), 14 are considered historic (before 1985). Thirty-three records were of individuals found only on roads, 52 records consisted of only 1 individual, and only 3 records in the database had greater than 10 observations.

2.3 Population Management Status

There is little management of Blanding's turtles in New Hampshire. Possession of Blanding's turtles, including manipulation of individuals for research, requires a permit from the NHFG. Several population studies have been conducted in New Hampshire; D. Carroll conducted a field investigation for rare turtles (i.e., Blanding's, spotted, *Clemmys guttata*, and wood, *Glyptemys insculpta*) in the Great Bay and Lamprey River areas. Recently, an extensive multi-year Blanding's turtle research project was conducted in two areas of New Hampshire: central New Hampshire (Dunbarton, Weare, Hopkinton) and southeastern New Hampshire (Lee, Durham, Newmarket; Jenkins and Babbitt 2003). The New Boston Air Force Station is currently investigating habitat use and movement of Blanding's turtles on their property (S. Najjar, New Boston Air Force Station, personal communication). Protective screening has been placed over Blanding's turtle nests to prevent predation in some areas, but this effort has not been practiced at a large scale.

2.4 Relative Quality of Habitat Patches

Ninety-one occupied habitat areas were mapped, ranging from 318 to 5,602 ha (mean 852 ha ±839 SD). A 1 km buffer around known Blanding's turtle records restricted the possible sizes of occupied areas. The presence and intensity of roads is a major threat and influences the quality of an area for Blanding's turtles. Total road density in these areas averaged 2.4 km/km^2 ± 1.4 SD (range 0-8 km/km^2; see element 3: Threats). Only 24 occupied areas lacked any state routes and interstates. In these areas, residential development was less than 10%.

2.5 Habitat Patch Protection Status

The percentage of conservation land in Blanding's turtle occupied areas was 16% (range 0-100%); fee ownership was 13% (0-100%), and conservation easement was 3% (range 0-25%). Sixty-nine occupied areas had less than 20% of land protected, 82 areas had less than 50% protected, and only 4 occupied areas had more than 70% protection. The total area protected in occupied areas ranged from 0 to 1,787 ha (mean = 147 ha).

2.6 Habitat Management Status

There is little habitat management in New Hampshire specifically for Blanding's turtles, although the species has been targeted for management on some lands protected by the Great Bay Partnership. Thirty-one wetland impoundments are managed, primarily for waterfowl, by the NHFG, and Blanding's turtles are known to occur in some of these areas. Artificial nesting areas have been created in some areas as part of mitigation during NHFG review of wetland impacts. Nesting areas have also been created on other lands, including some owned by the Army Corps of Engineers, but use of these nesting areas is unknown.

2.7 Sources of Information

Information on the condition of Blanding's turtle populations largely was a result of reports received from the RAARP and several localized research and inventory efforts (Carroll 1999, Jenkins and Babbitt 2003). Geographic Information Systems (GIS) were used to assess quantity and quality of known Blanding's turtle observations by using available data layers (e.g., University of New Hampshire Complex Systems).

2.8 Extent and Quality of Data

Most records consist of 1 or a few observations, many of which were encounters on roads (see element 2.2). Wetland occupation and habitat use at a fine scale (e.g., wetland polygons) is poorly understood for most of the New Hampshire range of Blanding's turtles, though several sites near Concord and Great Bay have been studied in greater detail (Jenkins and Babbitt 2003).

2.9 Condition Assessment Research

- Continue to add and update Blanding's turtle records in the New Hampshire Rare Species Database in accordance with Element Occurrence standards accepted by NHFG and the NHNHB.
- Coordinate with other states in the New England Blanding's Turtle Working Group (Massachusetts, Maine, New York) to build on existing research. An assessment of each state's Blanding's turtle populations will be included in the Northeast Regional Conservation Plan that will be conducted as part of a Science Support Partner Program grant. A model developed by B. Compton at the University of Massachusetts, Amherst, will be applied to New Hampshire's Blanding's turtle populations as part of this effort. This model (WETCROSS) will help indicate the quality of wetlands based on the likelihood of individual Blanding's turtles crossing roads.
- Identify viable populations and assess demographics. This was the highest ranking research item identified by the New England Blanding's Turtle Working Group (August 2004 survey).
- Assess population viability and habitat use on conservation land, in especially state parks and wildlife management areas. Short visual (e.g., basking and nesting) and trapping surveys should be used to assess relative condition of populations. Because multiple land uses in protected areas may threaten populations, longer surveys should be conducted at a sample of conservation lands (e.g., Bear Brook State Park, Pawtuckaway State Park, Hopkinton-Everett Flood Control Area, New Boston Air Force Station) to assess effects of land use.
- Assess isolation of populations in New England via genetics studies.

Element 3: Species and Habitat Threat Assessment

3.1.1 Development (Fragmentation, Habitat Loss and Conversion)

(A) Exposure Pathway

Blanding's turtles use a mosaic of wetland, aquatic, and upland habitats, often traveling a kilometer or greater among them. Thus, a large amount of land is required to protect a population. Reduction in habitat quality or availability may harm populations by causing direct mortality of individuals (construction and forestry equipment, drawdown while turtles hibernating) or indirect mortality due to increased dispersal across inhospitable habitat, increased predation, and increased desiccation.

Female turtles require bare ground and open canopies to lay eggs, and from late May to early July, they leave wetlands in search of suitable nesting habitat. If nesting habitat is not connected to occupied wetland habitat, adult mortality may occur. Humans and their pets may also disturb nesting females and their eggs, and although turtle populations are less sensitive to egg survival than to adult survival, high nest mortality or lack of nesting habitat may harm populations. Also, succession can reduce the quality of nesting areas and may result in reduced recruitment to local populations.

Blanding's turtles may use human-modified areas such as gravel pits, residential lawns, and agricultural areas, for nesting. Thus, adults in these areas are vulnerable to predation, road mortality, disturbance, and mowing equipment (Marchand and Litvaitis 2004*a*).

Nests near some ecological edges may also be more vulnerable to predation (Temple 1987).

(B) Evidence
An estimated 21,000 ha (51,000 acres) were required to maintain viable populations of Blanding's turtles in Maine (McCollough 1999). Although smaller areas may protect species where populations are denser (Fowle 2001), large blocks of connected habitat are needed to protect Blanding's turtles.

Because Blanding's turtles may use vernal pools and uplands, protection only of large wetlands is not adequate to protect Blanding's turtles (Southwell 2002). Southern New Hampshire is rapidly developing and lands are becoming more fragmented (SPNHF 2005). New Hampshire state regulations are currently ineffective at protecting species that use large wetland complexes, and building and disturbance setbacks from freshwater wetlands are not required under New Hampshire state wetland regulations (except for septic setbacks). Where they occur at the local level, they are not sufficient to protect wide ranging species such as Blanding's turtles without a larger scale planning effort.

As southern New Hampshire develops, wetlands will be threatened by myriad stressors (see Marsh and Shrub Wetland Profile). Although extensive marshes are not likely to be filled, small vernal pools can easily be overlooked during environmental reviews of dredge and fill permit applications (M.N. Marchand, personal observation). Likewise, landowners may remove beaver dams to protect their property with no approval or review process. Wetland drawdowns, especially those conducted in fall, may expose Blanding's turtles to predation, winterkill, and road mortality (Hall and Cuthbert 2000), especially where dispersing individuals are surrounded by dense development (Marchand and Litvaitis 2004*a*). The effect of managed wetland and lake drawdowns and other water manipulations on Blanding's turtles has not been evaluated in New Hampshire.

3.1.2 Transportation Infrastructure (Mortality, Fragmentation, Dispersal Barriers)

(A) Exposure Pathway
Human population density and development is rapidly increasing in southern New Hampshire (SPNHF 2005). Attendant increases in road densities and traffic volume pose direct threats to turtles, which are slow to cross wide roads. Small annual losses of only a few adult Blanding's turtles may result in population extirpation.

(B) Evidence
Blanding's turtles are capable of dispersing long distances through upland habitats (Joyal et al. 2001, Jenkins and Babbitt 2003), and roads that intersect turtle home ranges or migratory pathways will increase the chance of individuals being killed on roads. Thirty-three of 100 Blanding's turtle records (Element Occurrences) known from New Hampshire consisted entirely of individuals observed on roads. Additionally, low population densities and skewed age and sex ratios have raised concerns over the effect of road mortality on some turtle populations in the region (e.g., Joyal et al. 2000, Marchand and Litvaitis 2004a, Gibbs and Steen 2005). Computer modeling suggests that road densities as low as 1 km/ km^2 with fewer than 100 vehicles per lane per day will cause excessive loss of semiterrestrial turtles (e.g., Emydoidea, Gibbs and Shriver 2002). Only 10 of 91 known occupied Blanding's turtle areas in New Hampshire had road densities less than 1 km/km^2. Although density may be a good initial surrogate for investigating habitat quality, factors such as road width, traffic speed and volume, and position in the landscape should also be considered. Road shoulders, because of the availability of bare soil and open canopies, may attract nesting turtles, increasing the opportunity for road crossings of adult and hatchling turtles. Also, steep-sloping granite curbing can trap turtles on roadways and can decrease the chance of individuals successfully crossing roadways (Najjar, New Boston Air Force Base, personal communication).

3.1.3 Unregulated Take

(A) Exposure Pathway
Individual turtles are removed from local populations, and because populations depend on high adult survival, removal can lead to local extinction.

(B) Evidence
Large-scale commercial collection of Blanding's turtles appears to be low and NHFG has no evidence of commercial collection of Blanding's turtles in New Hampshire. However, reptile dealers have advertised Blanding's turtles in New Hampshire in the past

(Levell 2000). The loss of adult turtles from natural populations can have devastating effects for all species of turtles. Therefore, commercial collection in New Hampshire is worth further investigation and enforcement. Casual collection and relocation of individual Blanding's turtles is probably more common. People may move turtles to distant wetlands, ponds, or lakes, and may occasionally adopt Blanding's turtles as pets.

3.1.6 Predation and Herbivory (Subsidized or Introduced Predators)

(A) Exposure Pathway
Young turtles and eggs are vulnerable to predators, and the risk of predation increases when subsidized predators such as raccoons are supported by human development.

(B) Evidence
High predation rates at turtle nests may affect long-term recruitment (Marchand and Litvaitis 2004*b*). In southern New Hampshire, raccoons are the most common predator of turtle nests (Marchand et al. 2002), and elsewhere predation rates have reached 93% (Congdon et al. 1983) and 94% (Butler and Graham 1995).

Short-tailed shrews (*Blarina brevicauda*, Standing et al. 2000) and eastern chipmunks (*Tamias striatus*) (Grgurovic 2003) may also prey on neonate Blanding's turtles, and although protected by their size and hinged plastron, adult Blanding's turtles are occasionally injured or killed by predators (Standing et al. 1999, Congdon et al. 2000). In Missouri, 31% of Blanding's turtles collected had injuries or missing body parts (Kofron and Schreiber 1985).

3.2 Sources of Information

Information on threats came from literature reviews, summary reports, expert reviews, New England Blanding's Turtle Working Group meetings and questionnaire, and available GIS data layers from various sources.

3.3 Extent and Quality of Data

Some threats have been studied more in Massachusetts and southern Maine, and these data are relevant to New Hampshire. Although life span, age of maturity, and fecundity may vary, Blanding's turtles consistently mature late and depend on high adult survivorship. Road mortality and loss of contiguous habitat are known threats, and, though less understood, disease, invasive plants, genetic isolation, and effects of agriculture and forestry activities in New Hampshire are potential threats.

3.4 Threat Assessment Research

- The efficacy of Blanding's turtle management (e.g., water level management and agriculture), should be evaluated
- Populations that are isolated by anthropogenic barriers (e.g., high-traffic roads) should be identified, and options for increasing safe passage of traveling turtles should be considered
- Blanding's turtle populations should be monitored (e.g., with radio telemetry) in areas where underpass systems have been installed or are proposed

Element 4: Conservation Actions

- Protect large blocks of unfragmented habitat with a diversity of wetland complexes (see Habitat Protection Strategies).
- Work with towns to protect critical habitat through land acquisition, prime wetland designation, and wetland buffer regulations (see Habitat Protection Strategies).
- Maintain beaver flowages and their function in the landscape (see Marsh and Shrub Wetland Profile).
- Design and place roads and other transportation networks (e.g., railways, bike trails, sidewalks) to reduce threats to Blanding's turtles and other rare wildlife (see Roads strategies).
- Educate public about rules and regulations pertaining to Blanding's turtles and other reptiles and amphibians (e.g., sale and possession) through updated and improved NHFG website and other media (see Wildlife Collection strategies).
- Reduce anthropogenic food sources for predators (see Predator control strategies).

4.1.1 Identify Blanding's turtle habitat that will be crucial for protection through acquisition, easement, development restrictions, and mitigation (see Habitat Protection)

(A) Direct Threats Affected
All threats caused loss of extensive, interspersed, interconnected, and diverse wetland complexes

(B) Justification:

- Protecting and managing habitat for Blanding's turtle will reduce the opportunity for future development (especially road construction).
- Blanding's turtles depend on high annual adult survival rates. Removing threats that increase adult mortality is critical to long-term viability.
- Known Blanding's turtle habitat has been mapped, and future documentation will be incorporated into protection strategies. Priority habitats can be identified by GIS.
- Blanding's turtle require large blocks of relatively undeveloped land. These areas are rapidly disappearing, particularly in southern New Hampshire, and land protection for this species needs to start immediately.
- As new Blanding's turtle populations are documented, locations can easily be incorporated into land protection policy.

(C) Conservation Performance Objective

Protect and manage large blocks of habitat in southern New Hampshire to protect Blanding's turtles.

(D) Performance Monitoring

The area of land protected, and the type of protection afforded, can easily be summarized for a given year by ensuring that the conservation lands database is continually updated. Based on protection successes and failures, protection priorities can be adjusted. Statewide land protection efforts can be summarized into known, potential, and unlikely Blanding's turtle habitats.

(E) Ecological Response Objective

Protection of large unfragmented blocks of land with wetland and upland habitat will maintain adult survival rates and thus contribute to the health of Blanding's turtle in New Hampshire.

(F) Response Monitoring
Long-term monitoring is needed at a sample of priority sites to ensure that protection is effective and worthwhile. A combination of mark-recapture, radio telemetry, and basking and nest site surveys should be conducted to monitor long-term trends in population. Viable populations would be indicated by the density and structure of Blanding's turtle populations, threats to annual adult survival, and the area of land protected.

(G) Implementation
Known occupied Blanding's turtle habitat has been mapped by NHFG. New reports will be updated as verified records become available. Occupied Blanding's turtle habitats will be used to prioritize unfragmented blocks identified by the Comprehensive Wildlife Strategy process. Specific land protection might include the following:

- Work with the Great Bay Partnership to protect important Blanding's turtle habitat in the Coastal Watershed
- Add protection to and linkage between areas adjacent to large protected areas in south-central New Hampshire (especially Bear Brook, Pawtuckaway, and North Meadows State Parks)
- Identify and protect other large areas that are likely to support Blanding's turtles, including those in south-central New Hampshire
- Protect wetlands and uplands adjacent to slow rivers in southern New Hampshire (e.g., Lamprey River)
- Protect corridors between viable populations in New Hampshire, Massachusetts and Maine

When land is purchased with conservation of mitigation funds, or when existing habitat is enhanced or restored, protecting Blanding's turtles should be a priority. Other uses should be considered only when they do not jeopardize the long-term viability of Blanding's turtle populations. Therefore, ownership and management authority must be considered when acquiring pieces of conservation land.

(H) Feasibility
Protection of large blocks of habitat with diverse wetland complexes is compatible with other large-scale land protection priorities. Land values in southern New Hampshire are high and rising, so protection must be prioritized. Long-term monitoring is labor intensive, and so can only be initiated at a few priority sites.

4.1.2 Evaluate Blanding's turtle protection status and develop guidelines for regulatory review of threats to known or potential habitat, Regulation and Policy

(A) List of Direct Threats Affected
All habitat-based threats affected

(B) Justification
- The Blanding's turtle is currently listed as a Species of Special Concern, and this designation provides less protection than the New Hampshire Endangered Species Conservation Act (RSA 212-A).
- Restricting activities that harm Blanding's turtles will minimize mortality
- Because turtle habitat is under heavy pressure from development, protection is urgent
- New information on known and new populations will be incorporated into the review process.

(C) Conservation Performance Objective
Minimize threats to the Blanding's turtle through regulatory processes (residential, commercial, transportation and trail networks, and habitat management).

(D) Performance Monitoring
Guidelines will be developed so that NHFG project reviewers can provide a consistent and adequate response, and project reviewers will be able to indicate whether regulations are having a positive effect on Blanding's turtle habitat.

(E) Ecological Response Objective
To reduce the destruction of Blanding's turtle habitat in southern New Hampshire and maintain viable, connected populations.

(F) Response Monitoring
Long-term monitoring will be conducted at a few priority Blanding's turtle sites. Shorter sampling efforts (basking and nesting surveys) can be applied to a larger number of known or potential Blanding's turtle sites. If threats from development are possible and can't be avoided through the regulatory review, qualified individuals hired by developers should monitor local turtle populations.

(G) Implementation
The Blanding's turtle is currently listed as a special concern species in New Hampshire. This designation carries limited regulatory protection and the species may warrant additional protection under the New Hampshire Endangered Species Conservation Act (RSA 212-A). Therefore, Blanding's turtles should be considered for listing at the next revision. Meanwhile, NHFG has authority over wildlife and can review wetland dredge and fill applications submitted to the NHDES. NHFG biologists should develop standard guidelines so project reviewers at NHFG and DES have a consistent regulatory review and so that permit applicants can expect a consistent review. Although guidelines should provide consistency, further requirements may be required depending on the scope of the project and the viability of the local Blanding's turtle population.

(H) Feasibility
Sufficient information is available to consider Blanding's turtle for state protection under RSA 212-A. Standard guidelines could be developed based on other states' successes and failures and on recommendations from the New England Blanding's Turtle Working Group. Unfortunately, NHFG reviews projects through other state agency permitting processes (especially NHDES) and does not currently have a conservation permit process of its own. Thus, implementing strong regulations is likely to be challenging. Therefore, priority sites should receive the greatest regulatory review.

4.1.3 Coordinate a regional Blanding's turtle working group

In February 2004 the "Northeast Blanding's Turtle Working Group" was initiated with the goal of sharing resources and identifying regional priorities for conserving Blanding's turtles. In October 2004, the USFWS funded a grant proposal to produce a

regional status report and a conservation plan for Blanding's turtles in the Northeast, to assess road mortality and population viability through modeling, and to conduct population viability analyses for the entire Northeast region. Information gathered from this study will help determine if the Northeast Blanding's turtle population warrants federal endangered species listing as a Distinct Population Segment. In addition, results of this study will help focus future funding, identify common priorities, guide conservation groups to protect viable populations of turtles, and guide the development of future transportation projects (Science Support Partnership Program Study Plan 2004).

4.2 Conservation Action Research:

Work with the New England Blanding's Turtle Working Group to update and prioritize areas for protection based on models and results of ongoing Blanding's turtle research.

Element 5: References

5.1 Literature

Brecke, B., and J.J. Moriarty. 1989. *Emydoidea blandingi* (Blanding's turtle) Longevity. Herpetological Review 20:53.

Congdon, J.D., A.E. Dunham, and R.C. van Loben Sels. 1993. Delayed sexual maturity and demographics of Blanding's turtles (*Emydoidea blandingii*): implications for conservation and management of long-lived organisms. Conservation Biology 7:826-833.

Congdon, J.D., R.D. Nagle, O.M. Kinney, M. Osentoski, H.W. Avery, R.C. van Loben Sels, and D.W. Tinkle. 2000. Nesting ecology and embryo mortality: implications for hatchling success and demography of Blanding's turtles (*Emydoidea blandingii*). Chelonian Conservation and Biology 3:569-579.

Congdon, J.D., D.W. Tinkle, G.L. Breitenbach, and R.C. van Loben Sels. 1983. Nesting ecology and hatching success in the turtle *Emydoidea blandingi*. Herpetolgica 39:417-429.

Congdon, J.D., and R.C. van Loben Sels. 1993. Relationships of reproductive traits and body size with attainment of sexual maturity and age in Blanding's turtles (*Emydoidea blandingi*). Journal of Evolutionary Biology 6:547-557.

DePari, J.A., M.H. Linck, and T.E. Graham. 1987. Clutch size of the Blanding's turtle, *Emydoidea blandingi*, in Massachusetts. The Canadian Field-Naturalist 101:440-442.

Ernst, C.H., J.E. Lovich, and R.W. Barbour. 1994. Turtles of the United States and Canada. Smithsonian Instituted Press, Washington and London, USA.

Fowle, S.C. 2001. Priority sites and proposed reserve boundaries for protection of rare herpetofauna in Massachusetts. Natural Heritage and Endangered Species Program. Massachusetts Division of Fisheries and Wildlife, Westborough, Massachusetts, USA.

Gibbs, J.P., and D.A. Steen. 2005. Trends in sex ratios of turtles in the United States: Implications of road mortality. Conservation Biology 19:552-556.

Graham, T.E. 1999. *In* Maine Amphibians and Reptiles, M.L. Hunter, A.J.K. Calhoun, and M. McCollough. The University of Maine Press, Orono, Maine, USA.

Huse, W.H. 1901. The Testudinata of New Hampshire. Proceedings of the Manchester Institute of Arts and Sciences 2:47-51.

Jenkins, R., and K.J. Babbitt. 2003. Developing a conservation strategy to protect land habitat functions for New Hampshire's reptiles and amphibians using the Blanding's turtle (*Emydoidea blandingii*) as a flagship species. Final report submitted to the New Hampshire Fish & Game Department, Concord, New Hampshire, USA.

Joyal, L.A. 1996. Ecology of Blanding's (*Emydoidea blandingii*) and spotted (*Clemmys guttata*) turtles in southern Maine: population structure, habitat use, movements, and reproductive biology. M.S. Thesis, University of Maine, Orono, Maine, USA.

Joyal, L.A., M. McCollough, and M.L. Hunter, Jr. 2000. Population structure and reproductive ecology of Blanding's turtle (*Emydoidea blandingii*) in Maine, near the northeastern edge of its range. Chelonian Conservation and Biology 3:580-588.

Joyal, L.A., M. McCollough, and M.L. Hunter, Jr. 2001. Landscape ecology approaches to wetland species conservation: a case study of two turtle species in southern Maine. Conservation Biology 15: 1755-1762.

Kiviat, E. 1997. Blanding's turtle habitat requirements and implications for conservation in Dutchess

County, New York. Pages 377-382 *in* Proceedings: conservation, restoration, and management of tortoises and turtles, J.V. Abbema and P.C.H. Pritchard, editors. New York Turtle and Tortoise Society and Wildlife Conservation Society.

Kiviat, E., G. Stevens, R. Brauman, S. Hoeger, P.J. Petokas, and G.G. Hollands. 2000. Restoration of wetland and upland habitat for the Blanding's turtle, *Emydoidea blandingii*. Chelonian Conservaion Biology. 3:650-657.

Kofron, C.P., and A.A. Schreiber. 1985. Ecology of two endangered aquatic turtles in Missouri: *Kinosternon flavescens* and *Emydoidea blandingii*. Journal of Herpetology 19:27-40.

Linck, M.H., J.A. DePari, B.O. Butler, and T.E. Graham. 1989. Nesting behavior of the turtle, *Emydoidea blandingi*, in Massachusetts. Journal of Herpetology 23:442-444.

Marchand, M.N. and J.A. Litvaitis. 2004a. Effects of habitat features and landscape composition on the population structure of a common aquatic turtle in a region undergoing rapid development. Conservation Biology 18:758-767.

Marchand, M.N. and J.A. Litvaitis. 2004b. Effects of landscape composition, habitat features, and nest distribution on predation of simulated turtle nests. Biological Conservation 117:243-251.

Marchand, M.N., J.A. Litvaitis, T.J. Maier, and R.M. DeGraaf. 2002. Use of artificial nests to investigate predation on freshwater turtle nests. Wildlife Society Bulletin 30:1092-1098.

McCollough, M.A. 1999. Conserving a landscape for Blanding's and spotted turtles in Maine and New Hampshire. Abstracts of the 55th Annual Northeast Fish and Wildlife Conference, Manchester, New Hampshire, USA.

NatureServe. 2004. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: January 4, 2005).

Oliver, J.A. and J.R. Bailey. 1939. Amphibians and reptiles of New Hampshire exclusive of marine forms: Pages 195-217 in Biological Survey of the Connecticut watershed, H.E. Warfel, editor. New Hampshire Fish and Game Department Survey Report 4.

Pappas, M.J. and B.J. Brecke. 1992. Habitat selection of juvenile Blanding's turtles, *Emydoidea blandingii*. Journal of Herpetology 26:233-234.

Power, T.D., T.B. Herman, and J. Kerekes. 1994. Water colour as a predictor of local distribution of Blanding's turtles, *Emydoidea blandingii*, in Nova Scotia. The Canadian Field-Naturalist:17-21.

Ross, D. A., and R. K. Anderson. 1990. Habitat use, movements, and nesting of *Emydoidea blandingi* in central Wisconsin. Journal of Herpetology 24: 6-12.

Ross, D.A., and J.E. Lovich. 1992. Does the color pattern of two species of turtles imitate duckweed? Journal of Pennsylvania Academy Sciences 66:39-42.

Science Support Partnership Program. 2004. Study Plan Status Review and Conservation of Blanding's turtles in New England. A proposal to the U.S. Geological Survey-Biological Resources Division. U.S. Fish and Wildlife Service.

Society for the Protection of New Hampshire Forests. 2005. New Hampshire's Changing Landscape. Population growth and land use changes: what they mean for the Granite State. Executive Summary. Concord, New Hampshire, USA.

Southwell, D.K. 2002. Conservation assessment for Blanding's turtle (*Emydoidea blandingii*). USDA Forest Service, Eastern Region. Hiawatha National Forest, U.S. Forest Service Eastern Region, Escanaba, Michigan, USA.

Standing, K.L., T.B. Herman, and I.P. Morrison. 1999. Nesting ecology of Blanding's turtle (*Emydoidea blandingii*) in Nova Scotia, the northeastern limit of the species' range. Canadian Journal of Zoology 77:1609-1614.

Standing, K.L., T.B. Herman, and I.P. Morrison. 2000. Predation of neonate Blanding's turtles (Emydoidea blandingii) by short-tailed shrews (Blarina brevicauda). Chelonian Conservation and Biology 3:658-660.

Temple, S.A. 1987. Predation on turtle nests in increases near ecological edges. Copeia 250-252.

Therres, G.D. 1999. Wildlife species of regional conservation concern in the northeastern United States. Northeast Wildlife 54:93-100.

5.2 Data Sources

New Hampshire Natural Heritage Bureau. 2005. Database of Rare Species and Exemplary Natural Community Occurrences in New Hampshire.

Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

New Hampshire Reptile and Amphibian Reporting Program (RAARP). Coordinated by New Hampshire Fish & Game Department's Nongame & Endangered Species Program.

Element 6: List of Figures

Figure 1. Town distribution map of known Blanding's turtle locations in New Hampshire, March 2005. Town records reported included a photograph, specimen, or were reported by an expert observer. Most reports were received through the New Hampshire Reptile and Amphibian Reporting Program (RAARP).

SPECIES PROFILE

Eastern Box Turtle

Terrapene carolina carolina

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: SNA (Not Applicable)
Author: Michael N. Marchand, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Eastern box turtles are terrestrial generalists that use a variety of habitats including mesic forests, xeric uplands, open woodlands, pastures, old fields, thickets, and powerline clearings (Klemens 1993, Ernst et al. 1994, DeGraaf and Yamasaki 2001, Mitchell 2003). Although considered a terrestrial turtle, box turtles may make extensive use of a variety of wetlands, shallow streams, or muddy seepages (Klemens 1993, Quinlan et al. 2004, Marchand et al. 2004) as relief from high temperatures, concealment from predators (Dodd 2001), and for additional foraging opportunities (Marchand et al. 2004). A diversity of habitats in close proximity is apparently favored (Madden 1975, Klemens 1993), and box turtles may adjust habitat preference depending on season and temperature (Madden 1975, Dodd 2001, Marchand 2004).

During periods of inactivity, box turtles may bury in litter or rest in brush piles or briar patches (Stickel 1950). Openings in the forest canopy are important for basking individuals (Stickel 1950), and well-drained open canopy areas are required for nesting (Ernst et al. 1994). As temperatures drop in the fall, box turtles dig progressively deeper into soil where they spend the winter. Portions of the carapace are sometimes visible even in northern climates (Dodd 2001).

1.2 Justification

The eastern box turtle is a species of concern in the northeast (Therres 1999). States reporting declines of box turtles include Connecticut, Florida, Illinois, Indiana, Iowa, Maryland, Massachusetts, Missouri, New Jersey, New York, Ohio, Oklahoma, Tennessee, Virginia, West Virginia, and Wisconsin (Stickel 1978, Williams and Parker 1987, Lieberman 1994). Massachusetts and Connecticut consider the eastern box turtle a species of special concern, and in Maine eastern box turtles are listed as endangered (Hunter et al. 1999).

Box turtles are a long-lived species with delayed ages of sexual maturity, relatively low fecundity, and dependence on high adult survival. Therefore, they may be extremely vulnerable to increased mortality associated with rapid development in New England. The current and historic status of box turtles in New Hampshire is not known and needs further consideration.

1.3 Protection and Regulatory Status

- NHFG Rule FIS 803.02. Eastern box turtles shall not be imported to New Hampshire.
- NHFG Rule FIS 804.02. Eastern box turtles shall not be possessed in New Hampshire.
- NHFG Rule FIS 811.01. No person shall sell eastern box turtles in New Hampshire.
- Fill and Dredge in Wetlands; NHDES (RSA 482-A, Wt 302.04): For all affected major (more than 20,000 sq ft) and minor (3,000 to 20,000 sq ft) wetland, applicants must consider threats to rare species. Because box turtles often are associated with terrestrial habitats, protection of box turtles from this regulation is likely limited.

1.4 Population and Habitat Distribution

In New England the box turtle's range includes southeastern Maine, southeastern New Hampshire, eastern Massachusetts including Cape Cod and the islands, the Connecticut River region, and much of Rhode Island and Connecticut (Klemens 1993, DeGraaf and Yamasaki 2001). Box turtles do not occur in Vermont (Hunter et al. 1999). In Maine, box turtles have been reported in at least 13 towns (Hunter et al. 1999). However, reports distant from south-coastal Maine were likely released pets. Records in Maine consist largely of single individuals and do not attest to a population (P. deMaynadier, Maine Department of Inland Fisheries and Wildlife, personal communication).

In New Hampshire, the distribution and abundance of box turtles is not well known. A specimen was collected in Pelham, Rockingham County historically (Huse 1901) and submitted to the Manchester Institute of Arts and Sciences, but has apparently since been lost (Natural Heritage Rare Species Database 2004). Specimens from Lee were also reported (Huse 1901), suggesting that box turtles occurred in southern New Hampshire historically. Recently, remains of a box turtle were found at a pre-colonial excavation site from Lake Massabesic, New Hampshire (Largy 2003). This report may suggest that a native population of box turtles existed in New Hampshire historically.

Use and trade of box turtles by Native Americans has complicated our understanding of the historic distribution of the species (Adler 1968). Box turtles were occasionally consumed (Dodd 2001), were commonly used as ceremonial objects (Klemens 1993, Dodd 2001), and were transported, often north of the species' current range (Bleakney 1958, Adler 1968). Therefore, it is possible that box turtles were traded to New Hampshire from other locations where box turtles are currently more abundant (e.g., southern New England). Box turtle shells recovered in Ontario, north of the current range, have been considered not native (Bleakney 1958). However, Adler (1970) reported that Native Americans (primarily Iroquois) may have been responsible for the elimination of box turtles in western New York and possibly in southern Ontario.

The NHFG Nongame and Endangered Species Program has received reports of box turtles from 12 towns between 1992 and 2004 (RAARP). Most of these reports have not been verified, and 1 of these town observations (Merrimack) was later confirmed as an Ornate box turtle (*Terrapene ornata*). A report from Amherst was confirmed to be of released individuals. Reports of box turtles from central and northern New Hampshire (Wentworth Location, Eaton, Moultonborough) were most likely the result of released pets. Box turtles were extremely popular in the pet industry (Ernst et al. 1994, Lieberman 1994), and in New Hampshire, it was not illegal to possess Eastern box turtles until 1996.

In 1985, a box turtle was reported from Hudson, adjacent to the historic record in Pelham. During a survey for NHNHB, a recently deceased box turtle was discovered. Habitat surrounding the turtle was described as a dry oak forest with a power line right-of-way and a graminoid marsh (Korpi 1985). A follow-up survey has not been done. Taylor (1993) illustrates 2 additional locations in southeastern New Hampshire on the edge of Rockingham and Strafford Counties, and Dodd (2001) depicts 2 locations on the southern border of Maine and New Hampshire.

All known reports of box turtles in New Hampshire were of 1 individual, and there is no known evidence of breeding. Based on these reports and the distribution of eastern box turtles in Massachusetts and Maine, any box turtle populations that may occur in New Hampshire are likely to occur in the south central to southeastern portion of the State.

1.5 Town Distribution Map

No known populations.

1.6 Habitat Map

N/A

1.7 Sources of Information

Sources of information include the RAARP database, NHNHB Rare Species database, Massachusetts Natural Heritage Element Occurrence Information, and Maine Reptile and Amphibian Atlas (Hunter et al. 1999).

1.8 Extent and Quality of Data

The historic and current distribution of box turtles in

New Hampshire is not well known. Many observations made by RAARP volunteers have not included photographs and cannot be verified.

1.9 Distribution Research

NHFG will continue to evaluate reports received from the RAARP and will alert volunteers to changes in species status. Sightings should be followed by on-site surveys, which should describe habitat condition and perhaps historic suitability. When warranted, dogs may be used to locate turtles (Schwartz and Schwartz 1991). Because individual box turtles can be difficult to locate, searching potential habitat without a lead would likely not be effective.

NHFG should search archaeological excavation reports, communicate with groups conducting archaeological excavations, and compile verified historic occurrences of eastern box turtles. Reports describing archaeological excavations must be submitted to the New Hampshire Division of Historical Resources in compliance with federal regulations (Section 106, 1966 National Historic Preservation Act).

Element 3: Species and Habitat Threat Assessment

Threats to eastern box turtles have been assessed in other areas of the Northeast. The most significant threats include habitat loss and fragmentation, roads as barriers and agents of mortality, and commercial and casual collection. In New Hampshire, cold winters might have limited the species potential and historic distribution. Currently, the greatest threat to eastern box turtles in New Hampshire is a lack of knowledge regarding the species' presence. The popularity of eastern box turtles as pets and the resulting release of those pets to the wild have increased the difficulty of assessing the historic and current range of the species in New Hampshire.

Element 5: References

5.1 Literature

Adler, K. 1968. Elimination of box turtles in western New York state by prehistoric man. Journal of Herpetology 2:179.

Adler, K. 1970. The influence of prehistoric man of the distribution on the box turtle. Annals of the Carnegie Museum 41:263-280.

Bleakney, S. 1958. The significance of turtle bones from archaeological sites in southern Ontario and Quebec. The Canadian Field-Naturalist 72:1-5.

Dodd, C. K., Jr., 2001. North American box turtles. A natural history. University of Oklahoma Press, Norman, Oklahoma, USA.

DeGraaf, R.M., and M. Yamasaki. 2001. New England wildlife. Habitat, natural history, and distribution. University Press of New England, Hanover, New Hampshire, USA.

Ernst, C.H, R.W. Barbour, and J.E. Lovich. 1994. Turtles of the United States and Canada. Smithsonian Institution Press, Washington, D.C., USA.

Hunter, M.L., A.J.K. Calhoun, and M. McCollough. 1999. Maine amphibians and reptiles. The University of Maine Press, Orono, Maine, USA.

Huse, W.H. 1901. The Testudinata of New Hampshire. Proceedings of the Manchester Institute of Arts and Sciences 2:47-51.

Klemens, M.W. 1993. Amphibians and reptiles of Connecticut and adjacent regions. State Geological and Natural History Survey of Connecticut, Bulletin 112, Connecticut Department of Environmental Protection, Hartford, Connecticut, USA.

Korpi, J. 1985. Field survey to Merrill Hill on Aug 8. New Hampshire Natural Heritage Bureau.

Largy, T. 2003. Calcined bone taxa from Lake Massabesic, New Hampshire. Report submitted to Victoria Bunker, Inc.

Lieberman, S. 1994. Can CITES save the Box turtle? Endangered Species Technical Bulletin 19:1-17.

Madden, R. 1975. Home range, movements, and orientation in the eastern box turtle, *Terrapene carolina carolina*. Unpublished Ph.D. Dissertation. City University of New York, New York, USA

Marchand, M.N., M.M. Quinlan, and C.W. Swarth. 2004. Movement patterns and habitat use of eastern box turtles at the Jug Bay Wetlands Sanctuary, Maryland. Pages 55-61 *in* C.W. Swarth, W.M. Roosenburg, and E. Kiviat, Editors. Conservation and Ecology of Turtles of the Mid-Atlantic Region: A Symposium. Bibliomania, Salt Lake City, Utah, USA.

Mitchell, J.C. 2003. DRAFT Habitat management guidelines for amphibians and reptiles of the northeastern United States. Partners in Amphibian and Reptile Conservation.

Quinlan, M., C.W. Swarth, and M. Marchand. 2004. Abstract: Characteristics of a High-density eastern box turtle population on Maryland's coastal plain. Pages 55-61 *in* C.W. Swarth, W.M. Roosenburg, and E. Kiviat, Editors. Conservation and Ecology of Turtles of the Mid-Atlantic Region: A Symposium. Bibliomania, Salt Lake City, Utah, USA.

Schwartz, E.R., and C.W. Schwartz. 1991. A quarter-century study of survivorship in a population of three-toed box turtles in Missouri. Copeia 1991: 1120-1123.

Stickel, L.F. 1950. Populations and home range relationships of the box turtle, *Terrapene c. carolina* (Linnaeus). Ecological Monographs 20:351-378.

Stickel, L.F. 1978. Changes in a box turtle population during three decades. Copeia 1978:221-225.

Taylor, J.T. 1993. The Amphibians and reptiles of New Hampshire. Nongame and Endangered Wildlife Program, New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

Therres, G.D., Chairman of the Northeast Endangered Species and Wildlife Diversity Technical Committee. 1999. Wildlife species of regional conservation concern in the northeastern United States. Northeast Wildlife 54:93-100.

Williams, E.C. and W.S. Parker. 1987. A long-term study of a box turtle (*Terrapene carolina*) population at Allee Memorial Woods, Indiana, with emphasis on survivorship. Herpetologica 43:328-335.

5.2 Data Sources

NH Natural Heritage Bureau. 2005. Database of Rare Species and Exemplary Natural Community Occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

New Hampshire Reptile and Amphibian Reporting Program (RAARP). Coordinated by New Hampshire Fish & Game Department's Nongame & Endangered Species Program. Accessed February 10, 2005.

SPECIES PROFILE

Fowler's Toad

Bufo fowleri formerly *Bufo woodhousii fowleri*

Federal Listing: Not listed
State Listing: Special concern
Global Rank: G5T
State Rank: S3
Author: Kimberly, J. Babbitt, University of New Hampshire

Element 1: Distribution and Habitat

1.1 Habitat Description

Fowler's toad occurs mainly in habitats with loose, well-drained sandy or gravelly soils including riverbanks, lake margins, beach and coastal dune systems, and sandy or scrubby woodlands (Wright and Wright 1949, Smith 1961, Minton 1972, Green 1989, Breden 1987, Klemens 1993). Fowler's toads can be found along roadsides, near homes and gardens, and in fields and pastures (Wright and Wright 1949). Breeding habitat is generally the shallow margins of permanent water bodies, including lakes, farm ponds, rivers, and slow-moving streams (Wright and Wright 1949, Smith 1961, Breden 1988, Klemens 1993). Fowler's toads are facultative users of vernal pools (Wright and Wright 1949, Green 1989). Where the species co-occurs with the American toad (*Bufo americanus*), the Fowler's toad is often found in dryer areas than the American (Klemens 1993).

1.2 Justification

New Hampshire constitutes the northeastern limit of the range of the Fowler's toad. Little information on the Fowler's toad exists in New Hampshire and it is possible that the species occurs in low numbers. However, both historical and current written descriptions of the species distribution and numbers suggest that the species is abundant in some parts of New England. Thus, the lack of evidence of a robust population in southern New Hampshire may be cause for concern. Lack of information on this species in the state is the most serious threat, as it currently cannot be assessed whether the species is locally abundant but not widespread, or is rare. This information is crucial for informing habitat protection and species management guidelines.

1.3 Protection and Regulatory Status

There is no special protection for Fowler's toad. See Marsh and Shrub Wetlands habitat profile and Vernal Pool habitat profile for protection and regulatory status of breeding habitats.

1.4 Population and Habitat Distribution

The Fowler's toad range is southern New England westward through southeast New York, New Jersey and northern parts of Pennsylvania, the Midwest (parts of Michigan, Illinois and Ohio), and southern Ontario, Canada. Throughout its range in New England and New York, the species has an irregular or spotty distribution, although it is often described as being "widespread". The species occurs throughout the south, with the exception of coastal plain areas of Georgia and South Carolina and peninsular Florida. Fowler's toads are limited to the southern portion of the states of Vermont and New Hampshire and may reach the Atlantic Coast almost into Maine (Stewart and Rossi 1981, Krauss and Schuett 1982, Shaffer 1991, Harding 1997, Klemens 1993). It is the only native *Bufo* on Long Island, New York. Limited records exist for the species in New Hampshire.

The distribution pattern of this species in the state is poorly documented. However, it is likely that the species occurred irregularly or patchily in areas with appropriate habitat upland and breeding

habitat. There are a limited number of Fowler's toad records in the state (see Town Distribution Map). The documented historic sitings (more than 20 years old) are from the towns of Boscawen, Canterbury, Amherst, Hanover, and Milford (Oliver and Bailey 1939). Observations considered verified within the last 20 years are from the towns of Grafton, Concord, and Pembroke. Overall, available data suggest that either the species suffers from poor monitoring and documentation or that it is rare and therefore constitutes a very small proportion of the regional Fowler's toad population.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

1.7 Sources of Information

Information was obtained from an extensive literature search and from Michael Marchand, Wetlands Biologist, Nongame and Endangered Wildlife Program, NHFG.

1.8 Extent and Quality of Data

The collective published works on Fowler's toad provide little insight into the species in New Hampshire. There have been no systematic surveys for Fowler's toads in the state. The quality of the existing data on Fowler's toad distribution in the state is extremely poor.

1.9 Distribution Research

As there have been no systematic surveys conducted in the state, the first priority is to conduct such a survey to document the location of breeding populations. There is no evidence that the species occurred historically in the northern portion of the state; thus, monitoring and survey efforts should focus on southern New Hampshire. Given that the species may not be widespread, it is important to determine sizes of any existing populations and to assess the threat (from development, pollution, or isolation) of continued persistence of the remaining populations. Although Fowler's toads breed in the shallow areas of permanent aquatic sites, they are facultative vernal pool breeders. Thus, it would also be important to assess the location and type of breeding sites available in areas in which the species is documented. Because the species breeds later in the season than many other vernal pool breeding species, identification of appropriate vernal pool sites (e.g., long-hydroperiod vernal pools) is important.

Element 2: Species/Habitat Condition

2.1 Scale

2.2 Relative Health of Populations

There are not sufficient data available from which to make conclusions about population health or trends for this species.

2.3 Population Management Status

There are no population monitoring efforts for this species. The North American Amphibian Monitoring Program (NAAMP) is conducted annually in New Hampshire; however, no Fowler's toads have been reported.

2.4 Relative Quality of Habitat Patches

There are not sufficient data available to assess the quality of habitat patches for the Fowler's toads.

2.5 Habitat Patch Protection Status

There are insufficient data with which to assess protection status.

2.6 Habitat Management Status

There are no habitat management efforts being made for Fowler's toads. Because the distribution and abundance of the species is unknown, management efforts that might indirectly benefit this species cannot be assessed at this time.

2.7 Sources of Information

There are no sources of information beyond the RAARP and Natural Heritage databases.

2.8 Extent and Quality of Data

Although the literature can provide a general description of habitat associations for this species, distribution and population numbers are lacking for this species in New Hampshire. Because American toads are commonly misidentified as Fowler's toads, few records have been confirmed in New Hampshire (M. Marchand, NHFG, personal communication).

2.9 Condition Assessment Research

Basic distribution data for this species must be acquired. Understanding the location, size, and dispersal of existing populations will help protect the species. Areas for intensive, systematic surveys can be determined by an initial delineation of its potential habitat. Using remote sensing (e.g., aerial photography) and fieldwork, a GIS habitat layer could be created. Potential habitat could be determined by appropriate soil data layers with potential breeding site habitat. A list/formula should be developed that facilitates assessment of Fowler's toad population and habitat health. This list/formula could consider the following:

- Stability of the sub-population and/or metapopulation(s)
- Potential for genetic exchange between local populations
- Incidence of physical malformations or disease
- Water quality at breeding sites
- Proximity of the habitat patch to other potential habitat patches
- Proximity of the habitat to roads, development, and other disturbances
- Size and configuration of upland habitat

Element 3: Species and Habitat Threat Assessment

3.1.1 Development (Habitat Loss and Conversion)

(A) Exposure Pathway
Fowler's toads require sandy upland habitat near appropriate breeding sites. Many of these sites are along large river systems and lakes where development pressure is high, thus Fowler's toads may suffer loss of habitat and fragmentation. Development could result in local extirpation if adjacent areas are unsuitable habitat and distances between suitable habitats are beyond dispersal capabilities of Fowler's toads.

(B) Evidence
Because we lack information on Fowler's toad distribution, there is no direct evidence that this threat is occurring. However, the most likely areas in which Fowler's toads may occur are in the southern part of the state and along riverine areas such as the Connecticut and Merrimack Rivers. Given current population growth and development trends (Sundquist and Stevens 1999), and the planned expansion of I-93, it is likely that there will be increasing development pressures in areas where Fowler's toads may occur.

3.1.2 Transportation Infrastructure (Mortality, Fragmentation, Dispersal Barriers)

(A) Exposure Pathway
Direct mortality of toads caused by vehicle traffic can be significant and may be particularly problematic for small populations. Roads fragment toad habitat and may act as partial barriers to migration. Thus, roads may decrease toad dispersal, resulting in decreased exchange of individuals among populations and consequently reduce colonization/recolonization and gene flow among local populations.

(B) Evidence
Although specific studies of road impacts on Fowler's toads are not available, there is substantial evidence in the literature that roads are a significant source of direct mortality for migrating amphibians (Fahrig et al. 1995, Ashley and Robinson 1996, Mazerolle 2004). Given current population growth and development trends (Sundquist and Stevens 1999), and the planned expansion of I-93, it is likely that there will be increasing developmental pressures in areas where Fowler's toads may occur.

3.2 Sources of Information

Because distribution and population size information on this species is not known, the threats to this species are hypothetical and are drawn largely from the general literature and knowledge rather than specific

evidence for this species in New Hampshire.

3.3 Extent and Quality of Data

No relevant data exist for this species in the state, and relatively poor data exist for this species in general.

3.4. Threat Assessment Research

A survey is needed to document the occurrence and abundance of the species, as well as to determine the number of remaining populations, the size of those populations and the degree of connectivity (i.e., likelihood of exchange among populations).

Element 4: Conservation Actions

4.1.1 Identify locations of Fowler's toad populations and protect their habitat; Habitat Protection

(A) Development (Habitat Loss and Conversion), Transportation Infrastructure (Mortality, Fragmentation, Dispersal Barriers)

(B) Justification
Given limited resources for habitat acquisition and protection, adequate data on population locations and status should be obtained so that the most appropriate parcels can be targeted for protection or management.

(C) Conservation Performance Objective

The initial performance objective is to survey all potential Fowler's toad habitats. If populations were found, the performance objective would be to protect the most significant (as measured through populations size, size or quality of the habitat patch, and other metrics) habitat parcels. Maintenance of extant Fowler's toad populations on those parcels would be the final performance objective.

(D) Performance Monitoring

Appropriate performance monitoring would be the number of parcels protected and the retention of extant Fowler's toad populations that are stable or increasing (however, see below).

4.2 Conservation Action Research

Existing knowledge of New Hampshire's Fowler's toad populations is poor and this precludes any attempt to assess the likely outcome of conservation actions. A systematic survey of potential Fowler's toad populations must be undertaken. This survey could most easily be accomplished during the breeding season through a combination of breeding call surveys (this species has a *very* distinctive call), egg mass counts, and larval surveys. Potential survey sites can be determined using GIS (see section 2.9). Once existence and location of populations have been established, the next step would be to determine the size of each population via a mark and recapture study. If potentially viable populations are identified, research should focus on the dispersal capabilities of the species, the degree to which populations are connected, and the areal extent of upland habitat that should be protected to ensure that habitat loss and fragmentation are minimized.

Element 5: References

5.1 Literature

Ashley, E.P., and J.T. Robinson. 1996. Road mortality of amphibians, reptiles and other wildlife on the Long Point Causeway, Lake Erie, Ontario. Canadian Field-Naturalist 110: 403-412.

Breden, F. 1987. Population structure of Fowler's toad, *Bufo woodhousei fowleri*. Copeia 1987:386-395.

Breden, F. 1988. The natural history and ecology of the Fowler's toad, *Bufo woodhousei fowleri*, (Amphibia: Bufonidae) in the Indiana Dunes National Lakeshore. Fieldiana Zoology 49:1-16.

Fahrig, L., J.H. Pedlar, S.E. Pope, P.D. Taylor, and J.F. Wegner. 1995. Effect of road traffic on amphibian density. Biological Conservation 73:177-182.

Green, D. 1989. Fowler's toad, *Bufo woodhousii fowleri*, in Canada: Biology and population status. Canadian Field-Naturalist 103:486-496.

Harding, J.H. 1997. Amphibians and reptiles of the Great Lakes region. University of Michigan Press Ann Arbor, Michigan, USA.

Klemens, M.W. 1993. Amphibians and reptiles of Connecticut and adjacent regions. State Geological and Natural History survey of Connecticut, Bulle-

tin Number 112. Hartford, Connecticut, USA.

Krauss, F., and G.W. Schuett. 1982. A herpetofaunal survey of the coastal zone of northwest Ohio. Kirtlandia 35-38:21-54.

Mazerolle, M.J. 2004. Amphibian road mortality in response to nightly variations in traffic intensity. Herpetologica 60:45-53.

Minton, S.A., Jr. 1972. Amphibians and reptiles of Indiana. Monograph Number 3. Indiana Academy of Science. Indianapolis, Indiana, USA.

Oliver, J.A., and J.R. Bailey. 1939. Amphibians and reptiles of New Hampshire exclusive of marine forms: Pages 195-217 *in* Biological Survey of the Connecticut Watershed. New Hampshire Fish and Game Department Survey Rep. 4.

Shaffer, L.L. 1991. Pennsylvania amphibians and reptiles. Pennsylvania Fish Commission. Harrisburg, Pennsylvania, USA

Smith, P.W. 1961. The amphibians and reptiles of Illinois. Bulletin of the Illinois Natural History Survey, Number 28. Urbana, Illinois, USA.

Sundquist, D., and M. Stevens. 1999. New Hampshire's changing landscape: population growth, land use conversion, and resource fragmentation in the Granite State. New Hamphire, Concord, Society for the Protection of New Hampshire Forests and The Nature Conservancy, 159 pp.

Stewart, M.M., and J. Rossi. 1981. The Albany Pine Bush: a northern outpost for southern species of amphibians and reptiles in New York. American Midland Naturalist 106:282-292.

Wright, A.H., and A.A. Wright. 1949. Handbook of frogs and toads. Third edition. Comstock Publishing Associates. Ithaca, New York, USA.

SPECIES PROFILE

Hognose Snake

Heterodon platirhinos

Federal Listing: None
State Listing: Threatened
Global Rank: G5
State Rank: S3
Author: James Taylor, University of New Hampshire; Michael Marchand, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Eastern hognose snakes are found in open woodland, grasslands, and fields with sandy soil derived from glacial outwash (Michener and Lazell 1989). Natural vegetation commonly occurring in these New Hampshire sandy soils include white pine (*Pinus strobus*), pitch pine (*Pinus rigida*), scrub oak (*Quercus ilicifolia*), and a mixture of hardwoods (Michener and Lazell 1989). Hognose snakes feed largely on amphibians, especially toads (*Bufo* spp.); however, other prey may be taken (Edgren 1955, Platt 1969). Therefore, wetlands that are suitable for amphibian breeding may be an important habitat component, but prey preference could potentially vary regionally or locally depending on prey availability. Eggs are laid in sandy soils, usually during June-July, and young snakes emerge from nests in August-September (Ernst and Ernst 2003). Hibernation occurs individually in mammal burrows, loose soil, or down logs (Plummer 2002, Ernst and Ernst 2003).

1.2 Justification

The eastern hognose snake was listed as Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as of January 1, 2001 and is considered a species of regional concern in the northeastern United States (Therres 1999). In New England, the eastern hognose snake is listed as S2 in Rhode Island, S3S4 in Connecticut, and S4 in Massachusetts; it doesn't occur in Vermont or Maine.

New Hampshire's peripheral population of hognose snakes is state threatened (RSA 212-A, FIS 1000). Hognose snakes in New Hampshire probably have large home ranges (Plummer and Mills 2000, S. Najar, New Boston Air Force Base, personal communication) and are restricted to the Merrimack River corridor south of Concord, an area where development and human population increases are intense and remaining blocks of suitable habitat are becoming smaller and isolated (SPNHF 2005). In addition, the sandy, well-drained soils preferred by hognose snakes are easily converted to residential and commercial developments and are targeted for commercial sand extraction operations.

1.3 Protection and Regulatory Status

Listed as state threatened under RSA 212-A.

1.4 Population and Habitat Distribution

The eastern hognose snake is found from southern New England and Ontario south along Atlantic coast to Florida and west to Texas, Kansas, Nebraska, and South Dakota (Ernst and Ernst 2003). New Hampshire represents the northern limit of the species range on the east coast, where they are restricted to the sandy plain of the Merrimack River, extending from Concord on the north to the Massachusetts state line, as far east as Londonderry, and as far west as New Boston. In addition, 3 expert biologists have reported finding eastern hognose snakes historically in the Durham/Lee area of southeastern New Hampshire (Phillip Sawyer, formerly Professor of Zoology, University of New Hampshire; David Allen, formerly a biologist with the USDA Soil Conservation Service,

now known as the Natural Resource Conservation Service; John Litvaitis, Professor of Wildlife Ecology, University of New Hampshire. Sandy soils generated by glacial outwash, the critical habitat feature for hognose snakes, are common in the Durham/Lee area.

1.5 Town Distribution Map

1.6 Habitat Maps

The University of New Hampshire completed a potential habitat map for eastern hognose snakes within its New Hampshire range. These maps were primarily based on available GIS data layers including landcover, soils, elevation, and distance to a known hognose snake occurrence. An accuracy assessment has not been conducted on this model but maps should help prioritize areas to target for further surveys. One limitation of this mapping procedure is that soils data was not available for Merrimack and Belknap counties. Maps will need to be updated as new data layers (especially soils) become available.

1.7 Source of information

The major source of distribution information for New Hampshire was from the Reptile and Amphibian Reporting Program (RAARP) coordinated by the Nongame and Endangered Wildlife Program at NHFG, the rare species database maintained by the NHNHB, and literature reviews and professional knowledge of the authors. State and global heritage ranks were taken from NatureServe 2005. Habitat maps were completed by UNH, Complex Systems Research Center.

1.8 Extent and Quality of the Data

The extent of the eastern hognose snakes' current range in the state, given the clustering of records near the Merrimack River south of Concord, is fairly well known. Verified records in Manchester, Londonderry, Hollis, and Nashua are greater than 20 years old. More recently, unverified reports have been received for Londonderry and it is likely that a population still exists. Recent reports in Hudson are unverified but likely.

1.9 Distribution Research

Verify habitat suitability model by field surveying those sites likely to be most suitable for eastern hognose snakes (Fitzgerald 1994). Extensive time can be spent searching for hognose snakes with limited success. Therefore, surveys should be coordinated by the NHFG and could involve trained volunteers of the RAARP.

Element 2: Species/Habitat Condition

2.1 Scale

Abundance was evaluated throughout the New Hampshire range of eastern hognose snakes. Condition of specific locations can be evaluated by a GIS based on the habitat model described in Element 1.6 along with field surveys.

2.2 Relative Health

Information on the condition of hognose snakes in New Hampshire is not suitable to determine the viability of local populations. Several hognose snakes are reported to the NHFG annually; however, these observations largely consist of individual snakes, with very few locations having repeated observations. During the summer of 2002, the University of New Hampshire surveyed 6 sites for hognose snake presence but none were encountered (Oberkrieser and Litvaitis 2002). The New Boston Air Force Base incidentally encounters several snakes annually and densities appear low, but a systematic survey has not been conducted (S. Najar, New Boston Air Force Base, personal communication).

2.3 Population Management Status

There is very little population management and or research occurring for hognose snakes in New Hampshire. The New Boston Air Force Base, in cooperation with the NHFG and a local veterinarian, implanted a transmitter in 1 adult hognose snake during spring 2005. This snake has been tracked on a regular basis and NHFG and the NBAFB intend to implant transmitters in several additional adult hognose snakes as they are encountered.

2.4 Relative Quality of Habitat Patches

Sandy glacial outwash is plentiful along the Merrimack River in Hillsborough and Merrimack counties, as well as the Lee/Durham area of New Hampshire. The abundance of the prey base (principally toads and frogs) has not been quantified, but several species, including American toads (*Bufo americanus*), spring peepers (*Pseudacris crucifer*), gray treefrogs (*Hyla versicolor*), and pickerel frogs (*Rana palustris*), appear to be common in this area of the state. The range of another native amphibian, the Fowler's toad (*Bufo fowleri*), coincides fairly well with that of the hognose snake, but this overlap may be a consequence of preference for similar sandy habitats, rather than a prey specialization to Fowler's toads. Development is intense and human population densities are rapidly expanding in southern New Hampshire. Many remaining fragmented blocks of habitat may be too small to support viable local populations of hognose snakes. The scarcity of hognose snake encounters may be a reflection of low habitat quality or of other factors not yet clearly understood.

2.5 Habitat Protection Status

Only a few eastern hognose snake records are on or near conservation land (University of New Hampshire Complex Systems GRANIT data layer). These areas are generally small and fragmented (Stevens, 1998) and it is not known whether management of conservation parcels is compatible for hognose snakes.

2.6 Habitat Management Status

No habitat management has occurred specifically for hognose snakes in New Hampshire to date. Restoration of Pine Barrens in south-central New Hampshire (e.g., Concord) should improve habitat suitability for hognose snakes, but it is unknown whether source populations exist in close enough proximity to become established. Potential impacts to hognose snake habitats are assessed during the Nongame & Endangered Species Program review of newly proposed developments projects.

2.7 Sources of Information

Condition of hognose snake locations was assessed based on data from the RAARP and rare species database maintained by the NHNHB. See Element 1.6 for details on habitat maps.

2.8 Extent and Quality of the Data

The condition of hognose snakes in New Hampshire is extremely poorly understood. Predicted habitat models for hognose snakes have some limitations based on available GIS data layers (See Element 1.6).

2.9 Condition Assessment Research

Habitat assessments should be conducted where hognose snakes have been reported and where hognose snake models predict suitable habitat (see Element 1.6). Systematic sampling of hognose snake, vegetative composition, and amphibian assemblages and abundance needs to be conducted at sites where hognose snakes have been documented. Because hognose snakes are difficult to locate, searching for snakes and monitoring individuals will require multiple years and will use the combination of experienced herpetologists and trained technicians and possibly volunteers. Volunteers are not authorized to handle state-protected species without a permit; therefore, a reporting protocol coordinated by NHFG will need to define roles of those involved. At highest priority sites, hognose snakes should be monitored (radiotelemetry) to assess viability as well as basic life history requirements (e.g., home range size, habitat use). Known locations should be evaluated in detail using a GIS and field surveys to assess size, location, and juxtaposition of remaining habitat blocks and conservation parcels.

Element 3: Species and Habitat Threat Assessment

3.1.1 Development (Habitat Loss and Conversion)

(A) Exposure Pathway
The corridor along the Merrimack River in Hillsborough and Merrimack counties is heavily urbanized and continuing to grow in human population and development. Continuing habitat conversion may degrade preferred habitat, fragment it into areas too

small to support the home range of an individual, increase encounters with humans and other generalist predators, and reduce the prey base of anurans that this species relays on.

(B) Evidence
Urbanization often converts hognose snake habitat to pavement and mown lawns. Eastern hognose snakes are also noted for having relatively large home ranges [in Arkansas, 21.4-72.8 ha, mean of 50.2 +/- 6.4 ha, and at times moving as much as 600 m at a time (Plummer and Mills 2000)]; conversion of habitat to standard New Hampshire 0.8 ha (2 acre) building lots thus has great potential to negatively affect this species. Amphibian populations, likely the primary prey for hognose snakes, are adversely impacted by wetland filling (especially vernal pools) and development of surrounding uplands, resulting from residential and commercial development. Other prey may be taken (Platt 1969) and it is not known to what extent eastern hognose snakes depend on amphibian prey in New Hampshire.

3.1.2 Transportation Infrastructure (Road mortality)

(A) Exposure Pathway
Hognose snakes probably have large home ranges in New Hampshire. Roads fragment habitat, increasing mortality as snakes are forced to cross roads on a more frequent basis. Hognose snakes are relatively slow moving and therefore vulnerable while crossing roadways.

(B) Evidence
Given the probable large home range requirements of this species and high road densities along the Merrimack River corridor, the opportunity for deadly encounters with automobiles is probably high. The number of snakes found dead on roads has been enumerated at other locations (Ashley and Robinson 1996, Enge and Wood 2002), but the degree to which road mortality threatens population viability in New Hampshire is largely unknown but expected for slow-moving species or those with large home ranges.

3.1.3 Unregulated take (killing and collection of individuals)

(A) Exposure Pathway
Many people have an irrational fear or hatred for snakes. The eastern hognose snake has an extensive threat display (Lazell and Michener 1976) and is a heavy bodied snake that is commonly misidentified as a dangerous species. Removal of individuals from an already small population can reduce population size. Small populations are subject to many problems that threaten viability including demographic and environmental stochasticity, genetic drift, and inbreeding depression (Meffe and Carroll 1997).

(B) Evidence
At least several individual hognose snakes have been killed and reported to the NHFG. However, there is no information on the frequency with which this species is killed or collected by humans.

3.2 Sources of Information

Literature reviews and knowledge/ experience with the eastern hognose snake and the Merrimack River region by the authors are the major sources of this information.

3.3 Extent and Quality of Data

Information regarding threats is based on literature reviews from other states or known condition of New Hampshire's rapidly changing landscape. Site-specific threats to hognose snakes in New Hampshire are unknown because of limited occurrence and condition information.

3.4 Threat Assessment Research

Developments proposed in known or potential hognose snake habitat should be assessed for the species presence. If a known threat is proposed or implemented near a known hognose snake location, the local population should be monitored to assess impacts (e.g., development, recreation, gravel/sand extraction). Also, a subset of hognose snake locations should be monitored to assess threat and viability.

Element 4: Conservation Actions

The most immediate step is to document the location and condition of existing hognose snake populations in New Hampshire. This information should be used to guide habitat protection and management and develop a detailed recovery/protection plan outlining specific research, management, land protection, and other potential actions (e.g., captive rearing). Conservation objectives and monitoring responses will be evaluated for this plan based on distribution and condition research. However, distribution and condition research can take many years. Therefore, it is critical that while this work occurs that known information is incorporated into current land protection and management and education and outreach.

4.1.1 Restoration, Management, and Habitat Protection

Increase coordination among those conducting restoration, management, and protection of Pine Barrens and other sandy outwash areas along the Merrimack River to ensure that habitat needs of hognose snakes are incorporated and threats are avoided. Land protection should focus on protecting large parcels within the range of hognose snakes and linking these areas with other suitable linear habitats (e.g., riparian, powerlines). Providing these linkages and large protected areas may be partially consistent with protection of other species of high conservation concern (e.g., New England cottontails, black racers).

4.1.2 Outreach and Education

People continue to kill snakes, including hognose snakes, out of fear and lack of knowledge of the species status. NHFG needs to increase education and outreach materials (newspaper articles, website development) to the public regarding the biology and status of this species. Also, the NHFG should promote maximizing native landscaping (rather than manicured mowed lawns) in residential developments (newly proposed and established).

4.1.3 Regulation and Policy

Avoid impacts to known hognose snake habitat (i.e., development, non-compatible recreational uses). Proposed developments in potential hognose habitat should be evaluated based on habitat suitability (size and quality), and distance to other known hognose locations. NHFG evaluates projects potentially impacting hognose snake; however, there is currently no mechanism for reviewing projects where there are no wetland impacts. Because hognose snakes often occur in dry habitats, this is extremely problematic. Therefore, the NHFG should coordinate with other regulatory agencies to review impacts to terrestrial habitats in addition to the existing wetland review (i.e., NHDES site-specific review process).

4.2 Conservation Action Research

Investigate the possibility of reestablishing hognose snakes in restored or protected habitats within the historic New Hampshire range. Habitat management occurring at known hognose snake locations should include a hognose snake monitoring component.

Element 5: References

5.1 Literature

Ashley, E. P., and J. T. Robinson. 1996. Road mortality of amphibians, reptiles and other wildlife on the Long Pond Causeway, Lake Erie, Ontario. Canadian Field-Naturalist 110:403-412.

Edgren, R. A. 1955. The natural history of the hog-nosed snakes, Genus Heterodon: A review. Herpetologica. 11:105-117.

Enge, K. M., and K. N. Wood. 2002. A pedestrian road survey of an upland snake community in Florida. Southeastern Naturalist 1:365-380.

Ernst, C. H. and E. M. Ernst. 2003. Snakes of the United States and Canada. The Smithsonian Institution. Washington, D.C., USA and London, England.

Fitzgerald, E. C. 1994. Habitat suitability index models for three threatened snake species in an urban county. Masters thesis. University of Missouri-Columbia.

Lazell, J. D., and M. C. Michener. 1976. This broken archipelago: Cape Cod and the islands, amphibians and reptiles. Quadrangle, New York Times Book Company, New York, USA.

Michener, M. C., and J. D. Lazell, Jr. 1989. Distribution and relative abundance of the eastern hognose

snake, *Heterodon platirhinos*, in eastern New England. Journal of Herpetology 23:35-40.

Meffe, G. K and C. R Carroll. 1997. Principles of Conservation Biology, 2nd ed. Sinauer, Sutherland, Massachusetts, USA

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.5. NatureServe. Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed August 2, 2005).

Oberkrieser, M. and J. A. Litvaitis. 2002. Status of the hognose snake in the Merrimack River drainage of New Hampshire. Final report submitted to the New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

Platt, D.R. 1969. Natural history of the hognose snakes, Heterodon platyrhinos and Heterodon nasicus. University of Kansas Publications, Museum of Natural History 18: 253-420.

Plummer, M. V. 2002. Observations on hibernacula and overwintering ecology of eastern hog-nosed snakes (*Heterodon platirhinos*). Herpetological Review. 33:89-90.

Plummer, M. V, and N.E. Mills. 2000. Spatial ecology and survivorship of resident and translocated hognose Snakes (*Heterodon platirhinos*). Journal of Herpetology 34: 556-575.

Society for the Protection of New Hampshire Forests. 2005. New Hampshire's Changing Landscape. Population growth and land use changes: what they mean for the Granite State. Executive Summary. Concord, New Hampshire, USA.

Stevens, M, ed.. 1998. An Assessment of the Biodiversity of New Hampshire with Recommendations for Conservation Action. Scientific Advisory Group, New Hampshire Ecological Reserve System Project, Concord New Hampshire, USA.

Taylor, J. 1993. The Amphibians and Reptiles of New Hampshire. New Hampshire Fish & Game, Concord, New Hampshire, USA.

Therres, G. D., Chairman of the Northeast Endangered Species and Wildlife Diversity Technical Committee. 1999. Wildlife species of regional conservation concern in the northeastern United States. Northeast Wildlife 54:93-100.

5.2 Data Sources:

NH Natural Heritage Bureau. 2005. Database of Rare Species and Exemplary Natural Community Occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

New Hampshire Reptile and Amphibian Reporting Program (RAARP). Coordinated by New Hampshire Fish & Game Department's Nongame & Endangered Species Program.

SPECIES PROFILE

Jefferson Salamander and Blue-Spotted Salamander

Ambystoma jeffersonianum and Ambystoma laterale

Federal Listing: Not listed
State Listing: Special Concern (Jefferson), Not listed (blue-spotted)
Global Rank: G4 (Jefferson), G5 (blue-spotted)
State Rank: S2S3 (Jefferson), S4 (blue-spotted)
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Element 1: Distribution and Habitat

1.1 Habitat Description

Jefferson Salamander

Jefferson salamanders breed in palustrine wetlands, but spend most of their lives in nearby forested uplands (Klemens 1993, Faccio 2003). Jefferson salamanders can breed in several types of palustrine wetlands (i.e. grassy pasture ponds, small impoundments filled by seasonal stream, and vernal shrub swamps), but favor vernal pools (Klemens 1993). High breeding success in vernal pools is attributed to the absence of fish predators. To sustain a viable Jefferson salamander population, these pools must hold standing water until late summer in most years, so that the salamander larvae have sufficient time to develop and metamorphose (Harding 1997). This species attaches its egg masses to vegetation and dead branches within the water column of the vernal pool.

Jefferson salamanders prefer deciduous forest, but also occur in mixed deciduous-hemlock forest (Klemens 1993). This species also seems to prefer steep rocky areas with rotten logs and heavy duff layers (Klemens 1993). It seeks cover and hibernates in small mammal burrows, coarse woody debris, leaf litter, and stones (Faccio 2003, Klemens 1993). Jefferson salamanders have been observed at elevations ranging up to 1,700 feet (Klemens 1993, USFS 2002).

Blue-Spotted Salamander

Blue-spotted salamanders breed in fresh-water wetlands but spend most of their lives in nearby forested uplands (Downs 1989, Klemens 1993, Knox 1999). Blue-spotted salamanders use many wetlands types for breeding, including ephemeral and semi-permanent pools, swamps, ponds, marshes, ditches, and flooded sections of logging roads (Downs 1989, Klemens 1993, Knox 1999). In Connecticut, this species breeds frequently in acidic red maple/sphagnum moss swamps but also occurs in calcareous wetlands (Klemens 1993). Where the ranges of the closely related Jefferson salamanders (*Ambystoma jeffersonianum*) and blue-spotted salamanders overlap, Jefferson salamanders prefer ridge-top vernal pools, whereas blue-spotted salamanders seem to prefer lowland swamps (Klemens 1993). To sustain a viable blue-spotted salamander population, a wetland must hold standing water until late summer in most years so that the salamander larvae have time to develop and metamorphose (Harding 1997). Water depth in breeding wetlands is usually less than 40 cm (Knox 1999). This species sometimes attaches its eggs (singly or in small clusters) to grass and other wetland vegetation (Klemens 1993).

For upland habitat, blue-spotted salamanders prefer damp, deciduous, or mixed woodlands with moderate shade (Downs 1989, Knox 1999). Blue-spotted salamanders are commonly found in water-saturated loamy soil and damp crumbly sand (Downs 1989, Klemens 1993). They seek cover under rocks, rotting stumps and logs, moss, vegetative debris, small mammal burrows, woodpiles, and human debris (Klemens 1993, Knox 1999).

General

The size and configuration of upland habitat needed to sustain Jefferson, blue-spotted, or hybrid populations are unknown. They may require large areas of

undisturbed upland forest connected by suitable dispersal corridors to maintain metapopulations (Semlitsch 1998, USFS 2002). Salamanders may migrate several hundred meters from their breeding pools into the adjacent uplands (Williams 1973, Faccio 2003, Carr Research Laboratory and Hyla Ecological Services 2003).

1.2 Justification

Blue-spotted salamanders and Jefferson salamanders are known to form hybrids. Populations of pure blue-spotted or Jefferson salamander populations are probably very rare; however, a pure male of either species (blue-spotted or Jefferson) is required for the production of viable offspring. Only a handful of individuals have actually been genotyped as pure blue-spotted in New Hampshire, and only one pure Jefferson salamander has ever been identified in New Hampshire. These species and their hybrids may be sensitive to habitat disturbance.

1.3 Protection and Regulatory Status

Jefferson salamanders, blue-spotted salamanders, and their hybrids are not specifically protected in New Hampshire, although their habitats receive some protection. See Vernal Pool and Marsh & Shrub Wetlands Profiles.

1.4 Population and Habitat Distribution

Jefferson Salamander

This "species" is limited to the eastern United States and Canada. It ranges from western New England to eastern Illinois, north to Ontario, and south to central Kentucky to Virginia to Maryland (Klemens 1993, DeGraaf and Yamasaki 2001). In New England, it occurs west of the Connecticut River in Vermont, Massachusetts, and Connecticut; and east of the Connecticut River in southwestern New Hampshire and Massachusetts (Klemens 1993, French and Master 1986). Despite the New England range, populations consisting only of pure Jefferson salamanders are known from Pennsylvania southward to Kentucky and West Virginia (NatureServe 2004, Conant and Collins 1998). The Jefferson genotype was found in hybrid individuals (carrying more blue-spotted than Jefferson chromosome sets) in central Maine (Knox 1999).

In New Hampshire, only one pure Jefferson salamander has ever been identified (using DNA analysis). This was a pure male from Winchester in Cheshire County identified in 1984 (French and Master 1986, Bogart and Klemens 1997). It is unknown whether this male represented a pure or mixed pure-hybrid population (Bogart and Klemens 1997). Jefferson salamanders have been reported to the RAARP program for other towns in New Hampshire but it is not known whether these individuals represent pure Jefferson salamanders or hybrids dominated by either Jefferson or blue-spotted salamander genomes.

Blue-spotted salamander

This "species" ranges from the maritime provinces of Canada to southeastern Manitoba, southward to northern Illinois, east to New York, then north along the Atlantic coast through New England (Klemens 1993, DeGraaf and Yamasaki 2001). Disjunct populations are located in New Jersey, Long Island (NY), Iowa, and Labrador (Klemens 1993, DeGraaf and Yamasaki 2001). In New England, it occurs widely throughout eastern and central Massachusetts, southeastern New Hampshire, Maine, and the Lake Champlain lowlands in Vermont (Klemens 1993). Scattered populations occur in southwestern New England, but the species does not occur on Cape Cod (Klemens 1993). Only 2 populations of pure (non-hybrid) blue-spotted salamanders are known (one on Prince Edward Island, Canada; the other on Long Island, New York; Knox 1999), though 5 others are suspected in Massachusetts and Connecticut (Bogart and Klemens 1997).

In New Hampshire, pure blue-spotted salamanders have been documented in Hollis (1 female), Rockingham County (2 females and a male), and Strafford County (1 female) (Bogart and Klemens 1997). Additionally, hybrid blue-spotted salamanders (blue-spotted genotype dominant or equal to the Jefferson genotype) were reported in Hollis (4 females), Rockingham County (six females and an unsexed individual), and Strafford County (2 females) (Bogart and Klemens 1997). Taylor (1993) also reported several blue-spotted salamanders (pure or hybrid) observations from Strafford County, Rockingham County, and Hillsborough County, and 1 observation from Coos County. However, Taylor (1993) and Bogart and Klemens (1997) may have been reporting

some of the same individuals. Some of these individuals were museum specimens and may actually be historic records. Finally, RAARP has received several reports of blue-spotted salamander observations, but these reports do not distinguish between pure and hybrid salamanders. These reports are primarily from Rockingham and Strafford counties, but a couple of the reports are from Hillsboro,Cheshire , Coos and Merrimack counties.

Hybrids
Most of the individuals across the range of both species are likely hybrids (Klemens 1993). To produce viable offspring, hybrids must mate with a pure male of either parent species. Thus, pure diploid Jefferson salamander and blue-spotted salamander males are likely present throughout parts of New England, but the exact distribution of the pure genotype is unknown (Bogart and Klemens 1997).

Local populations of blue-spotted salamanders, Jefferson salamanders, and their associated hybrids, where they exist in New Hampshire, will be clustered in relatively undisturbed forest uplands around temporary and semi-permanent pools and other palustrine wetlands. Such a habitat mosaic, of palustrine wetlands embedded in forested upland, is common throughout New Hampshire but is increasingly fragmented by human development, especially in the southern portion of the state.

1.5 Town Distribution Map

1.6 Habitat Map
N/A

1.7 Sources of Information

Information relating to the distribution of this species was gathered during a literature review. Two primary sources of information and references were DeGraaf and Yamasaki (2001) and the "Species Data Collection Form" completed by the USFS (Wright and Marchand 2002); the latter included information from state databases, meetings, and expert reviews.

1.8 Extent and Quality of Data

No comprehensive survey has been conducted for these species in New Hampshire. Much of the existing distributional data for New Hampshire is unreliable because it does not distinguish between pure Jefferson salamanders, blue spotted salamanders, and their hybrids. The work of Bogart and Klemens (1997), which genetically identified 18 pure/hybrid blue-spotted salamanders from New Hampshire, is highly accurate, but of limited quantity. Regional distribution maps suggest that the species may be present throughout the state.

1.9 Distribution Research

Basic distribution data is lacking for Jefferson salamanders. Since this species is listed as imperiled/vulnerable in New Hampshire (i.e., state rank code = S2/S3) it may merit a statewide survey. Pure Jefferson salamanders may be present in southern Vermont and Ontario. Current distribution data are also lacking for blue-spotted salamanders. Blue-spotted salamanders may occur in relatively high densities in southern New Hampshire and have been documented in northern New Hampshire (Taylor 1993). It is present throughout Maine and is reported from southeastern Canada. Statewide surveys should be conducted for both species and their hybrids. This survey should distinguish (genetically) between pure and hybrid blue-spotted salamanders so that distribution maps can be drawn for pure populations, populations where pure forms and hybrids coexist, and hybrid populations that lack pure genotypes.

Element 2: Species/Habitat Condition

2.1 Scale

There are insufficient data from which to determine species condition.

2.2 Relative Health of Populations

There are insufficient data from which to determine the relative health of populations.

2.3 Population Management Status

Jefferson salamanders, blue-spotted salamanders, and their hybrids are not specifically protected or managed. No management plan exists for the population

from which the only pure Jefferson salamander was collected (see section 1.4).

2.4 Relative Quality of Habitat Patches

There are insufficient data from which to determine the relative quality of habitat patches.

2.5 Habitat Patch Protection Status

There are insufficient data from which to determine the habitat patch protection status.

2.6 Habitat Management Status

Salamander habitat is indirectly managed through wetland and water resource protection, forestry management regulations (i.e., New Hampshire RSA 482-A; New Hampshire Rule Chapters Wt 100-800; Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire), and through land preservation (e.g., conservation restrictions and land acquisitions).

These efforts are not specifically designed to manage for salamanders. Population growth and associated development will likely destroy or degrade potential habitat, despite measures aimed at slowing and redirecting development. Additionally, some forest management techniques (e.g., clear cutting) could also contribute to the fragmentation and degradation of potential habitat (deMaynadier and Hunter 1999, Pough and Wilson 1976 cited in DeGraaf and Yamasaki 2001, Faccio 2003).

Basic distribution and habitat use data for the species is needed to develop effective habitat management plans. In the absence of this basic data, habitat management efforts might focus on limiting disturbance in and around vernal pools that are embedded within a relatively large matrix of minimally disturbed forest. The goal of habitat management efforts should be to maintain habitat patches that allow for metapopulation dynamics (i.e., multiple pool/upland patches connected by dispersal habitat). Thus, the usefulness (to salamanders) of pool buffer zones and dispersal corridors between habitat patches needs to be evaluated.

2.7 Sources of Information

Information was gathered from published literature and New Hampshire laws and administrative codes. Two primary sources of information were DeGraaf and Yamasaki (2001) and Wright and Marchand (2002); the latter source included information from state databases, meetings, and expert reviews.

2.8 Extent and Quality of Data

See Section 1.8 above. Little is known about the extent and locations of Jefferson salamanders or blue-spotted salamanders in New Hampshire.

2.9 Condition Assessment Research

1. New Hampshire needs basic surveys to determine the presence and distribution of pure and hybrid Jefferson/blue-spotted salamanders. It may help to first delineate its potential habitat. A GIS habitat layer could be produced using remote sensing (e.g., aerial photography) and ground truthing. Potential habitat should be determined by comparing a vernal pool data layer to a forest cover data layer.

2. If pure populations are discovered, habitat, life history, and dispersal data should be collected. Scientists can then assess the effects of development, forest management, and other activity on local populations.

3. To assist in understanding habitat use and population health, surveys should record or consider the following:

- Stability of the sub-population and/or metapopulation(s)
- Potential for genetic exchange between local populations
- Incidence of physical malformations
- Water quality within the breeding wetlands
- Length and inter-annual variability of breeding wetland hydroperiods
- Real and potential fish presence/absence within the breeding wetlands
- Proximity of the habitat patch to other potential habitat patches
- Proximity of the habitat to roads, development, and other disturbances
- Size and configuration of upland habitat

Element 3: Species and Habitat Threat Assessment

3.1.1 Development (Habitat Loss and Conversion)

See Vernal Pool habitat profile, section 3.1.1

3.1.2 Transportation Infrastructure (Mortality, Fragmentation, Dispersal Barriers)

See Vernal Pools habitat profile, section 3.1.2

3.1.3 Development (Habitat Loss and Conversion)

See Vernal Pools habitat profile, section 3.1.3

3.1.4 Unsustainable Harvest (Forestry Operations and Management)

See Vernal Pool Habitat Profile, section 3.1.4

3.1.5 Non-Point Source Pollution (Chemical Contaminants, Nutrients (Eutrophication))

(A) Exposure Pathway
Chemical toxins include mercury, pesticides, herbicides, fungicides, gasoline, oil, cleaning products, and many other substances that are not naturally found, or are not naturally found in such high concentrations. These toxins reach wetlands via atmospheric deposition, surface or subsurface runoff, or direct deposition. Fertilizers can leach into soil and ground and surface water and eventually arrive in wetlands where it may cause algal and bacterial blooms.

(B) Evidence
A limited number of studies have explored the effects of toxins on ambystomatids that occur in eastern North America. Generally, studies show that toxins affect hatching success, growth and development, behavior, frequency of deformities, and mortality (Boone and Semlitsch 2001, Bridges 1997, Howard et al. 2002, Hatch and Burton 1998). These effects can vary with species and ecological context (Sparling et al. 2001). Through a variety of mechanisms, toxins and other threats (e.g., UV-B radiation and low pH), may act synergistically to amplify harm to amphibians (Kagan et al. 1984, Hatch and Burton 1998, Zaga et al. 1998, Monson et al. 1999, Blaustein et al. 2001). Toxins may also harm prey resources, which might also affect survival and fecundity.

Algal and bacterial blooms (as well as the fertilizers themselves) may be toxic to salamanders or cause anoxia, which affects salamanders or prey resources. Larvae often exhibit decreased feeding and swimming activity, and increased disequilibrium, paralysis, incidence of abnormalities and edemas, and mortality (Marco et al. 1999, Baker and Waights 1994). Terrestrial phases of these species may alter feeding behavior in the presence of nitrogenous fertilizers (e.g., Hatch et al. 2001). Fertilizers may have a synergistic effect with other threats, such as low pH (Hatch and Blaustein 2000). Farm fertilizer use, lawn-care fertilizer use, and human septic/farm animal manure disposal may affect salamanders differently based on the ratios of their component nutrients and their application rates.

3.1.6 Acid Deposition

(A) Exposure Pathway
Acid rain and contaminated runoff and discharge may increase soil and water acidity within salamander habitat.

(B) Evidence
Mole salamanders exhibited a decreased hatching success, larval survival, embryonic developmental rates, and abundance of egg masses at low water pH levels (Pough 1976, Rowe et al. 1992, Rowe and Dunson 1993, Horne and Dunson 1994a, 1994b). Swimming activity of blue-spotted salamanders decreased with decreasing pH (Kutka 1994). Similarly negative effects of low water pH have been observed in other amybstomatids and amphibian species (as summarized in Kiesecker 1996). Additionally, metal mobility, and hence toxicity of metals to salamanders, changes with pH (Rowe et al. 1992, Rowe and Dunson 1993, Horne and Dunson 1994b, Horne and Dunson 1995a, 1995b). Research with other amphibians has demonstrated a negative synergistic interaction between low pH and other threats (e.g., UV-B radiation; Long et al. 1995, Hatch and Blaustein 2000).

Low soil pH may lead to increased desiccation among terrestrial salamanders, and terrestrial salamanders may avoid habitat that has acidic soil. Jefferson salamanders experienced reduced whole body water and Na^+ concentrations at increased soil acidity, and preferentially chose substrates with higher

pH (Horne and Dunson 1994a). In the same study, pH of pond water and adjacent soil were highly correlated (Horne and Dunson 1994a). Wyman (1988) also found that spotted salamander distribution was significantly influenced by soil pH.

3.1.7 Scarcity (Hybridization)

(A) Exposure Pathway
Jefferson-blue-spotted salamander hybrids may come to dominate salamander populations where pure Jefferson salamanders are also present (see section 1.4). Through competition with hybrids or with pure blue-spotted salamanders, or through local extinction events, pure Jefferson salamanders may be eliminated, and thus, the species as a pure lineage may go extinct.

(B) Evidence
Jefferson and blue-spotted salamanders hybridize throughout much of their range (Conant and Collins 1998), and other hybrid combinations occur at the western extent of the Jefferson range (Bogart and Klemens 1997). Changes in regional climate, caused by global warming, may facilitate future range overlap. Hybrid populations seem unsustainable without sexual stimulation from pure males, but the pure genome is either not, or only temporarily, incorporated into the lineage (Bogart and Klemens 1997). Hybrids are usually dominant where they are present (Bogart and Klemens 1997). Hybrids may be better adapted to a wider range of habitats and environmental conditions than either parent species.

Hybridization is viewed as a very serious threat by the research and conservation communities (see Wright and Marchand 2002). However, hybridization seems a natural evolutionary step for two species that recently diverged due to temporary geographic isolation (for evolutionary history, see Bogart and Klemens 1997). Were this evolution untouched by human influence, both or either species might still go extinct. Alternatively, they might re-merge into a single species, or survive as two species. The threat is more the potential for human influence to impact this process (i.e., through habitat destruction and fragmentation), than the hybridization itself.

3.2 Sources of Information

Information about threats was compiled from an extensive literature review and from personal communications and observations.

3.3 Extent and Quality of Data

The genetic and reproductive mechanisms of hybridization and the effects of low pH on ambystomatid salamanders are well documented. The impacts of other threats are less well documented. However, some threats (e.g., road effects, logging) have been well documented for other similar species.

3.4 Threat Assessment Research

Additional research is needed to establish and thoroughly detail the specific effects of most of these threats (except effects of low pH). Yet foremost, New Hampshire needs a systematic survey to determine the distribution of blue-spotted and Jefferson salamanders.

Element 4: Conservation Actions

Refer to the Vernal Pools habitat profile for a complete list of conservation actions that are intended to protect vernal pools and vernal pool wildlife.

4.1.1 Amphibian Migration Facilitation, Restoration and Management/Education and Outreach

(A) Direct Threats
Transportation Infrastructure (Mortality, Fragmentation, Dispersal Barriers)

(B) Justification
Roads may often cut across major amphibian migration routes, although often in small, spatially discrete areas. In this context, "amphibian" refers to species such as spotted salamanders, Jefferson salamanders, blue-spotted salamanders, marbled salamanders, wood frogs, and spring peepers that migrate en masse from upland landscapes to vernal pools in the spring. Roads threats to amphibian populations are increasing in New Hampshire, as development in the state accelerates (Sundquist and Stevens 1999). Installing tunnels beneath roads that intersect amphibian migration routes will facilitate dispersal. Road signs may alert drivers to the possibility of migrating am-

phibians and lessen amphibian mortality caused by traffic. Community education may further decrease the threat of road traffic to migrating amphibians. Community members can help salamanders cross roads and witness the migrations at these locations (see Jackson 1996, 2003, Jackson and Tyning 1989).

(C) Conservation Performance Objective:
The objective is to reduce the impacts of roads on amphibian population and metapopulation dynamics, and thus maintain viable populations of breeding amphibians.

(D) Performance Monitoring:
Potential indicators that can be easily monitored include:

- Number of road-killed salamanders where roads cross migration routes, before and after tunnels have been installed
- Nightly counts of migrating animals during peak migration (warm rainy nights during March-May)
- Number of salamanders and other amphibians observed crawling through installed tunnels
- Egg mass abundance before and after tunnels have been installed

Overall, road kills are expected to be negatively correlated with egg mass abundance, despite normal annual fluctuations in salamander breeding population size and egg production. Tunnels should increase migration success, leading to an increase in successful breeding.

(E) Ecological Response Objective
The short-term objective of installing tunnels and facilitating migration is to increase migration success and thus the breeding pool of amphibians. If new roads and tunnels are installed simultaneously, then the objective is to have no effect on breeding populations.

(F) Response Monitoring
If feasible, baseline population growth rates of target species could be established prior to migration facilitation, and then changes in population growth rates following migration facilitation could be used as a response indicator. However, amphibian populations fluctuate naturally from year to year, so monitoring efforts should continue for several years (five or more) to try to differentiate actual response from natural variation. Comparison of growth rates, counts of road mortality, nightly migration surveys, and use of tunnels should elucidate the effect of the conservation action.

(G) Implementation
- Locate intersections between roads and amphibian migration routes
- Determine pre-facilitation road kill frequencies and growth rates (i.e., conduct road kill and egg mass surveys)
- Implement migration facilitation program (i.e., migration tunnels, road signs, volunteer observers).
- After facilitation implementation, determine annual road kill frequencies and growth rates
- Monitoring growth rates and road kill frequencies until they have stabilized or are consistently positive
- Continue migration facilitation unless it is deemed unnecessary ineffective

Facilitation activities could be coordinated at the state level by a government, non-profit, or consulting group. Facilitation could alternatively be implemented and monitored at the municipal level. Volunteers should be trained and utilized to perform much of this conservation action.

(H) Feasibility
It is possible to implement this conservation action wherever volunteers are willing to help amphibians cross roads. Installation of tunnels and signs will require funding. This action is likely to improve the success of amphibian road crossings.

4.2 Conservation Action Research

Critical holes exist in knowledge of blue-spotted and Jefferson salamanders in New Hampshire. This general lack of knowledge bars the confident prescription of conservation actions. The first step is to conduct a statewide survey. Survey sites can be selected using aerial photographs and GIS data layers (as has been done in Massachusetts; contact the Massachusetts Natural Heritage Program at: natural.heritage@state

.ma.us), as well as local knowledge. Surveys should target adults, eggs, or larvae. Genotypes must be analyzed to confirm the genetic identity of individuals; thus, surveyors must clip toes of captured animals or gather eggs for DNA analysis.

Maintaining vernal pool habitat, upland habitat, and dispersal corridors will be the most effective way to protect Jefferson salamanders, if populations exist in New Hampshire. Research should address:

- Dispersal capability in both undisturbed and variously disturbed (e.g., suburbia, forest clearcuts) habitats
- Degree of isolation and regional persistence mechanism of local populations in New Hampshire and neighboring states
- Threats to the species

Research should be used to develop specific conservation actions and best management practices for this species. Such a conservation management plan should be developed in cooperation with those neighboring states and provinces that also contain the species.

Element 5: References

5.1 Literature

Ash, A.N., and K.H. Pollock. 1999. Clearcuts, salamanders, and field studies. Conservation Biology. 13: 206-208.

Ashley, E.P., and J.T. Robinson. 1996. Road mortality of amphibians, reptiles and other wildlife on the Long Point Causeway, Lake Erie, Ontario. Canadian Field-Naturalist. 110: 403-412.

Baker, J.M.R., and V. Waights. 1994. The effects of nitrates on tadpoles of the treefrog (*Litoria caerulea*). Herpetological Journal .4: 106-108.

Barbour, R.W. 1971. Amphibians and reptiles of Kentucky. University Press of Kentucky, Lexington.

Blaustein, A.R., L.K. Belden, A.C. Hatch, L.B. Kats, P.D. Hoffman, J.B. Hays, A. Marco, D.P. Chivers, and J.M. Kiesecker. 2001. Ultraviolet radiation and amphibians. Pages 63-79 *in* C.S. Cockell and A.R. Blaustein, editors. Ecosystems, Evolution, and Ultraviolet Radiation. Springer, New York.

Blaustein, A.R., and J.M. Kiesecker. 2002. Complexity in conservation: lessons from the global decline of amphibian populations. Ecology Letters. 5: 597-608.

Bogart, J.P., and M.W. Klemens. 1997. Hybrids and genetic interactions of mole salamanders (*Ambystoma jeffersonianum* and *A. laterale*) (Amphibia: Caudata) in New York and New England. American Museum Novitates 3218. New York: American Museum of Natural History.

Boone, M.D., and R.D. Semlitsch. 2001. Interactions of an insecticide with larval density and predation in amphibian experimental communities. Conservation Biology. 15: 228-238.

Bridges, C.M. 1997. Tadpole swimming performance and activity affected by acute exposure to sublethal levels of carbaryl. Environmental Toxicology and Chemistry. 16: 1935-1939.

Brown, S. 1999. Effectiveness of compensatory wetland mitigation in Massachusetts. Assoc. Mass. Wetland Sci. Newsletter. 20: 5.

Chazal, A.C., and P.H. Niewiarowski. 1998. Responses of mole salamanders to clearcutting: using field experiments in forest management. Ecological Applications. 8: 1133-1143.

Conant, R., and J.T. Collins. 1998. A field guide to reptiles and amphibians of eastern and central North America. Third edition, expanded. Houghton Mifflin Company, Boston, Massachusetts, USA.

DeGraaf, R.M., and M. Yamasaki. 2001. New England wildlife: habitat, natural history, and distribution. University Press of New England, Hanover, New Hampshire.

deMaynadier, P.G., and M.L. Hunter. 2000. Road effects on amphibian movements in a forested landscape. Natural Areas Journal. 20: 56-65.

deMaynadier, P.G., and M.L. Hunter. 1999. Forest canopy closure and juvenile emigration by pool-breeding amphibians in Maine. Journal of Wildlife Management. 63: 441-450.

Faccio, S.D. 2003. Postbreeding emigration and habitat use by Jefferson and spotted salamanders in Vermont. Journal of Herpetology. 37: 479-489.

Fahrig, L., J.H. Pedlar, S.E. Pope, P.D. Taylor, and J.F. Wegner. 1995. Effect of road traffic on amphibian density. Biological Conservation. 73: 177-182.

Forman, R.T.T., and R.D. Deblinger. 2000. The ecological road-effect zone of a Massachusetts (U.S.A.) suburban highway. Conservation Biology. 14: 36-46.

Freda, J. and W.A. Dunson. 1986. Effects of low pH and other chemical variables on the local distribution of amphibians. Copeia. 1986: 454-466.

French, T.W., and L.L. Master. 1986. Geographic distribution: *Ambystoma jeffersonianum* (Jefferson salamander). Herpetological Review. 17: 26.

Gibbs, J.P. 1998a. Distribution of woodland amphibians along a forest fragmentation gradient. Landscape Ecology. 13: 263-268

Gibbs, J.P. 1998b. Amphibian movements in response to forest edges, roads, and streambeds in southern New England. Journal of Wildlife Management. 62: 584-589.

Harding, J.H. 1997. Amphibians and reptiles of the Great Lakes region. The University of Michigan Press, Ann Arbor.

Harper, C.A., and D.C. Guynn, Jr. 1999. Factors affecting salamander density and distribution within four forest types in the Southern Appalachian Mountains. Forest Ecology and Management. 114: 245-252.

Hatch, A.C., L.K. Belden, E. Scheessele, and A.R. Blaustein. 2001. Juvenile amphibians do not avoid potentially lethal levels of urea on soil substrate. Environmental Toxicology and Chemistry. 20: 2328-2335.

Hatch, A.C., and A.R. Blaustein. 2000. Combined effects of UV-B, nitrate, and low pH reduce the survival and acticity level of larval Cadcades frogs (*Rana cascadae*). Archives of Environmental Contamination and Toxicology. 39: 494-499.

Hatch, A.C. and G.A. Burton, Jr. 1998. Effects of photoinduced toxicity of fluoranthene on amphibian embryos and larvae. Environmental Toxicology and Chemistry. 17: 1777-1785.

Horne, M.T., and W.A. Dunson. 1994a. Behavioral and physiological responses of the terrestrial life stages of the Jefferson salamander, *Ambystoma jeffersonianum*, to low soil pH. Archives of Environmental Contamination and Toxicology. 27: 232-238.

Horne, M.T., and W.A. Dunson. 1994b. Exclusion of the Jefferson salamander, *Ambystoma jeffersonianum*, from some potential breeding ponds in Pennsylvania: effects of pH, temperature, and metals on embryonic development. Archives of Environmental Contamination and Toxicology. 27: 323-300.

Horne, M.T., and W.A. Dunson. 1995a. Toxicity of metals and low pH to embryos and larvae of the Jefferson salamander, *Ambystoma jeffersonianum*. Archives of Environmental Contamination and Toxicology. 29: 110-114.

Horne, M.T., and W.A. Dunson. 1995b. Effects of low pH, metals, and water hardness on larval amphibians. Archives of Environmental Contamination and Toxicology. 29: 500-505.

Howard, J.H., S.E. Julian, and J. Ferrigan. 2002. Golf course design and maintenance: impacts on amphibians. USGA Turfgrass and Environmental Research Online. 1: 1-21.

Jackson, S.D. 2003. Proposed design and considerations for use of amphibian and reptile tunnels in New England. Department of Natural Resources Conservation, University of Massachusetts at Amherst, Amherst.

Jackson, S.D. 1996. Underpass systems for amphibians. *In* G.L. Evink, P. Garrett, D. Zeigler, and J. Berry, editors. Trends in Addressing Transportation Related Wildlife Mortality: Proceedings of the Transportation Related Wildlife Mortality Seminar; FL-ER-58-96. State of Florida Department of Transportation, Tallahassee.

Jackson, S.D., and T.F. Tyning. 1989. Effectiveness of drift fences and tunnels for moving spotted salamanders (*Ambystoma maculatum*) under roads. Pages 93-99 *in* T.E.S. Langton, editor. Amphibians and Roads: Proceedings of the Toad Tunnel Conference. ACO Polymer Products, Shefford, England.

Joly, O., C. Miaud, A. Lehmann, and O. Grolet. 2001. Habitat matrix effects on pond occupancy in newts. Conservation Biology. 15: 239-248.

Kagan, J., P.A. Kagan, and H.E. Buhse, Jr. 1984. Light-dependent toxicity of alpha-terthienyl and anthracene toward late embryonic stages of *Rana pipiens*. Journal of Chemical Ecology. 10: 1115-1122.

Kiesecker, J.M. 1996. pH induced growth reduction and its effects on predator-prey interactions between *Ambystoma tigrinum* and *Pseudacris triseriata*. Ecological Applications. 6: 1325-1331.

Klemens, M.W. 1993. Amphibians and reptiles of Connecticut and adjacent regions. Bull. 112. Hartford: Connecticut State Geological and Natural History Survey.

Knapp, S.M., C.A. Haas, and D.N. Harpole. 2003. Initial effects of clearcutting and alternative silvicultural practices on terrestrial salamander abundance. Conservation Biology. 17: 752-762.

Knox, C.B. 1999. Blue-spotted salamander. *In* M.L. Hunter, A.J.K. Calhoun, and M. McCollough, editors. Maine Amphibians and Reptiles. The University of Maine Press, Orono.

Kutka, F.J. 1994. Low pH effects on swimming activity of *Ambystoma* salamander larvae. Environmental Toxicology and Chemistry. 13: 1821-1824.

Lefcort, H., K.A. Hancock, K.M. Maur, D.C. Rostal. 1997. The effects of used motor oil, silt, and the water mold *Saprolegnia parasitica* on the growth and survival of mole salamanders (Genus *Ambystoma*). Environmental Contamination and Toxicology. 32: 383-388.

Long, L.E., L.S. Saylor, M.E. Soule. 1995. A pH/UV-B synergism in amphibians. Conservation Biology. 9: 1301-1303.

Marco, A., C. Quilchano, and A.R. Blaustein. 1999. Sensitivity to nitrate and nitrite in pond-breeding amphibians from the Pacific Northwest. Environmental Toxicology and Chemistry. 18: 2836-2839.

Mazerolle, M.J. 2004. Amphibian road mortality in response to nightly variations in traffic intensity. Herpetologica. 60: 45-53.

McLeod, R.F., and J.E. Gates. 1998. Response of herpetofaunal communities to forest cutting and burning at Chesapeake Farms, Maryland. American Midland Naturalist. 139: 164-177.

Monson, P.D., D.J. Call, D.A. Cox, K. Liber, and G.T. Ankley. 1999. Photoinduced toxicity of fluoranthene to northern leopard frogs (*Rana pipiens*). Environmental Toxicology and Chemistry. 18: 308-312.

Naughton, G.P., C.B. Henderson, K.R. Foresman, and R.L. McGraw. 2000. Long-toed salamanders in harvested and intact Douglas-fir forests of western Montana. Ecological Applications. 10: 1681-1689.

Oliver, J.A., and J.R. Bailey. 1939. Amphibians and reptiles of New Hampshire exclusive of marine forms: Pages 195-217 *in* Biological Survey of the Connecticut Watershed. New Hampshire Fish and Game Department Survey Rep. 4.

Pechmann, J.H.K., R.A. Estes, D.E. Scott, and J.W. Gibbons. 2001. Amphibian colonization and use of ponds created for trial mitigation of wetland loss. Wetlands. 21: 93-111.

Petranka, J.W. 1999. Recovery of salamanders after clearcutting in the southern Appalachians: a critique of Ash's estimates. Conservation Biology. 13: 203-205.

Petranka, J.W. 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington D.C.

Petranka, J.W., M.P. Brannon, M.E. Hopey, and C.K. Smith. 1994. Effects of timber harvesting on low elevation populations of southern Appalachian salamanders. Forest Ecology and Management. 67: 135-147.

Petranka, J.W., M.E. Eldridge, K.E. Haley. 1993. Effects of timber harvesting on Southern Appalachian salamanders. Conservation Biology. 7: 363-370.

Pough, F.H. 1976. Acid precipitation and embryonic mortality of spotted salamanders, *Ambystoma maculatum*. Science. 192: 68-70.

Raymond, L.R., and L.M. Hardy. 1990. Demography of a population of *Ambystoma talpoideum* (Caudata: *Ambystomatidae*) in north-western Louisiana. Herpetologica. 46: 371-382.

Rothermel, B.B. and R.D. Semlitsch. 2002. An experimental investigation of landscape resistance of forest versus old-field habitats to emigrating juvenile amphibians. The Journal of the Society for Conservation Biology. 16: 1324.

Rowe, C.L., W.J. Sadinski, and W.A. Dunson. 1992. Effects of acute and chronic acidification on three larval amphibians that breed in temporary ponds. Archives of Environmental Contamination and Toxicology. 23: 339-350.

Rowe, C.L., and W.A. Dunson. 1993. Relationships among abiotic parameters and breeding effort by three amphibians in temporary wetlands of central Pennsylvania. Wetlands. 13: 237-246.

Shoop, R.C., and T.L. Doty. 1972. Migratory orientation by marbled salamanders (*Ambystoma opacum*) near a breeding area. Behavioral Biology. 7: 131-136.

Semlistch, R.D., D.E. Scott, J.H.K. Pechmann, and J.W. Gibbons. 1993. Phenotypic variation in the arrival time of breeding salamanders: individual repeatability and environmental influences. Journal of Animal Ecology. 62: 334-340.

Semlitsch, R.D. 1998. Biological delineation of terrestrial buffer zones for pond-breeding salamanders. Conservation Biology. 12: 1113-1119.

Sparling, D.W., G.M. Fellers, and L.L. McConnell. 2001. Pesticides and amphibian population declines in California, USA. Environmental Toxicology and Chemistry. 20: 1591-1595.

Sundquist, D., and M. Stevens. 1999. New Hamp-

shire's changing landscape: population growth, land use conversion, and resource fragmentation in the Granite State. New Hamphire, Concord, Society for the Protection of New Hampshire Forests and The Nature Conservancy, 159 pp.

U.S. Forest Service. 2002. Green Mountain National Forest /White Mountain National Forest species viability evaluation expert panel notes on the Jefferson salamander (*Ambystoma jeffersonianum*). Panel held 25 June 2002, Manchester, NH.

Uzzel, T.M. 1964. Relations of the diploid and triploid species of the *Ambystoma jeffersonianum* complex (Amphibia: Caudata). Copeia. 1964: 257-300.

Vasconselos, D., and A.J.K. Calhoun. 2004. Movement patterns of adult and juvenile *Rana sylvatica* (LeConte) and *Ambystoma maculatum* (Shaw) in three restored seasonal pools in Maine. Journal of Herpetology. 38: 551-561.

Williams, P.K. 1973. Seasonal movements and population dynamics of four sympatric mole salamanders, genus *Ambystoma*. Ph.D. dissertation. Indiana University.

Windmiller, B.S. 1996. The Pond, the forest, and the city: spotted salamander ecology and conservation in a human-dominated landscape. Dissertation, Tufts University, Medford, Massachusetts, USA.

Wright, K., and M. Marchand. 2002. Species Data Collection Form: *Ambystoma jeffersonianum*. White Mountain Species Assessment..

Wyman, R.L. 1988. Soil acidity and moisture and the distribution of amphibians in five forests of south-central New York. Copeia. 1988: 394-399.

Zaga, A., E.E. Little, C.F. Rabeni, and M.R. Ellersieck. 1998. Photoenhanced toxicity of a carbamate insecticide to early life stage anuran amphibians. Environmental Toxicology and Chemistry. 17: 2543-2553.

SPECIES PROFILE

Marbled Salamander

Ambystoma opacum

Federal Listing: Not listed
State Listing: Endangered
Global Rank: G5
State Rank: S1
Authors: Kimberly J. Babbitt and Jessica S. Veysey, University of New Hampshire

Element 1: Distribution and Habitat

1.1 Habitat Description

Marbled salamanders breed in seasonally flooded, palustrine wetlands, but spend most of their lives in the forested uplands surrounding these wetlands (Noble and Brady 1933, Bishop 1941, Petranka 1989, Klemens 1993). Marbled salamanders use several types of palustrine wetlands (e.g., ephemeral pools and streams, fishless swamps, ponds with low water levels) for breeding and nesting (Noble and Brady 1933, Bishop 1941, Petranka 1989). Eggs are laid along the exposed edges of the wetlands, and wetlands must flood in the late fall or early winter in order for eggs to hatch (Bishop 1941, Petranka 1989). Salamanders hide nests, usually in bare mineral soil, beneath leaf litter, grass clumps, or logs, or within root complexes (Jackson et al. 1989, Petranka 1990, Figiel and Semlitsch 1995). To sustain a viable marbled salamander population, a wetland must hold standing water for about 10 months in most years (approximately September to June), so that the salamander larvae have sufficient time to develop and metamorphose (Noble and Brady 1933, Bishop 1941).

For upland habitat, marbled salamanders seem to prefer deciduous or mixed-deciduous woodlands (Klemens 1993), especially oak-maple and oak-hickory woods (Minton 1972) and floodplain forests (Petranka 1998). Marbled salamanders also seem to favor dry, friable soils, including sand and gravel deposits and rocky slopes (Bishop 1941, Klemens 1993). Marbled salamanders can inhabit somewhat drier areas than other *Ambystoma* species (Bishop 1941). Marbled salamanders use deeply imbedded rocks or logs (Klemens 1993) as cover objects, and probably use small mammal burrows as shelter throughout most of the year and as hibernacula in the winter (DeGraaf and Yamasaki 2001, Smyers et al. 2002). In Connecticut, this species was observed at elevations ranging from 30 to 335 m (Klemens 1993).

The area and configuration of upland habitat needed to sustain a marbled salamander population is unknown, but probably varies according to local site conditions. This species likely operates as metapopulations, which require a multitude of habitat patches (i.e., breeding wetland and adjacent upland forest) connected by habitat that is hospitable to dispersing salamanders, in order to persist (Semlitsch 1998). At the local population level, salamanders in Indiana migrated an average distance of 194 m (range 0- 450 m) from breeding wetlands into the surrounding uplands (Williams 1973 as cited in Semlitsch 1998).

1.2 Justification

The marbled salamander is at the northern periphery of its range in New Hampshire and is the rarest amphibian species in the state. Few documented occurrences of the species exist for New Hampshire; however, a systematic survey to determine the location of all potential populations has not been conducted. The southern distribution of this species in the state, together with intensive developmental pressure in the same area, places this species at significant risk of extirpation.

1.3 Protection and Regulatory Status

The marbled salamander is listed as Endangered un-

der the New Hampshire Endangered Species Conservation Act (RSA 212-A). See the vernal pools habitat profile for regulations of vernal pool habitat.

1.4 Population and Habitat Distribution

The marbled salamander is endemic to the eastern half of the United States. It ranges from southern New Hampshire, west through southeastern New England and Pennsylvania to the Lake Michigan region, and south to eastern Texas and northern Florida (Klemens 1993, DeGraaf and Yamasaki 2001, NatureServe 2004). In New England, this species occurs throughout Connecticut, Rhode Island, Massachusetts east of the Connecticut River, and in the Berkshire Hills of western Massachusetts (Klemens 1993, DeGraaf and Yamasaki 2001). One specimen was collected from western Vermont (DeGraaf and Yamasaki 2001).

Historically, marbled salamanders were reported from Milford (Hoopes 1938) and Hollis (NHNHB 1965), both in Hillsborough County south-central New Hampshire. Records from RAARP (2005) indicated that a marbled salamander was observed in Hinsdale, Cheshire County in 2000 (photo verified), and another was possibly observed in Hollis in 1997 (no photo or specimen but near location of historic report). A statewide survey and more recent documentation of this species are lacking.

Populations of marbled salamanders, where they exist in New Hampshire, will likely be clustered in relatively undisturbed forest uplands around temporary and seasonally flooded wetlands. Such a habitat mosaic, of seasonally-flooded wetlands embedded in forested upland, is common throughout much of New Hampshire, but is increasingly fragmented by human development, especially in the southern portions of the state, which is where this species is most likely to occur.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

Known sites were mapped (historic and recent). A potential habitat map was not created for this species.

1.7 Sources of Information

Information relating to the distribution of this species was gathered through an extensive literature review.

1.8 Extent and Quality of Data

No comprehensive survey has been conducted for this species in New Hampshire. The species was known to occur in southern New Hampshire historically (Hoopes 1938, Taylor 1993) and the New Hampshire RAARP has record of a possible sighting in 1997 and a vouchered sighting in 2000 from south-central and southwestern New Hampshire, respectively.

1.9 Distribution Research

Current distribution data are lacking for marbled salamanders, and it is necessary to determine whether and where the species persists in the state. Surveying for the marbled salamander should focus on appropriate habitat across the southern portion of the state. Using remote sensing (e.g., aerial photography, land cover), a potential habitat layer should be created in a Geographic Information Systems (GIS). Priority sites should be inventoried in the field. Since this wetland identification technique is somewhat limited by the size of vernal pools, by the season during which the photographs were taken, and by the tree species surrounding the pools, field surveys should also be conducted.

The surveying should be conducted in the fall to look for migrating adults and nests, and in the spring to look for larvae. During the spring, surveyors can dip-net for larvae; surveying prior to egg hatching by other vernal-pool breeding salamanders would help ensure likely capture of marbled salamander larvae (as accurate identification of larval ambystomatids can be difficult).

Element 2: Species/Habitat Condition

2.1 Scale

There are insufficient data from which to determine species condition.

2.2 Relative Health of Populations

There are no data on population number or population sizes from which to determine relative health of populations. However, as it is likely that the species occurs in low numbers, it may be in danger of extirpation.

2.3 Population Management Status

No specific management plans exist for populations at these observation locations. Confirmation of the existence of these populations is necessary. Additionally, a systematic survey, focused on southern New Hampshire, is needed to locate other potential marbled salamander populations. Population management plans can be created after populations have been identified.

2.4 Relative Quality of Habitat Patches

There are not sufficient data available with which to assess the quality of habitat patches for the marbled salamanders.

2.5 Habitat Patch Protection Status

There are insufficient data with which to assess protection status.

2.6 Habitat Management Status

Marbled salamander habitat is indirectly managed through wetland and water resource protection, forestry management regulations (i.e., New Hampshire RSA 482-A; New Hampshire Rule Chapters Wt 100-800; Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire), and through land preservation (e.g., conservation restrictions and land acquisitions).

These efforts are not specifically designed to manage for marbled salamanders. Population growth and associated development will likely destroy or degrade potential marbled salamander habitat, despite measures aimed at slowing and redirecting development. Additionally, some forest management techniques (e.g., clear cutting) could also contribute to the fragmentation and degradation of potential marbled salamander habitat (deMaynadier and Hunter 1999, Pough and Wilson 1976 cited in DeGraaf and Yamasaki 2001, Faccio 2003).

Basic distribution and habitat use data for the species are needed to develop effective habitat management plans. In the absence of these basic data, habitat management efforts might focus on limiting disturbance in and around vernal pools that are embedded within a relatively large matrix of minimally disturbed forest. The goal of habitat management efforts should be to maintain habitat patches that allow for metapopulation dynamics (i.e., multiple pool/upland patches connected by dispersal habitat). Thus, the usefulness (to salamanders) of pool buffer zones and dispersal corridors between habitat patches needs to be evaluated.

2.7 Sources of Information

Information relating to the condition of this species and its habitat was gathered during an extensive literature review, a review of New Hampshire laws and administrative codes, and a review of the New Hampshire RAARP.

2.8 Extent and Quality of Data

See element 1.8. No information is available on the condition of this species and its habitat in New Hampshire.

2.9 Condition Assessment Research

- Monitor populations for habitat patch occupancy and determine stability and growth rates of local populations.
- Determine potential for regional dynamics at metapopulation level (i.e., determine interaction of spatial arrangement of viable habitat, local threats, and dispersal capacity of the species).

Element 3: Species and Habitat Threat Assessment

3.1.1 Scarcity (Natural Rarity)

(A) Exposure Pathway

The current known distribution of this species suggests that it may be extremely rare in the state, and may occur as only 1 or 2 populations, putting it at

risk of demographic stochasticity.

(B) Evidence
There are no data available from which to analyze this threat. However, the generally increased risk of extinction for small, isolated populations is well established.

3.2 Sources of Information

Information on marbled salamander distribution was obtained from the RAARP database.

3.3 Extent and Quality of Data

Other than the records in the RAARP database, there are no data on this species in the state.

3.4 Threat Assessment Research

Because there is so little information about this species in the state, establishing a research program to assess threat is premature. The most important research is a systematic survey and mapping of the distribution of this species in New Hampshire and adjacent areas of Massachusetts. If populations are documented in New Hampshire, local threats can be assessed. The Jefferson salamander profile contains a more extensive examination of threats assessment research, and threats to the marbled salamander would be essentially the same (with the exception of hybridization).

Element 4: Conservation Actions

Since the current distribution of this species in New Hampshire is unknown, it is impossible to evaluate the urgency of threats to, and the impacts of prospective conservation actions on, specific salamander populations and habitat patches. See the Jefferson salamander profile for a more extensive list of conservation actions that would be appropriate for marbled salamanders if several populations are identified.

Element 5: References

5.1 Literature

Bishop, S.C. 1941. The salamanders of New York. N.Y. State Museum Bulletin 324:1-365.

DeGraaf, R.M., and M. Yamasaki. 2001. New England wildlife: habitat, natural history, and distribution. University of New England Press, Hanover, New Hampshire, USA.

deMaynadier, P.G., and M.L. Hunter. 1999. Forest canopy closure and juvenile emigration by pool-breeding amphibians in Maine. Journal of Wildlife Management 63:441-450.

Faccio, S.D. 2003. Postbreeding emigration and habitat use by Jefferson and spotted salamanders in Vermont. Journal of Herpetology 37:479-489.

Fahrig, L., J.H. Pedlar, S.E. Pope, P.D. Taylor, and J.F. Wegner. 1995. Effect of road traffic on amphibian density. Biological Conservation 73: 177-182.

Figiel, C.R., Jr., and R.D. Semlitsch. 1995. Experimental determination of oviposition site selection in the marbled salamander, *Ambystoma opacum*. Journal of Herpetology 29:452-454.

Hoopes, I. 1938. Marbled salamander from New Hampshire. Bulletin of New England Museum of Natural History 87:16-17.

Jackson, M.E., D.E. Scott, and R.A. Estes. 1989. Determinants of nest success in the marbled salamander (*Ambystoma opacum*). Canadian Journal of Zoology 67: 2277-2281.

Klemens, M.W. 1993. Amphibians and reptiles of Connecticut and adjacent regions. Bull.112. Hartford: Connecticut State Geological and Natural History Survey.

Minton, S.A., Jr. 1972. Amphibians and reptiles of Indiana. Indianapolis: Indiana Academy of Science.

NatureServe. 2004. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.1. NatureServe, Arlington, Virginia. Available at http://www.natureserve.org/explorer. (Accessed: 17 December 2004).

Noble, G.K., and M.K. Brady. 1933. Observation on the life history of the marbled salamander, *Ambystoma opacum* (Amphibia, Urodela, Ambystomatidae). Journal of Herpetology 11: 169-176.

Petranka, J.W. 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington D.C.

Petranka, J.W. 1990. Observations on nest site selection, nest desertion, and embryonic survival in marbled salamanders. Journal of Herpetology 24: 229-234.

Petranka, J.W. 1989. Density-dependent growth and

survival of larval *Ambystoma*: evidence from whole-pond manipulations. Ecology 70:1752-1767.

Semlitsch, R.D. 1998. Biological delineation of terrestrial buffer zones for pond-breeding salamanders. Conservation Biology 12: 1113-1119.

Smyers, S.D., M.J. Rubbo, V.R. Townsend, Jr., and C.C. Swart. 2002. Intra- and interspecific characterizations of burrow use and defense by juvenile ambystomatid salamanders. Herpetologica 58: 422-429.

Sundquist, D., and M. Stevens. 1999. New Hampshire's changing landscape: population growth, land use conversion, and resource fragmentation in the Granite State. New Hampshire, Concord, Society for the Protection of New Hampshire Forests and The Nature Conservancy. 159 pp.

Taylor, J. 1993. The amphibians and reptiles of New Hampshire. New Hampshire Fish and Game Department, Concord New Hampshire, USA.

Windmiller, B.S. 1996. The pond, the forest, and the city: spotted salamander ecology. Dissertation, Tufts University, Medford, Massachusetts, USA.

5.2 Data Sources

NH Natural Heritage Bureau. 2005. Database of Rare Species and Exemplary Natural Community Occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

New Hampshire Reptile and Amphibian Reporting Program (RAARP). Coordinated by New Hampshire Fish and Game's Nongame and Endangered Species Program.

SPECIES PROFILE

Mink Frog

Rana septentrionalis

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S3S4
Author: Kim A. Tuttle, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The mink frog inhabits the cold waters of lakes, ponds, stream edges, springs, and occasionally peatlands of northern New Hampshire. The mink frog is almost entirely aquatic. It prefers to forage, breed, and hibernate in shallow, permanently open water with abundant emergent vegetation, especially lily pads (*Nymphaea spp.)* and pickerelweed (*Pontedaria cordata*) (DeGraaf and Yamasaki 2001). Adults often feed from lily pads far from shore; adult and larval aquatic invertebrates are common prey (Conant and Collins 1998, Stockwell 1999). Mink frogs lay eggs in a globular jelly mass attached to submerged vegetation, especially the stems of spatterdock (*Nuphar spp.*) or water lily. Egg masses eventually fall from the stems and drop to the bottom where they develop (Stockwell 1999).

1.2 Justification

Mink frogs are seldom seen or recorded because of their shy nature and unique habitat preferences. Few data are available for this species in New Hampshire. Its preference for the combination of cold, oxygen rich water and lily pads may restrict the mink frog to few suitable habitats. Lily pads are associated with warmer water and are not common in cold, northern water bodies (A. Schafermeyer, NHFG, personal communication). Water temperature may restrict mink frogs to northern regions because colder water has higher oxygen levels, which are required for embryo development (Stockwell 1999).

1.3 Protection and Regulatory Status

This species has no special protection in New Hampshire.

1.4 Population and Habitat Distribution

Mink frogs are restricted to areas north of the 43^0 N parallel in Maine, northern Ontario, Quebec, and Labrador, and west to Minnesota (Stockwell 1999). Historical locations of mink frogs in New Hampshire are clustered in the northern Connecticut River watershed towns of Coos and Grafton counties. This distribution is an artifact of the biological surveys conducted by Oliver and Bailey in 1938 and 1939 for the NHFG. Reptile and amphibian surveys, incidental to fish distribution surveys, were conducted in the Connecticut River watershed but not in the Androscoggin and Saco watersheds. More recent amphibian surveys have revealed occurrences of mink frog across Coos County to Wentworth's Location and Errol on the Maine border, and south to Livermore and Thornton in Grafton County. Mink frogs can be locally common in New Hampshire's North Country water bodies such as the Magalloway River in Wentworth's Location and marshes at the edge of Lake Umbagog (L.Wunder, Lake Umbagog National Wildlife Refuge, personal communication).

1.5 Town Distribution Map

1.6 Habitat Map

A habitat map was not completed for this species.

1.7 Sources of Information

Status and ranking information was taken from NatureServe (2005). New Hampshire Reptile and Amphibian Reporting Program (RAARP) records, Taylor (1993), and Oliver and Bailey (1939) were the primary sources of locality records. Habitat and life history information was taken from published literature. Michael Marchand, NHFG, provided comments on drafts.

1.8 Extent and Quality of Data

The distribution, habitat use, and condition of mink frog populations in New Hampshire are not well understood. This assessment was limited to records in scientific reports, records reported to the New Hampshire RAARP by an expert, and to reports that included a specimen or clear photograph.

1.9 Distribution Research

Continued efforts by RAARP volunteers are needed to identify and report mink frog locations, especially in the southern part of its range in Grafton and Carroll counties. In the North Country, Little Diamond Pond in North Stewartstown, and Back Lake and East Inlet, Pittsburg appear to be have suitable habitat for mink frogs and should be surveyed (A. Schafermeyer, NHFG, personal communication). Scotts Bog, Indian Stream, and the Connecticut Lakes in Pittsburg need to be rechecked to update 1985 occurrence records. Mink frogs and other reptile and amphibian species should be incorporated into comprehensive habitat monitoring efforts, particularly in northern New Hampshire where many species reach the edge of their range. North American Amphibian Monitoring Program (NAAMP) routes should be expanded to include more northern routes in New Hampshire. Mink frogs seem to be easily detected by call surveys during night sampling.

Element 3: Species Threat Assessment

The loss or degradation of cold, shallow water habitats with lily pads and pickerelweed in northern New Hampshire may pose the greatest threat to mink frogs.

Element 4: Conservation Actions

See Marsh and Shrub Wetlands, Peatlands, and Aquatic habitats for relevant conservation strategies. Maintaining natural emergent vegetation at the borders of ponds and wetlands, especially lily pads and pickerelweed, will help maintain the viability of mink frogs and other wetland dependent organisms.

Element 5: References

5.1 Literature

Conant, R., and J.T. Collins. 1998. Reptiles and amphibians: Eastern and central North America (3rd edition). Houghton Mifflin, Boston, Massachusetts, USA.

DeGraaf, R.M., and M. Yamasaki. 2001. New England wildlife: habitat, natural history, and distribution. University Press of New England, Hanover, New Hampshire, USA.

Oliver, J.A., and J.R. Bailey. 1939. Amphibians and reptiles of New Hampshire exclusive of
marine forms: Pages 195-217 *in* Biological Survey of the Connecticut watershed, H.E. Warfel, editor. New Hampshire Fish and Game Department Survey Report 4.

Stockwell, S.S. 1999. Mink frog. Pages 107-110 *in* Maine Amphibians and Reptiles, Hunter, M. L. Jr., A. J. Calhoun, and M. McCollough, editors. The University of Maine Press, Orono, Maine, USA.

Taylor, J. 1993. The Amphibians and Reptiles of New Hampshire. Nongame and Endangered Wildlife Program. New Hampshire Fish and Game. Concord, New Hampshire, USA.

5.2 Data Sources

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. http://www.natureserve.org/explorer. (Accessed: March 11, 2005).

New Hampshire Reptile and Amphibian Reporting Program (RAARP) database. Maintained by the New Hampshire Fish and Game, Nongame and Endangered Species Program, Concord New Hampshire. (Accessed: February 14, 2005).

SPECIES PROFILE

Northern Leopard Frog

Rana pipiens

Federal Listing: Not listed
State Listing: Special Concern
Global Rank: G5
State Rank: S3
Author: Kimberly, J. Babbitt and Nicole A. Freidenfelds, University of New Hampshire

Element 1: Distribution and Habitat

1.1 Habitat Description

Northern leopard frogs require 3 distinct habitats for breeding, foraging, and overwintering. Breeding (May to late June), egg deposition, and tadpole development occur in shallow standing water and emergent vegetation, such as lake inlets, slow streams, ponds, temporary wetlands holding water until at least July or August (e.g., long-hydroperiod vernal pools), overflows, or the backwater of rivers (Merrell 1977, Hine et al. 1981, Hunter et al. 1999, Alberta Sustainable Resource Development 2003). The best spawning habitat is marked by ample vegetation and a lack of fish (Merrill 1977).

During the summer, adult, juvenile, and young-of-the-year frogs are typically found near water (Alberta Sustainable Resource Development 2003). However, leopard frogs will travel 1 to 2 km from major waterbodies to wet meadows, pastures, hay fields, scrub vegetation, sedge meadows, drainage and irrigation ditches, or damp wooded areas (Hunter et al. 1999, Kendell 2002). Leopard frogs cannot withstand prolonged freezing and therefore overwinter in permanent waterbodies that do not freeze to the bottom (Schmid 1982, Costanzo et al. 1992, Layne 1992, 1993, Hunter et al. 1999, Russell and Bauer 2000, Alberta Sustainable Resource Development 2003). Hibernacula are most often located in springs, streams, spillways below dams, or in deeper lakes and ponds (Emery et al. 1972, Merrell 1977, Cunjak 1986). Within waterbodies, leopard frogs have been found hibernating under rocks, logs, leaf litter, vegetation, or in depressions in sand or mud (Emery et al. 1972).

1.2 Justification

Leopard frogs have apparently declined throughout much of New England. The decline is likely related to farm abandonment, forest regeneration, and decreases in grassland. The current distribution and abundance of northern leopard frogs, and the status of remaining populations in New Hampshire, are poorly known.

1.3 Protection and Regulatory Status

Leopard frogs are not specifically protected. Breeding wetlands are regulated through NHDES Wetlands Bureau (RSA 482-A and Administrative Rules). Uplands are generally not regulated.

1.4 Population and Habitat Distribution

The northern leopard frog (or, more specifically, the northern leopard frog complex) has a broad distribution in the United States and Canada. Northern leopard frogs range from New England to the mid-Atlantic to west of the Rockies, and in Canada, populations exist from southeastern British Columbia east to the Maritimes. The northern leopard frog is absent from most of the southeast. Throughout its range, the species often has a spotty distribution and is considered critically imperiled (S1) or imperiled (S2) in several states in the west and south and in British Columbia. In New England, the species is considered imperiled (S2) in Connecticut and Rhode Island, Vulnerable (S3) in New Hampshire and Maine, and apparently secure (S4) in Vermont and Massachusetts (Nature Serve 2001). Throughout New England, the species

has a very spotty distribution and is strongly associated with grassy riparian floodplains. For example, in Connecticut, Klemens (1993) found that the species is restricted mainly to the Housatonic and Connecticut drainage basins and their tributaries.

In New Hampshire, records submitted to RAARP database were verified for the following areas between 1992 and 2004: Coos County (Errol, Pittsburg), Merrimack County (Concord), Rockingham County (Portsmouth), and Sullivan County (Charlestown). Reports from a number of other towns have not been verified with a photograph or specimen. Most observations were from the Merrimack River, Connecticut River, Androscoggin River, and associated floodplains.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

N/A

1.7 Sources of Information

Information relating to the distribution and status of this species was gathered through a literature review and from NatureServe, as well as from the RAARP database.

1.8 Extent and Quality of Data

No comprehensive survey has been conducted for this species in New Hampshire, thus detailed distribution data are lacking. Because leopard frogs are commonly confused with pickerel frogs (*Rana palustrus*), a photograph is required to verify records submitted to the RAARP. Many new populations are likely to be identified in the future (M. Marchand, NHFG, personal communication).

1.9 Distribution Research

Current distribution data are poor for northern leopard frogs. Surveys should focus on grassy riparian floodplains.

Element 2: Species Condition

2.1 Scale

There are insufficient demographic data from which to determine species condition.

2.2 Relative Health of Populations

Data are insufficient to determine population health.

2.3 Population Management Status

There are no management efforts for any particular northern leopard frog population in New Hampshire at this time.

2.4 Relative Quality of Habitat Patches

Data are insufficient to determine relative quality of habitat patches.

2.5 Habitat Patch Protection Status

There are insufficient data to assess protection status for this species.

2.6 Habitat Management Status:

Northern leopard frog habitat is not specifically managed in New Hampshire.

2.7 Sources of Information:

No information was found pertaining to leopard frog status in New Hampshire.

2.8 Extent and Quality of Data:

No information was found pertaining to leopard frog status in New Hampshire.

2.9 Condition Assessment Research

- Acquire and map basic distribution data for this species, using remote sensing and GIS to delineate potential habitat and surveys to determine actual distribution
- Conduct population and metapopulation stud-

ies to determine growth rates, stability, dispersal, habitat use (and landscape distribution of critical habitats)
- Determine threats to local populations and develop population and habitat management plans if feasible

Element 3: Species and Habitat Threat Assessment

3.1.1 Development (Fragmentation, Habitat Loss and Conversion)

(A) Exposure Pathway
The loss of leopard frog habitat will result in a population reduction. Habitat loss and fragmentation restrict gene flow, impede recolonization, and compound environmental stochasticity, often leading to local extirpation (Alberta Sustainable Resource Development 2003, Blaustein et al. 1994, Corn 1994). In New Hampshire, the most significant threat comes from development in riparian floodplains and farmland.

(B) Evidence
Habitat loss is believed to be one of the causes of northern leopard frog declines in Washington, Oregon, Idaho and Montana (Alberta Sustainable Resource Development 2003). The extent to which wetland loss and alteration have affected northern leopard frog populations in New Hampshire is unknown; however, significant loss of early successional grassland habitat and farmland has been well documented (see Grasslands habitat profile). Degradation or loss of critical habitat may be deleterious to leopard frog populations (Pope et al. 2000), and because metapopulations depend on the regional flow of genes and individuals, local extirpations can lead to widespread population collapse (Seburn and Seburn 2000, Alberta Sustainable Resource Development 2003, Blaustein et al. 1994, Marsh and Trenham 2001).

3.1.2 Transportation Infrastructure

(A) Exposure Pathway
Road traffic can kill leopard frogs and may be particularly problematic for small populations. Roads fragment habitat and act as partial barriers to migration, leading to the aforementioned restrictions on gene flow and re-colonization. When (meta) population dynamics are thus disrupted, the species may not remain viable.

(B) Evidence
Amphibians are especially vulnerable to traffic mortality because they migrate between wetland and upland habitats, and because individuals are inconspicuous and sometimes move slowly (Trombulak and Frissell 2000). Ehmann and Cogger (1985) estimated that more than 5 million amphibians and reptiles are killed each year on roads in Australia. Research conducted in the Ottawa area indicates that anuran populations decrease in size with increasing traffic volume (Fahrig et al. 1995). Additionally, Carr and Fahrig (2001) found that traffic can influence leopard frog abundance at least 1.5 km from the population and that more vagile species, such as northern leopard frogs, are more strongly affected by road traffic.

3.1.3 Non-Point Source Pollution (Chemical Contaminants)

(A) Exposure Pathway
Pesticide wetting agents can interfere with cutaneous respiration in metamorphosed and adult frogs and with gill respiration in tadpoles, leading to indirect or direct mortality. Chemicals can suppress the immune system, cause endocrine disruption and developmental malformations, and alter behavior which may lead to decreased vigor, ability to fight off disease, reproduce, or escape predation, thereby increasing the chance of mortality.

(B) Evidence
The northern leopard frog is a frequent subject of toxicity experiments (e.g., see Hoffman et al. 2003). Leopard frogs are commonly found near agricultural areas where they are exposed to pesticides, herbicides, and nutrient (fertilizer) runoff. Low levels of nitrates can cause reduced activity, feeding, reproductive ability, and increases in deformities in tadpoles (Hecnar 1995). Allran and Karasov (2000) report that nitrate slowed the growth of leopard frog larvae. Such a decrease in growth as a larva can have a significant detrimental impact later in the life of a frog by decreasing survival, size as an adult, rate of sexual maturation, mate selection, and locomotion ability for preda-

tor evasion (Allran and Karasov 2000). Ouellet et al. (1997) found higher rates of limb deformities in northern leopard frogs in Ontario, Canada at sites in agricultural area and suggested that contaminants were the likely cause. In addition, *Rana pipiens* tadpoles are also sensitive (e.g., have lower survival, experience paralysis, delayed growth, or abnormal behavior) to low concentrations of insecticides and herbicides commonly used in forest management (Berrill et al. 1994, Berrill et al. 1995). It has also been demonstrated that, for leopard frogs, pesticides can act as immunosuppressive agents at sub-lethal doses that are present in wild frogs. The immunosuppressive effects of pesticides may be contributing to amphibian declines by rendering exposed populations susceptible to common pathogens (Gilbertson et al. 2003). Hayes et al. (2002) reported that very small doses (0.1 ppb) of the commonly used herbicide Atrazine can cause hermaphroditism in northern leopard frogs.

Because of the low buffering capacity of most water bodies in New Hampshire, northern leopard frogs may be at risk from decreased environmental pH resulting from sulfur dioxide and nitrogen oxides emitted by burning of fossil fuels. Simon et al. (2002), found that frogs experimentally exposed to pH 5.5 had spleens colonized with both Gram-positive and Gram-negative bacteria whereas spleens of frogs exposed to pH 7.0 either were sterile or exhibited little bacterial colonization. Resulting systemic infections combined with decreased natural defenses may in part cause increased mortality in leopard frogs (Simon et al. 2002). Leopard frogs collected early in the spring, immediately following hibernation, but prior to the breeding season, exhibited 100% mortality within the first 4 days of exposure to pH 5.5 (Vatnick et al. 1999). Frogs collected later in the season, post-breeding and prior to hibernation, exhibited 58% mortality over the 10 days of exposure. Prolonged exposure to pH less than 4.0 is lethal for leopard frogs, and bacterial infection, inhibition of yolk plug retraction, thoracic swelling, and caudal curling occur at a pH less than 6.3 (Watkins-Colwell and Watkins-Colwell 1998).

3.1.4 Non-Point Source Pollution (Runoff)

(A) Exposure Pathway

Eutrophication from fertilizer and farm runoff can cause an increase in snail populations that serve as the host for the trematode *Ribeiroia ondatrae* whose larvae (cercariae) infect larval leopard frogs, forming metacercarial cysts that cause malformations. Individuals with malformations are at increased risk of predation and have lower survival rates. Other diseases, both emerging and existing, can cause morbidity and mortality. Immune systems suppressed by, for example, exposure to contaminant (see 3.1.3), can render frogs susceptible to diseases with which they can normally cope. Populations that experience high disease rates may become locally extirpated.

(B) Evidence

Widespread reports of malformed amphibians in North America have prompted investigations into the causes of the deformities. Some amphibian deformities may be the result of a trematode known as *Ribeiroia ondatrae* (Sessions and Ruth 1990, Johnson et al. 2002). Larvae (cercariae) of this parasite infect amphibians around the base of the hind limbs where they form subcutaneous cysts (metacercariae), often causing improper formation of the developing limb bud. If the malformations are severe enough to impair movement, the individual may die due to a reduced ability to acquire food, avoid predators, and reproduce. In addition to eutrophication, loss or replacement or natural wetlands with artificial impoundments (e.g., dams, farm ponds), and introduction of non-indigenous species have all been associated with increases in trematode populations (Johnson et al. 2002). However, not all malformations are cause by the trematode (see previous section), and research on northern leopard frogs in adjacent states suggests multiple causes for malformations (Meteyer et al. 2000).

Amphibians are known to be susceptible to a variety of diseases, including many diseases of fish (Crawshaw 1992). Mortality in northern leopard frogs has often been associated with the condition called red leg, which is not a disease but a condition of kidney failure (Gibbs et al. 1971, Hine et al. 1981). It is often associated with infection by *Aeromona hydrophila*, a naturally occurring and widespread bacterium. Ordinarily, this pathogen only affects individuals whose immune systems have been weakened by stress and does not affect entire populations.

The fungal disease chytridiomycosis has been found repeatedly at the sites of mass deaths of amphibians

in Australia and North and Central America and was implicated in northern leopard frog declines in Colorado in the 1970s. Chytridiomycosis has now been reported from 38 species of amphibians, representing 12 different families (Daszak et al. 1999).

3.2 Sources of Information

Information about threats was compiled from a literature review.

3.3 Extent and Quality of Data

The northern leopard frog is one of the most studied amphibian species; therefore the quality of the data for the species is reasonably good. There is a significant amount of experimental toxicity research on this species; however, relating laboratory experiments to on-the-ground threats is difficult. We lack data for populations of northern leopard frogs in New Hampshire, so the threats to this species are drawn largely from the general literature and knowledge rather than from specific evidence for this species in New Hampshire. Clearly, the loss of farmland and grassland has resulted in loss of habitat for this species, and this threat remains today.

3.4 Threat Assessment Research

Additional research is needed to establish and thoroughly detail the threat that pesticides and contaminants pose to northern leopard frogs in New Hampshire. However, the most needed research is a systematic survey and mapping of the distribution of this species in the state. Determination of the location and sizes of extant populations is necessary to inform potential land management or protection aimed at this species. Documentation of the effects of development on northern leopard frog population dynamics and dispersal behavior is also vitally needed, as habitat loss and fragmentation and roads are the highest-ranking threats affecting this species.

Element 4: Conservation Actions

A lack of knowledge about northern leopard frogs in New Hampshire precludes specific conservation. Thus, 4.1.3 of the grassland habitat profile (Permanently Protect Grasslands), broadened to include grassy riparian floodplains and associated aquatic breeding sites, constitutes the most important conservation action.

4.2 Conservation Action Research

Mapping potential northern leopard frog habitat and conducting a systematic survey for the species is the most critical research needed to inform conservation activities.

Element 5: References

5.1 Literature

Alberta Sustainable Resource Development. 2003. Status of the northern leopard frog (*Rana pipiens*) in Alberta: Update 2003. Alberta Sustainable Resource Development, Fish and Wildlife Division, and Alberta Conservation Association, Wildlife Status Report No. 9. Edmonton, AB. 61pp.

Allran, J.W., and W.H. Karasov. 2000. Effects of Atrazine and nitrate on northern leopard frog (*Rana pipiens*) larvae exposed in the laboratory from posthatch through metamorphosis. Environmental Toxicology and Chemistry 19:2850-2855.

Berger, L., R. Speare, P. Daszak, D.E. Green, A.A. Cunningham, C.L. Coggin, M.A. Ragan, A.D. Hyatt, K.R. MacDonald, H.B. Hines, K.R. Lips, G. Marantelli, and H.T. Parkes. 1998. Chytridiomycosis causes amphibian mortality associated with population declines in the rainforests of Australia and Central America. Proceedings of the National Academy of Sciences 95:9031-9036.

Berrill, M., S. Betram, L. McGillivray, M. Kolohan, and B. Pauli. 1994. Effects of low concentrations of forest-use pesticides on frog embryos and tadpoles. Environmental Toxicology and Chemistry 13:657-664.

Berrill, M., S. Betram, B. Pauli D. Coulson, M. Kolohan, and D. Ostrander. 1995. Comparative sensitivities of amphibians to single and pulsed exposures of the forest-use insecticide fenithrothion. Environmental Toxicology and Chemistry 14: 1011-1018.

Bishop, C.A. 1992. The effects of pesticides on amphibians and the implications for determining causes of declines in amphibian populations. Pp. 67-70 in Declines in Canadian amphibian popula-

tions: designing a national monitoring strategy (C. A. Bishop and K. E. Petit, eds.). Canadian Wildlife Service Occasional Paper No. 76, Ottawa, ON. 120pp.

Blaustein, A.R., D.B. Wake, and W.P. Sousa. 1994. Amphibian declines: judging stability, persistence, and susceptibility of populations to local and global extinctions. Conservation Biology 8:60-71.

Carr, L.W., and L. Fahrig. 2001. Effects of road traffic on two amphibian species of differing vagility. Conservation Biology 15:1071-1078.

Corn, P.S. 1994. What we know and don't know about amphibian declines in the west. Pp. 59-67 in Sustainable ecological systems: Implementing an ecological approach to land management. U.S.D.A. Forest Service General Technical Report RM-247, Fort Collins, CO. 363pp.

Costanzo, J.P., R.E. Lee Jr., and P.H. Lortz. 1992. Responses of freeze-tolerant and freeze-intolerant frogs to freezing. Cryobiology 29:616-631.

Crawshaw, G.J. 1992. The role of disease in amphibian decline. Pp. 60-62 in Declines in Canadian amphibian populations: designing a national monitoring strategy. (C. A. Bishop and K. E. Petit, eds.). Canadian Wildlife Service Occasional Paper No. 76, Ottawa, ON. 120pp.

Cunjak, R.A. 1986. Winter habitat of northern leopard frogs, *Rana pipiens*, in a southern Ontario stream. Canadian Journal of Zoology 64:255-257.

Daszak, P., L. Berger, A.A. Cunningham, A.D. Hyatt, D.E. Green, and R. Speare. 1999. Emerging infectious diseases and amphibian declines. Emerging Infectious Diseases 5:735-748.

Ehmann, H., and H. Cogger. 1985. Australia's endangered herpetofauna: a review of criteria and policies. Pp. 435-447 in Biology of Australasian frogs and reptiles. (G. Grigg, R. Shine, and H. Ehmann, eds.) Surrey Beatty & Sons, NSW.

Emery, A.R., A.H. Berst, and K. Lodaira. 1972. Under-ice observations of wintering sites of leopard frogs. Copeia 1972:123-126.

Fahrig, L., J.H. Pedlar, S.E. Pope, P.D. Taylor, and J.F. Wegner. 1995. Effect of road traffic on amphibian density. Biological Conservation 73:177-182.

Gibbs, E.L., G.W. Nace, and M.B. Emmons. 1971. The live frog almost dead. BioScience 21:1027-1034.

Gilbertson, M., G.D. Haffner, K.G. Drouillard, A. Albert, and B. Dixon. 2003. Immunosuppression in the northern leopard frog (*Rana pipiens*) induced by pesticide exposure. Environmental Toxicology and Chemistry 22:101-110.

Harfenist, A., T. Power, K.L. Clark, and D.B. Peakall. 1989. A review and evaluation of the amphibian toxicological literature. Canadian Wildlife Service, Environment Canada. 222 pp.

Hayes, T.B., A. Collins, M. Lee, M. Mendoza, N. Noriega, A.A. Stuart, and A. Vonk. 2002. Hermaphroditic, demasculinized frogs after exposure to the herbicide Atrazine at low ecologically relevant doses. Proceedings of the National Academy of Sciences 99:5476-5480.

Hecnar, S.J. 1995. Acute and chronic toxicity of ammonium nitrate fertilizer to amphibians from southern Ontario. Environmental Toxicology and Chemistry 14: 2131-2137

Hine, R.L., B.L. Les, and B.F. Hellmich. 1981. Leopard frog populations and mortality in Wisconsin, 1974-76. Wisconsin Dept. of Natural Resources Technical Bulletin No. 122. Madison, WI. 39 pp.

Hoffmann, D.J., B.A. Rattner, G.A. Burton, Jr., J. Cairns, Jr. eds. 2003. Handbook of Ecotoxicology. Second edition. Lewis Publishers/CRC Press. Boca Raton, Florida.

Hunter, M.L. Jr., A.J.K. Calhoun, and M. McCollough. 1999. Maine amphibians and reptiles. The University of Maine Press, Orono, Maine. 252 pp.

Johnson, P.T. J., K.B. Lunde, E.M. Thurman, E.G. Ritchie, S.N. Wray, D.R. Sutherland, J.M. Kapfer, T.J. Frest, J. Bowerman, and A.R. Blaustein. 2002. Parasite (*Ribeiroia ondatrae*) infection linked to amphibian malformations in the western United States. Ecological Monographs 72:151-168.

Kendell, K. 2002. Survey protocol for the northern leopard frog. Alberta Sustainable Resource Development, Fish and Wildlife Division, Alberta Species at Risk Report No. 43, Edmonton, AB. 30pp.

Klemens, M.W. 1993. Amphibians and reptiles of Connecticut and adjacent regions. Bull. 112. Hartford: Connecticut State Geological and Natural History Survey.

Layne, J.R. Jr. 1992. Postfreeze survival and muscle function in the leopard frog (*Rana pipiens*) and the wood frog (*Rana sylvatica*). Cryobiology 29:759.

Layne, J.R. Jr. 1993. Postfreeze recovery of gastrocnemius muscles of *Rana pipiens* and *R. sylvatica*. Journal of Herpetology 27:478-480.

Marsh, D.M., and P.C. Trenham. 2001. Metapopula-

tion dynamics and amphibian conservation. Conservation Biology 15:40-49.

Merrell, D.J. 1977. Life history of the leopard frog, *Rana pipiens*, in Minnesota. Bell Museum of Natural History, University of Minnesota, Minneapolis, MN.

Meteyer, C.U, I.K. Loeffler, J.F. Fallon, A. Converse, E. Green, J.C. Helgen, S. Kersten, R. Levey, L. Eaton-Poole, and J.G. Burkhart. 2000. Hindlimb malformations in free-living northern leopard frogs (*Rana pipiens*) from Maine, Minnesota, and Vermont suggest multiple etiologies. Teratology. 62: 151-171.

NatureServe. 2002. Rana pipiens. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.1. NatureServe, Arlington, Virginia. Available at http://www.natureserve.org/explorer.

Ouellet, M., J. Bonin, J. Rodrigue, J.L. DesGranges, and S. Laire. 1997. Hindlimb deformities (ectromelia, ectrodactyly) in free-living anurans from agricultural habitats. Journal of Wildlife Diseases 33:95-104.

Pope S.E., L. Fahrig, and H.G. Merriam. 2000. Landscape complementation and metapopulation effects on leopard frog populations. Ecology 81: 2498-2508.

Russell, A.P., and A.M. Bauer. 2000. The amphibians and reptiles of Alberta. A field guide and primer of boreal herpetology, second edition. University of Calgary Press and University of Alberta Press, Calgary and Edmonton, AB. 279 pp.

Schmid, W.D. 1982. Survival of frogs in low temperature. Science 215:687-698.

Seburn, D.C. and C.N.L. Seburn. 2000. Conservation priorities for the amphibians and reptiles of Canada. Prepared for World Wildlife Fund Canada and the Canadian Amphibian and Reptile Conservation Network. 92 pp.

Sessions, S.K. and S.B. Ruth. 1990. Explanation for naturally occurring supernumerary limbs in amphibians. The Journal of Experimental Zoology. 254:38-43.

Simon, M.P., I. Vatnick, H.A. Hopey, K. Butler, C. Korver, C. Hilton, R.S. Weimann, and M.A. Brodkin. 2002. Effects of acid exposure on natural resistance and mortality of adult *Rana pipiens*. Journal of Herpetology. 36: 697-699.

Trombulak, S.C., and C.A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14:18-30.

Vatnick, I., M.A. Brodkin, M.P. Simon, B.W. Grant, C.R. Conte, M. Gleave, R. Myers, and M.M. Sadoff. 1999. The effects of exposure to mild acidic conditions on adult frogs (*Rana pipiens* and *Rana clamitans*): Mortality rates and pH preferences. Journal of Herpetology 33: 370-374.

Watkins-Colwell, K.A., and G.J. Watkins-Colwell. 1998. Differential survivorship of larval leopard frogs (*Rana pipiens*) exposed to temporary and permanent reduced pH conditions. Bulletin of the Maryland Herpetological Society 34:64-75.

SPECIES PROFILE

Ribbon Snake

Thamnophis sauritus

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S5
Author: Kim A. Tuttle and M.N. Marchand, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The common ribbon snake is a slender, semi-aquatic snake often observed near the edges of emergent marshes, wet meadows, scrub-shrub wetlands, beaver impoundments, bogs, river and stream floodplains, and vegetated shorelines of ponds and lakes (Ernst and Ernst 2003, M. Marchand personal observation). Ribbon snakes generally avoid deep water but will swim readily along the surface. Juveniles and gravid females may use uplands (Smith 2002), but the extent of use is not well established. Most ribbon snakes documented in New England have been found below 305 m (1,000 ft) elevation (Oliver and Bailey 1939, Klemens 1993).

Possible hibernacula include muskrat (*Ondatra zibethica)* bank burrows and lodges (Ernst and Ernst 2003), ant mounds, mammal tunnels, and rock crevices (Carpenter 1953, Hansknecht et al. 1999). Though ribbon snakes eat primarily amphibians (Carpenter 1952), they will also consume lesser amounts of mice, spiders, small fish, and insects.

1.2 Justification

The common ribbon snake was listed as a species of conservation concern in the northeastern United States due to a lack of data and a suspected decline (Therres 1999). The species is near the northern limit of its range in New England and is listed as a species of special concern in Maine, Vermont, Connecticut and Rhode Island because of uncommon and localized populations that appear to have declined (Klemens 1993). Ribbon snakes could be used as indicator species (e.g., for contaminants) because of their dependence on amphibians as prey and use of both aquatic and upland habitats (Smith 2002). Also, ribbon snake occupation may indicate high quality wetland habitat that could support other species of conservation concern such as spotted turtle (*Clemmys guttata),* leopard frog (*Rana pipiens),* and blue-spotted (*Ambystoma laterale)* and four-toed salamanders (*Hemidactylium scutatum)* (Klemens 1993).

1.3 Protection and Regulatory Status

No special protection in New Hampshire.

1.4 Population and Habitat Distribution

Ribbon snakes occur east of the Mississippi River from southern Ontario and southern Maine to southeastern Louisiana and the Florida Keys, with isolated records from Nova Scotia (Ernst and Ernst 2003). Two subspecies, the eastern ribbon snake (*T. sauritus sauritus)* and the northern ribbon snake (*T. sauritus septentrionalis)* may occur in New England (Conant and Collins 1998). The range of the northern ribbon snake includes Nova Scotia and extends from southern Maine westward through New Hampshire, Vermont, and New York. The northern limit of the eastern ribbon snake includes the southern parts of Vermont, New Hampshire, and Maine (Conant and Collins 1998). Most Maine records are from York County, and no distinction was made between the two ribbon snake subspecies (Hunter et al. 1999).

In New Hampshire, the majority of records are from the south. County records of ribbon snakes include Carroll, Cheshire, Hillsborough, Merrimack,

and Sullivan (Oliver and Bailey 1939). A 1920 record from Sanbornton (Museum of Comparative Zoology Herpetology Collection at Harvard) is the only documented record for Belknap County.

Recent unverified reports from Sanbornton and New Hampton (Belknap County) suggest the need for further documentation. Recent verified observations of ribbon snakes include Groton (Grafton County), Rindge (Cheshire County), Amherst, Weare, and Lyndeborough (Hillsborough County), Pittsfield, Bradford, Hooksett, Allenstown (Merrimack County), New Durham, Lee, Rochester, Strafford, and Durham (Strafford County), and Portsmouth, Auburn, Raymond, and Nottingham (Rockingham County). There are no confirmed records of the ribbon snake in Coos County.

1.5 Town Distribution Map

1.6 Habitat Map

See Marsh and Shrub Wetlands map.

1.7 Sources of Information

Status and ranking information was taken from NatureServe (2005). New Hampshire RAARP records and Taylor (1993) were the primary source of locality records. Online museum collection databases (Museum of Comparative Zoology, Harvard and Yale Peabody Museum) were searched for historical records. Habitat and life history information was taken from published literature.

1.8 Extent and Quality of Data

The distribution, habitat use, and condition of ribbon snake populations in New Hampshire are not well understood. This assessment was limited to those records that were included in museum collections, were found in scientific reports, were reported to RAARP by a trained expert, or that included a specimen or clear photograph. Trained observers will likely result in many new town records.

1.9 Distribution Research

Encourage RAARP volunteers to identify and report ribbon snake locations, especially in those areas where records are scarce (e.g. Belknap, Carroll, Grafton, and Sullivan counties). Systematic surveys and research are needed to provide more information regarding the condition and habitat requirements of populations. Ribbon snakes, and other rare reptiles and amphibians, should be incorporated into habitat inventories and management and restoration efforts.

Element 3: Threat Assessment

Wetland loss and degradation and shoreline modification are the greatest threats to ribbon snakes. See Threats in Marsh and Shrub Wetlands habitat profile.

Element 4: Conservation Strategies

See Marsh and Shrub Wetlands habitat type for relevant conservation strategies.

Element 5: References

5.1 Literature

Carpenter, C.C. 1952. Comparative ecology of the common garter snake (*Thamnophis s. sitalis),* the ribbon snake (*Thamnophis s. sauritus),* and Butler's garter snake (*Thamnophis butleri)* in mixed populations. Ecological Monographs 22:236-258.

Carpenter, C.C. 1953. A study of hibernacula and hibernating associations of snakes and amphibians in Michigan. Ecology 34:74-80.

Conant, R., and J.T. Collins. 1998. Reptiles and amphibians: Eastern and central North America (3rd edition). Houghton Mifflin, Boston, Massachusetts, USA.

Ernst, C.H., and E.M. Ernst. 2003. Snakes of the United States and Canada. The Smithsonian Institution. Washington, D.C., USA and London, England.

Hansknecht, K.A., T.R. Creque, and C.H. Ernst. 1999. *Thamnophis sauritus sauritus.*

Hibernaculum. Herpetological Review 30:104.

Klemens, M.W. 1993. Amphibians and reptiles of Connecticut and adjacent regions. State Geological and Natural History Survey of Connecticut. Bulletin No.112. Connecticut Department of Environmental Protection, Hartford, Connecticut, USA.

NatureServe. 2005. NatureServe Explorer: An online

encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. Available http: /www.natureserve.org/explorer. Accessed 2005 February 4.

Oliver, J. A. and J. R. Bailey. 1939. Amphibians and reptiles of New Hampshire exclusive of marine forms: Pages 195-217 *in* Biological Survey of the Connecticut watershed, H.E.Warfel, editor. New Hampshire Fish and Game Survey Report 4.

Smith, K. 2002. COSEWIC status report on the eastern ribbonsnake *Thamnophis sauritus* in Canada, in COSEWIC assessment and status report on the eastern ribbonsnake *Thamnophis sauritus*. Committee on the Status of Endangered Wildlife in Canada. Ottawa.

Taylor, J. 1993. The Amphibians and Reptiles of New Hampshire. Nongame and Endangered Wildlife Program. New Hampshire Fish and Game Department. Concord, New Hampshire, USA.

Therres, G.D. 1999. Wildlife species of regional conservation concern in the northeastern United States. Northeast Wildlife 54:93-100.

5.2 Data Sources

New Hampshire Reptile and Amphibian Reporting Program (RAARP) database. Maintained by the New Hampshire Fish and Game, Nongame and Endangered Species Program, Concord New Hampshire. Accessed 2005 February 14.

SPECIES PROFILE

Smooth Green Snake

Opheodrys vernalis

Federal Listing: None
State Listing: None
Global Rank: G5
State Rank: S3
Authors: Kim A. Tuttle and M. N. Marchand, New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

Smooth green snakes may be found in a variety of open or lightly forested habitats such as pastures, old fields, wet meadows, marsh borders, coastal grasslands, pine barrens, blueberry barrens, and grassy hilltops (Klemens 1993, New Hampshire Reptile and Amphibians Reporting Program 2005). Smooth green snakes feed primarily on invertebrates including arthropods, caterpillars, grasshoppers, slugs and earthworms. Females may lay two or more clutches of well developed eggs a season, usually in July- August, in piles of rotting vegetation or sawdust, rotting logs and stumps or mammal burrows (Ernst and Ernst 2003). Ant mounds, rock crevices and mammal burrows may be used during hibernation (Carpenter 1953, Ernst and Ernst 2003).

1.2 Justification

Anecdotal accounts appear to indicate a decline in smooth green snake abundance since the mid-1900s in southern New England (Klemens 1993) and in other areas (Brodman et al. 2002). Since that time, many early successional habitats that smooth green snakes prefer have become reforested or have been converted to residential and commercial developments (Klemens 1993, SPNHF 2005). The maintenance of lawns and hayfields by mowing can lead to direct mortality of individual smooth green snakes. Frequent mowing may reduce habitat suitability by altering the diversity of vegetation and soil moisture, potentially limiting the abundance of prey such as gastropods (Kjoss and Litvaitis 2001a). Insecticides reduce prey bases and direct mortality to smooth green snakes (George and Stickel 1949).

1.3 Protection and Regulatory Status

No special protection in New Hampshire.

1.4 Population and Habitat Distribution

The smooth green snake likely occurs throughout most of New Hampshire including documented records on Star Island, Isles of Shoals (Taylor 1993, D. Hayward, personal communication). A 2003 record from Berlin in Coos County represents the most northerly location in the state for this species. Other records for Coos County (i.e., Gorham, Shelbourne) are historic (Oliver and Bailey 1939). In a historic unpublished report, Donald Carle, a professor of science at Keene Teachers College, wrote "They have been reported at the tree line on Mount Monadnock in Jaffrey, on top of Mount Stinson in the White Mountains and at the tree line next to the cog railroad going up Mt. Washington."

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

The University of New Hampshire (J. Taylor, Zoology Department, and S. Hale, Complex Systems Research Center) was contracted to map predicted smooth green snake habitat. The New Hampshire Landcover data layer was the primary source of data.

Hayfields, pastures, and orchards were considered favorable habitats. Proximity to known smooth green snake locations was also incorporated. Maps will need field verification.

1.7 Sources of Information

Status and ranking information was taken from NatureServe (2005). New Hampshire Reptile and Amphibian Reporting Program (RAARP) records and Taylor (1993) were the primary source of locality records. Online museum collection databases (Museum of Comparative Zoology, Harvard and Yale Peabody Museum) were searched for historical records. The University of New Hampshire completed predicted habitat maps.

1.8 Extent and Quality of Data

The distribution, habitat use, and condition of smooth green snake populations in New Hampshire are not well understood. This assessment was limited to high quality records that were included in museum collections, were found in scientific reports, or were reported to the New Hampshire Reptile and Amphibian Reporting Program by a trained expert or reports that included a specimen or clear photograph. We suspect that smooth green snakes in towns with historic observations probably have not been extirpated but rather these areas have not received recent survey effort targeting this species.

1.9 Distribution Research

Systematic surveys (either taxonomically or habitat-based) are needed to assess the distribution, relative abundance and condition of populations in different habitats and how populations respond to habitat management (e.g., mowing, prescribed burns). Systematic surveys must first assess the most efficient sampling protocols (Kjoss and Litvaitis 2001b).

Element 2: Species/Habitat Condition

No information is available to evaluate the condition of smooth green snake populations in New Hampshire although they are thought to be in decline (See element 1.9).

Element 3: Species and Habitat Threat Assessment

The loss and degradation of early successional habitats and grasslands, along with frequent mowing or insecticide spraying, pose the greatest threats to smooth green snakes. See Threats in Grassland Habitat Profile for discussion of threats.

Element 4: Conservation Strategies

See associated habitat profiles for relevant conservation strategies.

Element 5: References

5.1 Literature

Brodman, R., S. Cortwright, and A. Resetar. 2002. Historical changes of reptiles and amphibians of northwest Indiana fish and wildlife properties. American Midland Naturalist 147:135-144.

Carpenter, C. C. 1953. A study of hibernacula and hibernating associations of snakes and amphibians in Michigan. Ecology 34:74-80.

Crother, B. I. Committee Chair, J. Boundy, J. A. Campbell, K. De Queiroz, D. R. Frost, R. Highton, J. B. Iverson, P. A. Meylan, T. W. Reeder, M. E. Seidel, J. W. Sites, Jr., T. W. Taggart, S. G. Tilley, and D. B. Wake. 2000. Scientific and standard English names of amphibians and reptiles of North America north of Mexico, with comments regarding confidence in our understanding. Society for the Study of Amphibians and Reptiles. Herpetological Circulars. 29

Ernst, C. H. and E. M. Ernst. 2003. Snakes of the United States and Canada. The Smithsonian Institution. Washington, D.C., USA and London, England.

George, J. L. and W. H. Stickel. 1949. Wildlife effects of DDT dust used for tick control on a Texas prairie. American Naturalist. 42:228-237.

Kjoss, V.A. and J.A. Litvaitis. 2001a. Community structure of snakes in a human-dominated landscape. Biological Conservation. 1-8.

Kjoss, V. A. and J.A. Litvaitis. 2001b. Comparison of 2 methods to sample snake communities in early successional habitats. Wildlife Society Bulletin 29: 153-157.

Klemens, M. W. 1993. Amphibians and reptiles of Connecticut and adjacent regions. State Geological and Natural History Survey of Connecticut. Bulletin No.112. Connecticut Department of Environmental Protection, Hartford, Connecticut, USA.

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. Available http: /www.natureserve.org/explorer. (Accessed: August 2, 2005).

Oliver, J. A. and J. R. Bailey. 1939. Amphibians and reptiles of New Hampshire exclusive of marine forms: Pages 195-217 in H.E.Warfel, editor, Biological Survey of the Connecticut watershed. New Hampshire Fish and Game Department Survey Report 4.

Society for the Protection of New Hampshire Forests. 2005. New Hampshire's Changing Landscape. Population growth and land use changes: what they mean for the Granite State. Executive Summary. Concord, New Hampshire, USA.

Taylor, J. 1993. The Amphibians and Reptiles of New Hampshire. Nongame and Endangered Wildlife Program. New Hampshire Fish and Game Department. Concord, New Hampshire, USA.

5.2 Data Sources

New Hampshire Reptile and Amphibian Reporting Program (RAARP) database. Maintained by the New Hampshire Fish and Game Department, Nongame and Endangered Species Program, Concord New Hampshire (Accessed: August 2, 2005)

SPECIES PROFILE

Spotted Turtle

Clemmys guttata

Federal Listing: Not listed
State Listing: Special Concern
Affected Species: N/A
Global Rank: G5
State Rank: S3
Author: Michael, N. Marchand, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Spotted turtles (*Clemmys guttata*) require large habitats with a diversity of wetland types and hydroperiods, and they tolerate only limited development of uplands and disturbance by humans (Fowle 2001, Joyal et al. 2001, Hinderliter 2003). Spotted turtle aquatic and wetland habitats include marshes, wet meadows, ponds, forested and shrub swamps, fens, shallow slow-moving streams and rivers, and vernal pools (Ernst et al. 1994, Fowle 2001).

Habitat use may shift seasonally and vary geographically, and overland movements among wetlands may be greater than 500 m (Milam and Melvin 2001). Vernal pools often are used extensively in spring and early summer (Joyal et al. 2001, Milam and Melvin 2001. Female spotted turtles usually lay eggs in open canopied uplands, generally between late May and early July (Ernst et al. 1994). Human-altered sites (e.g., pastures, road edges, yards, and agricultural areas) may be used (Carroll 1991, Joyal 1999, Joyal et al. 2001), as may hummocks in emergent wetlands (Milam and Melvin 2001). When summer temperatures are high, spotted turtles may estivate in permanent wetlands (fens, swamps, marshes, ponds, and rivers) and seasonal pools (Fowle 2001, Milam and Melvin 2001, Hinderliter 2003).

1.2 Justification

Spotted turtles use a large matrix of wetland and upland habitats, and because of life history characteristics (e.g., late age of maturity, low fecundity, and high adult survival) are extremely sensitive to small increases in mortality. And because spotted turtles need large protected areas with relatively limited development, maintaining viable populations of spotted turtles should benefit many other rare and common organisms. For example, habitat use may overlap with that of Blanding's turtle (*Emydoidea blandingii*); both species were found in similar shallow-water habitats in southern New Hampshire (Jenkins and Babbitt 2003).

The spotted turtle is declining throughout its range (Litzgus and Mousseau 2004) and is of conservation concern in the Northeast (Therres 1999). Spotted turtles are listed as endangered in Vermont, threatened in Maine, and a Species of Special concern in Massachusetts and New Hampshire. Because their habitat overlaps with the highest human population densities in New Hampshire, spotted turtles are particularly vulnerable in this area and are threatened especially by encroachment of roads.

1.3 Protection and Regulatory Status

- See Marsh and Shrub Wetland profile for regulations regarding wetland impacts.
- NHFG Rule FIS 803.02. Importation. Spotted turtles shall not be imported to New Hampshire
- NHFG Rule FIS 804.02. Possession. Spotted turtles shall not be possessed in New Hampshire
- NHFG Rule FIS 811.01. Sale of Reptiles. No person shall sell spotted turtles in New Hampshire

1.4 Population and Habitat Distribution

Populations range from southern Maine, south along

the Atlantic coast, to Florida, as well as to southern Ontario, New York, Pennsylvania, Ohio, Indiana, Michigan, and Illinois (Ernst et al. 1994). In New Hampshire, Huse (1901) reported that spotted turtles were found 'everywhere'; however, Oliver and Bailey (1939) knew of only one documented occurrence. Towns with historic records (before 1985) but no recent verified records include Mount Vernon (Oliver and Bailey 1939), Goffstown (1982) and Pembroke (1983). The majority of known spotted turtle locations are concentrated in southeastern New Hampshire (See section 1.5). However, NHFG has received reports far from the core area in the southeast, including two reports in Ossipee, one report in Richmond, and two in Grafton and on the Enfield/Canaan border. An unverified report was received from Effingham, the town east of Ossipee. Though the record in Richmond is isolated from other reports in New Hampshire, reports in the adjacent Massachusetts town of Warwick (Massachusetts Natural Heritage Program) support the validity of this observation. Reports in the Grafton area need further investigation.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

Known spotted turtle habitats (element occurrences) were buffered conservatively by 500 m (Inferred Extent, NatureServe Element Occurrence specifications, 2002), and overlapping buffers were merged. These areas were considered occupied. For each occupied area, a number of variables was measured, including size (ha), area of potentially suitable wetland habitat (ha), conservation land (ha, percent), road density, and amount of development (ha, percent).

1.7 Sources of Information

Distribution information came largely from RAARP. High quality records were submitted to NHNHB and incorporated in the New Hampshire Rare Species Database (NHRSD). New Hampshire studies included an assessment by D. Carroll along the Lamprey River and a graduate research study by M. Hinderliter in 2003.

1.8 Extent and Quality of Data

Location records incorporated into the NHRSD consisted of high quality observations (photographs, specimens, or expert observer). Because spotted turtles are secretive and difficult to detect, focused efforts will likely result in new town records.

1.9 Distribution Research

- Ask RAARP volunteers to gather more information on towns with limited species distribution information and towns distant from the core New Hampshire population (e.g, Richmond, Ossippee, and Grafton/Enfield/Canaan).
- Conduct visual and trapping surveys at locations where the species has not been reported but is most likely to occur because of available habitat.
- NHFG should coordinate this effort and involve other state and federal agencies, universities, non-government organizations, and expert observers.

Element 2: Species/Habitat Condition

2.1 Scale

Habitat quality was assessed based on known occupied sites (500 m buffer around locations; see element 1.6).

2.2 Relative Health of Populations

There is little information on the abundance and condition of spotted turtle populations in New Hampshire. There are only 64 records (Element Occurrences) in the Rare Species Database maintained by the NHNHB (as of 8 April 2005), seven of which are considered historic (before 1985). Thirty-eight records consisted of 1 spotted turtle observation, and only 2 records in the database had greater than 10 observations. Eleven records were of individuals found only on roads.

2.3 Population Management Status

There is little management of spotted turtles in New Hampshire. Possession of spotted turtles, including manipulation of individuals for research, requires a permit from NHFG. Several individuals have been

permitted to conduct mark-recapture studies, and D. Carroll, who has extensive knowledge of turtle biology, has conducted long-term monitoring of a local New Hampshire population. A search for rare turtles (e.g., Blanding's, spotted, and wood, *Glyptemys insculpta*) was conducted in the Great Bay and Lamprey River areas, and13 blocks of relatively extensive and contiguous suitable habitat were identified (Carroll 1999). In addition, 14 spotted turtles were monitored at sites in the coastal watershed as part of M. Hinderliter's graduate research.

2.4 Relative Quality of Habitat Patches

Sixty-five occupied habitat areas were mapped, ranging from 95 to 2,702 ha (mean 227 ha ± 357 SD), and a 500 m buffer around known spotted turtle records restricted the possible sizes of occupied areas.

Roads are a major threat to spotted turtles. In southern New Hampshire, spotted turtles crossed roads in every month from April to August at all 3 sites where roads were near wetlands (Hinderliter 2003). Average road density in mapped occupied areas was 3 km/km^2 ± 3 SD (range 0-16 km/km^2). Thirty-one occupied areas lacked any state routes and interstates, and in these areas, the percent of residential development was 11 % ± 18 SD (range 0-68 %). Only 2 sites had road densities less than 1 km/km^2, one of which was 0.9 km/km^2. The mean residential development within occupied areas was 13% ± 20 SD (range 0-91%).

Large, unfragmented habitats with a diversity of wetland types will be necessary to maintain viable populations of spotted turtles (Milam and Melvin 2001, Hinderliter 2003). In general, an undisturbed buffer of more than 400 m around wetland edges may be necessary to protect nesting, estivation, foraging, and travel sites of local spotted turtles (Milam and Melvin 2001), and 430 ha of wetlands and uplands may be needed for a population of 600 adult spotted turtles (Fowle 2001).

2.5 Habitat Patch Protection Status

The percentage of conservation land in spotted turtle habitat was 15 % ± 23 SD (range 0-99%); mean fee ownership was 13% ± 22 SD (range 0-99 %) and mean conservation easement was 2 % ± 6 SD (range 0-40 %). Fifty occupied areas had less than 20% of land protected, 60 areas had less than 50% protected, and only 3 occupied areas had more than 70% protection.

Of these 3 areas, all had road densities greater than 1.0 km/km^2 and 2 were bisected by a major state route. The total area protected in occupied lands ranged from 0 to 730 ha (mean = 39 ha ± 103). No mapped occupied areas were greater than 50% protected, had road densities less than 2 km/km^2, and lacked major routes.

2.6 Habitat Management Status

There is little management of spotted turtles in New Hampshire. Artificial nesting areas have been created in some areas as part of mitigation during NHFG review of wetland impacts and on other lands, but use of these nesting areas is unknown. Thirty-one wetland impoundments are managed, primarily for waterfowl, by NHFG, and spotted turtles occur in some of these areas.

2.7 Sources of Information

Available information on the condition of spotted turtle populations largely was a result of reports received from the RAARP and several localized research and inventory efforts (Carroll 1999, Hinderliter 2003). Using available data layers from various sources (e.g., University of New Hampshire Complex Systems), GIS were used to assess quantity and quality of known spotted turtle.

2.8 Extent and Quality of Data

Most records consist of only 1 or a few observations, and many were encounters on roads (see element 2.2). Wetland occupation and habitat use at a fine scale (e.g., wetland polygons) is poorly understood for most of the New Hampshire range of spotted turtles, though a few populations in southeastern New Hampshire have been studied in more detail (e.g., Hinderliter 2003).

2.9 Condition Assessment Research

- Continue to add and update spotted turtle records in the NHRSD in accordance with

Element Occurrence standards accepted by the NHFG and the NHNHB
- Prioritize and continue existing research with other New England states
- Identify viable populations and assess population sizes and structures
- Assess population viability and habitat use on Conservation Land, especially in State Parks and Wildlife Management Areas. Short visual (e.g., basking and nesting) or trapping surveys should be used to assess the relative condition of populations. Because multiple uses of protected habitat might threaten spotted turtles, longer surveys should be conducted at a sample of conservation lands to assess effects of land use. Studying populations in these areas would lead to better management of areas not in conservation land and could provide benchmarks for comparison with populations in disturbed and fragmented areas

Element 3: Species Threat Assessment

Threats to spotted turtles are similar to those of Blanding's turtles (see Threat Ranking Form) and are not discussed in detail here. The greatest threats include loss and fragmentation of large wetland complexes due to development and road construction and mortality of adults from vehicles and, possibly, agricultural machinery. Commercial collection may be a larger threat to spotted turtles than to Blanding's turtles because of the spotted turtles' smaller size and value in the international pet trade. For a discussion of threats, see Blanding's turtle profile (element 3) and habitat profiles (especially Marsh and Shrub Wetlands, Vernal Pools).

3.2 Sources of Information

Information on threats came from literature reviews, summary reports, expert reviews, and available GIS data layers from various sources.

3.3 Extent and Quality of Data

Habitat fragmentation and loss, as well as road mortality of spotted turtles, are known threats. Potential threats such as disease, invasive plants, genetic isolation, and effects of agriculture and forestry in New Hampshire are less understood.

3.4 Threat Assessment Research

- Evaluate the effects of land management (e.g., water level manipulation, agriculture, and recreation) on spotted turtles.
- Identify populations that are isolated by an anthropogenic barrier (e.g., high traffic road) and identify options for increasing connectivity for spotted turtles.
- Monitor spotted turtle populations (e.g., with radio telemetry) in areas where underpass systems have been installed or are proposed.

Element 4: Conservation Actions

- Protect spotted turtle habitat through acquisition, easement, and regulation (see Land Protection Strategies):
  - Protect large blocks of unfragmented habitat with a diversity of wetland complexes.
  - Use spotted turtle habitat to prioritize conservation of land.
  - Work with towns to protect critical habitat through land acquisition, prime wetland designation, and wetland buffer regulation.
  - Develop guidelines for landowners, managers, and towns to enhance and protect resources important to spotted turtles.
  - Maintain beaver flowages.
  - Minimize threats to wetlands such as vernal pools used by spotted turtles.
  - Maintain natural vegetation along wetland edges
- Promote wetland restoration, enhancement, and creation projects in areas that will benefit spotted turtles (e.g., restore shallow, wet meadow in agricultural areas) (see Marsh & Shrub Wetland strategies)
- Evaluate current protection status for spotted turtles and consider protection under New Hampshire Endangered Species Conservation Act (RSA 212-A). Develop guidelines for spotted turtles for use during environmental project reviews.
- Design roads and other transportation networks (e.g., railways, bike trails, sidewalks) to reduce threats to spotted turtles and other rare wildlife

(see Roads strategies)

- Educate public about rules and regulations pertaining to spotted turtles and other reptiles and amphibians (e.g., sale and possession) through updated NHFG website and other media (see Wildlife Collection strategy)
- Reduce anthropogenic food sources for predators (see Predator control strategy)

Element 5: References

5.1 Literature

Carroll, D.M. 1991. The year of the turtle. A natural history. Camden House Publishing, Incorporated, Charlotte, Vermont, USA.

Caroll, D.M. 1999. Lamprey River and Great Bay area turtle habitat investigations. Preliminary map report. Unpublished data.

Ernst, C.H., J.E. Lovich, and R.W. Barbour. 1994. Turtles of the United States and Canada. Smithsonian Instituted Press, Washington and London, USA.

Fowle, S.C. 2001. Priority sites and proposed reserve boundaries for protection of rare herpetofauna in Massachusetts. Natural Heritage and Endangered Species Program. Massachusetts Division of Fisheries and Wildlife, Westborough, Massachusetts, USA.

Hinderliter, M.G. 2003. Seasonal movements, habitat usage, home range, and conservation of spotted turtles (*Clemmys guttata*) in southern New Hampshire. Master's Thesis. University of New Hampshire, Durham, New Hampshire, USA.

Huse, W.H. 1901. The Testudinata of New Hampshire. Proceedings of the Manchester Institute of Arts and Sciences 2:47-51.

Jenkins, R., and K.J. Babbitt. 2003. Developing a conservation strategy to protect land habitat functions for New Hampshire's reptiles and amphibians using the Blanding's turtle (*Emydoidea blandingii*) as a flagship species. Final report submitted to the New Hampshire Fish & Game Department.

Joyal, L.A. 1999. *In* Maine Amphibians and Reptiles, Hunter, M.L., Jr., A.J.K. Calhoun, and M. McCollough, editors. The University of Maine Press, Orono, Maine, USA.

Joyal, L.A., M. McCollough, and M.L. Hunter, Jr. 2001. Landscape ecology approaches to wetland species conservation: a case study of two turtle species in southern Maine. Conservation Biology 15: 1755-1762.

Litzgus, J.D., and T.A. Mousseau. 2004. Demography of a southern population of the spotted turtle (Clemmys guttata). Southeastern Naturalist. 3: 391-400.

Milam, J.C., and S.M. Melvin. 2001. Density, habitat use, movements, and conservation of spotted turtles (Clemmys guttuta) in Massachusetts). Journal of Herpetology 35:418-427.

NatureServe. 2004. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: 4 January 2005).

Oliver, J.A. and J.R. Bailey. 1939. Amphibians and reptiles of New Hampshire exclusive of marine forms: Pages 195-217 *in* Biological Survey of the Connecticut watershed, H.E. Warfel, editor. New Hampshire Fish and Game Department Survey Report 4.

Therres, G.D. 1999. Wildlife species of regional conservation concern in the northeastern United States. Northeast Wildlife 54:93-100.

5.2 Data Sources

NH Natural Heritage Bureau. 2005. Database of Rare Species and Exemplary Natural

Community Occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

New Hampshire Reptile and Amphibian Reporting Program (RAARP). Coordinated by

New Hampshire Fish and Game Department's Nongame and Endangered Species Program.

Element 6: List of Figures

Figure 1. Town distribution map of known spotted turtle locations in New Hampshire, March 2005. Town records reported included a photograph, specimen, or were reported by an expert observer. Most reports were received through the New Hampshire Reptile and Amphibian Reporting Program (RAARP).

SPECIES PROFILE

Timber Rattlesnake

Crotalus horridus

Federal Listing: Not listed
State Listing: Endangered
Global Rank: G4
State Rank: S1
Authors: James Taylor, University of New Hampshire; Michael Marchand, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Timber rattlesnakes in the northeast spend the winter in a communal den, a rocky area with crevices leading to a hibernaculum below frost line (Brown 1993). They emerge from the den in May, and proceed to transient habitat, a relatively exposed rocky area where they can alternately bask and seek shelter from the sun; this may or may not be the den site. Males and non-gravid females often bask until the skin is shed, before making extensive movements into summer range habitat, often mixed deciduous forest. Gravid females are relatively sedentary and remain near exposed slopes and protective rocks until parturition, usually in September (Brown et al. 1982). Males pursue reproductive females by scent pheromone trails in order to mate with them, usually mid- to late summer. The resulting copulations provide sperm that is retained through hibernation for next years' ovulation (M. McCurley, personal communication).

The timber rattlesnake is a sit-and-wait predator, primarily preying on small mammals and birds to a lesser extent (Ernst and Ernst 2003). All individuals of the population return to the den in September. Depending on weather conditions, they may bask at the den, but they often go into the den immediately upon return. Young snakes may follow the scent trails of adults to find communal den sites (Reinert and Zappalorti 1988)

1.2 Justification

The Northeast Endangered Species and Wildlife Diversity Technical Committee determined that the timber rattlesnake is a species of regional concern in the northeastern United States. This species warrants federal endangered or threatened species listing consideration, including prelisting status reviews (Therres 1999). In New England, timber rattlesnakes are listed as extirpated in Maine and Rhode Island, and endangered in Connecticut, Massachusetts, Vermont, and New Hampshire. In New Hampshire, the timber rattlesnake is likely the most endangered of any wildlife species, as there is only one known extant population. Timber rattlesnakes have large home ranges, especially males, and individuals may be killed as they cross roads or as human-snake encounters increase (see element 3). Southern New Hampshire is rapidly developing, and large undeveloped tracts of land needed to sustain timber rattlesnake populations are dwindling rapidly. As a result, opportunities for natural recolonization or restoration have been substantially reduced.

1.3 Protection and Regulatory Status

Listed as state endangered and protected by the Endangered Species Conservation Act (RSA 212-A). A petition to list the timber rattlesnake as federally endangered was submitted in September 1991; this petition was rejected by the USFWS in January 1992.

1.4 Population and Habitat Distribution

Rattlesnakes have been historically reported from scattered locations throughout the southern half of the state, extending into the White Mountains. Clusters of reports came from along the Connecticut River in the southwest corner of the state, along the

Merrimack River, the Lakes Region, and from the edge of the White Mountains. Historic locations for timber rattlesnakes included Rattlesnake Island in Lake Winnipesaukee (reportedly the site of heavy nineteenth century depredations for the manufacture of rattlesnake oil (Oliver and Bailey 1939)), and other locations near the lake; the Mt. Thorn area in Bartlett (Allen 1899); Dan Hole Pond (Carle 1953) in Tuftonboro; Bear Brook State Park and Pinckney Hill in Allenstown and Rattlesnake Hill in Hooksett; the Mt Wantastiquet/Rattlesnake Mountain area of Hinsdale, Chesterfield, Swanzey and Winchester; and Fall Mountain in Walpole. Oliver and Bailey (1939) note that a Conservation Officer reported that rattlesnakes were occasionally killed in the Mt. Monadnock area, although these reports may not be confirmed.

In addition, there are many geographic features named for rattlesnakes in New Hampshire (table 1). Some of these were indeed probably named for the animal being present there, although one must bear in mind that almost all reports of rattlesnakes in recent times referred to milk snakes (*Lampropeltis triangulum*), a harmless snake which 'rattles' its tail against the ground when disturbed, making a sound that people may mistake for that of a rattlesnake.

There is now only one known extant population. No rattlesnakes were reported from 1981 to 1991, despite efforts to search for them at locations that they had traditionally inhabited, e.g., Pinckney Hill in Allenstown, Mt. Wantastiquet in Chesterfield, Dan Hole Pond in Tuftonboro (Carle 1958). In 1991, a forester accurately reported a rattlesnake to the author, and the den site was located in 1992.

1.5 Town Distribution Map

N/A

1.6 Habitat Map

UNH (J. Taylor, Department of Zoology and S. Hale, Complex Systems Research Center) completed a potential habitat map for timber rattlesnakes for New Hampshire. Maps for timber rattlesnake were primarily derived from the New Hampshire Landcover 2001 dataset, soils dataset, and the digital elevation model (UNH Complex Systems Research Center, GRANIT), as well as data on development and unfragmented forests. The landcover, soil, and aspect data layers were then combined to produce a final layer with all possible combinations of favorable/non-favorable landcover and transient/non-transient soil types, and aspect categories. Various query combinations can be performed to extract polygons matching user-defined criteria. Finally, the maps were overlain with the location of all geographic features containing 'rattlesnake' in their name. There were no available soils data for Merrimack and Belknap counties, the White Mountain National Forest, and other parts of the North Country.

1.7 Source of information

The major sources of information included the authors' professional experiences, scientific literature, historic newspaper articles, and personal communications with current experts and laymen.

1.8 Extent and Quality of the Data

Historical occurrence data are good, although the extent to which geographic features with 'rattlesnake' in their names actually attest to existence of the animals at that location is uncertain. In addition, not all historic den sites within larger known metapopulations are likely documented.

1.9 Distribution Research

Field-survey sites historically occupied by timber rattlesnakes in New Hampshire and those identified as potential through habitat mapping efforts (see element 1.6). Site assessments should include an assessment of potential habitat based on surrounding land-uses. All potential reports from the public should be forwarded to one contact person at NHFG. NHFG biologists or individuals contracted by the state should follow-up on any credible reports of rattlesnakes in undocumented locations.

Element 2: Species/Habitat Condition

2.1 Scale

The information discussed in this profile focuses on the one known extant population but discusses historic populations when appropriate.

2.2 Relative Health

The condition and viability of the extant population needs further detailed evaluation. Based on limited information, the population seems relatively stable over the last decade, and reproductive females continue to produce viable offspring. However, because there is only one known den site, the population is extremely vulnerable to human-induced or natural extirpation resulting from demographic or environmental stochasticity. There are also concerns about the genetic health of the population and the possibility of genetic drift and inbreeding depression (see element 3, Threats).

2.3 Population Management Status

No official population management occurs for timber rattlesnakes at this time. The known population is periodically monitored by conservation officers at NHFG, biologists, and expert naturalists.

2.4 Relative Quality of Habitat Patches

At the known extant site, existing habitat quality is relatively high. Most of the summer range is undeveloped continuous mixed deciduous forest, some of which is in protected as conservation land, and road density is low. However, much of the critical habitat is on private land. Because rattlesnakes roam widely (> 5 km) Brown 1993), one occasionally leaves the forested summer range and enters human development, where it may encounter humans (see element 3-Threats).

Several sites bearing the rattlesnake have been destroyed by gravel extraction activities or development (see element 3-Threats). A historic den site at Pinckney hill, in close proximity to Bear Brook State Park was apparently active at least up to 1983 (A. Chaput, personal communication) and was the site of the killing of 10 adult timber rattlesnakes by the landowner in September, 1976 (H. Laramie, personal communication).

2.5 Habitat Protection Status

The area of habitat currently permanently protected is not sufficient to maintain a population or metapopulation of timber rattlesnakes in New Hampshire (see Conservation Actions).

2.6 Habitat Management Status

Habitat protection is a top priority for this species in New Hampshire, either through fee-simple acquisition or acquisition of conservation easements (see Conservation Actions). Some activities such as limited forestry may not be detrimental long-term to timber rattlesnakes, especially if conducted during frozen conditions and the den site is not harmed. Limited managed timber harvesting may provide openings in the forest canopy that provide opportunities for basking individuals. However, this needs further review; a habitat and population management plan needs to be created for this site.

2.7 Sources of Information

The site has been periodically monitored by biologists, expert naturalists, and conservation officers. Other sources of information include a timber rattlesnake assessment for the White Mountain National Forest (Sweeney and Marchand 2002), historical documents (Oliver and Bailey 1939, Carle 1958), and an on-site assessment conducted by Bill Brown (Brown 2002).

2.8 Extent and Quality of the Data

Several individual rattlesnakes from the extant population have been monitored by radio-telemetry in recent years, but movement data are limited for the site, especially for males. Hibernacula and important basking sites are known, but unknown sites may exist. The condition of several historically occupied den sites has been evaluated, but other sites need further field surveys.

2.9 Condition Assessment Research

Annual monitoring should be expanded to include regular monitoring of the den and basking sites, as well as summer activity of males. At a minimum, annual counts of the number of snakes entering and exiting den sites and the number of young born and surviving winter should be conducted. Marking individual snakes (e.g., colored rattle) will help determine biological parameters of the populations, movement

patterns, and identify individuals that are observed at a distance from the den site. Historic or potential den sites should be evaluated for potential expansion of the known site. Genetic studies should be conducted to assess local genetic distinctiveness and possible effects of small population sizes.

Element 3: Species and Habitat Threat Assessment

3.1.1 Scarcity (Natural Rarity)

(A) Exposure Pathway
Problems with small population size are well supported in ecological theory (Meffe and Carroll 1998). The population growth rate of the timber rattlesnake in the northern part of its range is survival-limited, with late female sexual maturity (7-11 years, Brown 1991), individual reproduction at 3 to 4 year intervals (Brown 1991), small litter size (6-9 on average, but as low as 3 observed in New Hampshire), and high juvenile mortality (Brown 1993). Because of these traits, recovery of a depleted population is slow. Such a life history requires a long adult lifespan with low adult mortality, and in a small population, the premature death of a single adult may significantly harm a local populations. Small populations are also susceptible to genetic drift, inbreeding depression, and demographic and environmental stochasticity (Meffe and Carroll 1998). Brown (1993) estimated that a minimum population size of timber rattlesnakes to be viable might consist of 30-40 individuals, including at least 3-5 reproductive females (Brown 1993). However, if adult mortality were increased by human actions, a population of this size would likely not be viable.

(B) Evidence
Individual timber rattlesnakes from a hibernaculum in Pennsylvania were more closely related to each other than they were to snakes from other hibernacula, suggesting inbreeding (Bushar et al. 1998). Since there is only one known den in New Hampshire, this problem may be exacerbated. Most timber rattlesnake populations have a mixture of black phase and yellow phase individuals. The New Hampshire population is unusual in that most individuals are strongly melanistic. However, Art Chaput (personal communication) once told the author that he had seen yellow phase individuals in New Hampshire, and an old local newspaper photograph shows a man with what appears to be a yellow phase animal. The loss of the yellow phase and colorations unknown in other timber rattlesnake populations suggest possible future genetic challenges in this population due to genetic drift and/or inbreeding depression. At least one newborn had a scoliolitic spine with external adhesion, probably a birth defect (H. B. Bechtel, MD, personal communication). However, the genetic characteristics of the extant population need further analysis.

3.1.2 Development

(A) Exposure Pathway
Residential and commercial developments may directly destroy habitat (den sites, basking sites, transient, summer range) required by local rattlesnake populations. As a result, prey sources may be reduced, preferred vegetation may be altered, and snakes may become more vulnerable to humans and other predators. NHFG may have to dedicate significant time to relocating snakes that are found in human developments. Automobiles can result in direct mortality of individuals (Aldridge and Brown 1995), and road construction near rattlesnake populations will increase access to those areas. Recreational demands (e.g., ATV, bike, and hiking trails) on private and public lands may also impact rattlesnake populations by increasing snake-human encounters.

(B) Evidence
Male rattlesnakes are especially vulnerable during mating season, when they are more likely to encounter humans and cross roads (Aldridge and Brown 1995). Several individuals have been found in residential developments in New Hampshire, at least two snakes being killed by local residents. Much of the known timber rattlesnake habitat is on private land and residential and/or commercial developments will likely be proposed over time if these lands are not protected. Effects of recreational activities on the current population need further evaluation.

3.1.3 Development (Habitat Loss and Conversion)

(A) Exposure Pathway
Timber rattlesnakes congregate in den sites during winter. Extracting of gravel or rock at the den site

will destroy a critical habitat component for local rattlesnake populations. In addition, large vehicles carrying rock and gravel could kill individual snakes if within transient or summer range habitat. In New Hampshire, there is only one known den site, so any disturbance to the den site or surrounding habitats could be catastrophic.

(B) Evidence:
Several sites in New Hampshire having "rattlesnake" names are currently or have been destroyed by commercial mining extractions (e.g., Rattlesnake Mountain, Concord; Rattlesnake Hill, Hooksett).

3.1.4 Unregulated Take

(A) Exposure Pathway
All other populations in New Hampshire have been destroyed by human actions. People tend to fear snakes, especially venomous species, and will kill snakes when they are encountered. In addition, because snakes congregate at den sites, knowledgeable collectors (commercial pet trade, personal use) are capable of depleting or eliminating local populations (Tyning 1992, Klemens 1993). In fact, one individual, Rudy Komarek, has reportedly greatly contributed to population depletions, including populations in New York and Massachusetts (Brown et al. 1994). The current New Hampshire population is vulnerable to illegal killing and collection. As a survivorship-limited species, loss of a single reproductive female from the remaining population may be enough to reduce the net reproductive rate below what is sustainable, leading to local and state extinction.

(B) Evidence
Unregulated take and persecution are undoubtedly the reasons behind extirpation of populations at traditional locations. Legislation once encouraged the killing of rattlesnakes, and zealous collectors and "bounty" hunters have decimated populations in the state.

3.2 Sources of Information

Sources included professional experiences, direct observation of the extant population, and searches of traditional locations, literature reviews, and personal communications.

3.3 Extent and Quality of Data

The major threats to the extant population are known. The frequency of unregulated take and other sources of unnatural mortality are probably not completed known.

3.4 Threat Assessment Research

Constant monitoring of the population is required to document potential and actual threats to the only known extant population.

Element 4: Conservation Actions

As a first step to protecting timber rattlesnakes in New Hampshire, the NHFG needs to develop a detailed recovery plan for timber rattlesnakes in New Hampshire. This plan will more thoroughly detail monitoring and research needs, education and technical assistance, habitat protection, restoration and management, and recovery goals. To ensure that timber rattlesnakes are not extirpated from New Hampshire, conservation efforts should focus on maintaining and/or restoring multiple metapopulations in New Hampshire, which will require a combination of efforts. The immediate primary goal is to protect the known existing population. Specific recovery goals need to be established. Specific conservation objectives and monitoring responses will be evaluated for this plan based on available information and will be updated as new monitoring or other information becomes available. In the interim, the status of the extant population must be monitored intensely each year.

4.1.1 Habitat Protection

Habitat protection will be critical to the future survival of timber rattlesnakes in New Hampshire. Ideally, all habitat used by female rattlesnakes should be protected, along with known habitat used by male snakes, and dispersal corridors to other historic or potential den locations. It is imperative that the areas around the den be afforded maximum protection and that all activities proposed in the protected area be compatible with timber rattlesnake conservation. Land values in southern New Hampshire are high, and a large land purchase will require a coordinated

effort among state agencies, conservation agencies, municipalities, and private funding.

4.1.2 Technical Assistance and Education

Information about the perilous state of the rattlesnake in New Hampshire should be made available to those close to (e.g., residential neighborhoods) or working in the summer range of occupied timber rattlesnake habitat (e.g., foresters), and the general public (NHFG website, press releases), along with information about rattlesnake biology, contact information in case a rattlesnake is encountered, and penalties for harming, harassing, or killing a rattlesnake. However, secrecy about the exact location is critical in preventing unscrupulous people from destroying individuals or critical habitat components (Brown 1993).

4.1.3 Restoration and Management

Timber rattlesnake populations are known to exist in a metapopulation structure, with several den sites within dispersal distances of each other. In New Hampshire, only one den is known to remain, although habitat in close proximity may remain.

Captive breeding has been successfully initiated for other endangered fauna in New Hampshire (e.g., Karner blue butterfly). Although captive breeding of rattlesnakes is relatively new, there are individuals and organizations within New England that have the experience to at least begin experimental captive breeding. Goals of captive breeding would include maintaining a genetic stock of New Hampshire rattlesnakes, in the event that a catastrophic event occurs in the natural population. Captive-breed individuals could also be used to augment the natural population, both in terms of number of individuals and genetic material. Appropriate methodology for breeding and releasing individual snakes would require detailed discussion prior to taking any actions.

Translocation of rattlesnakes to formerly occupied dens has been suggested as a possible conservation strategy (Brown 1993). However, this technique needs further evaluation and intense monitoring if implemented (see Dodd and Seigel 1991). In studies of nuisance timber rattlesnakes translocated from state parks in North Carolina to less populated areas, Sealy (1995) found that the snakes did not thrive. Reinert and Rupert (1999) conducted a controlled radiotelemetry study in which behavior of translocated rattlesnakes was compared to that of residents and found immediate and long-term negative effects of translocation. There are too few rattlesnakes in New Hampshire to attempt this at present without the initiation of a captive breeding program. Release of captive-raised neonates to augment existing populations may a more feasible option (Conner et al. 2003).

Appropriate habitat management in rattlesnake habitat will be addressed when a full recovery plan is developed. Likely, there should be several buffers of varying distances from the den and basking sites that allow different levels of management and recreational activities (Brown 1993). Appropriate habitat management must be clearly communicated to those involved (e.g., foresters).

Although not a primary conservation technique, fencing to prevent rattlesnakes from entering private property or other threatening habitat has been suggested. However, preventing rattlesnakes from accessing habitat could be considered take of an endangered species habitat (Amato and Rosenthal 2001). Fencing should not be used as a justification for the construction of residential or commercial structures in rattlesnake habitat. Fencing may be a viable option if snakes continually enter an existing residential area at the periphery of the snakes' summer range.

4.1.4. Regulation and Policy

Continue to actively pursue and enforce violations that involve humans illegally killing rattlesnakes. Monitoring of the local population will help determine what habitat should be reviewed and protected during NHFG's review of proposed developments.

4.2 Conservation Action Research

The extant population must be monitored to assess viability and success of proposed conservation actions. For example, individual age-specific survivorship and reproductive data should be taken annually so that over time life-table methods can be used to estimate the net reproductive rate. The genetic structure of the existing New Hampshire population should be analyzed and compared to other populations in the region.

Element 5. References

5.1 Literature

[For thorough bibliographies on timber rattlesnakes, see Bill Brown (1991, 1993)]

Allen, G. M. 1899. Notes on the Reptiles and Amphibians of Intervale, New Hampshire. Proc. Boston Soc. Nat. Hist. 29:63-75.

Amato, C. A. and R. Rosenthal. 2001. Endangered species protection in New York after STATE V. SOUR MOUNTAIN REALTY, INC. Environmental Law Journal. 10:117-145.

Brown, W. S. 2002. Conservation and management of New Hampshire's endangered timber rattlesnake (*Crotalus horridus*): Preliminary recommendations. Unpublished final report to New Hampshire Fish & Game, Nongame and Endangered Species Program.

Brown, W. S. 1991. Bibliography of Crotalis horridus. in Tyning, Thomas F., ed. Conservation of the Timber Rattlesnake in the Northeast. Massachusetts Audubon Society, Lincoln MA.

Brown, W. S. 1993. Biology, Status, and Management of the Timber Rattlesnake (*Crotalis horridus*): A Guide for Conservation. Herpetological Circular no. 22. Society for the Study of Amphibians and Reptiles.

Brown, W. S., L. Jones, and R. Stechert. 1994. A case in herpetological conservation: notorious poacher convicted of illegal trafficking in timber rattlesnakes. Bulletin Chicago Herpetological Society.

Brown, W.S., D.W. Pyle, K.R. Greene, and J.B. Friedlander. 1982. Movements and temperature relationships of timber rattlesnakes (*Crotalus horridus*) in northeastern New York. Journal of Herpetology. 16:151-161.

Bushar, L.M., H. K. Reinert, and L. Gelbert. 1998.Genetic variation and gene flow within and between local populations of the timber rattlesnake, *Crotalus horridus*. Copeia 1998:411-422.

Carle, H. D. 1958.What has happened to our snake populations? Bull. NH Acad. Sci. August 1958.

Conner, R. N., D. C. Rudolph, D. Saenz, R. R. Schaefer, and S. J. Burgdorf. 2003. Herpetological Review. 34:314-317.

Dodd, C. K. and R. A. Seigel. 1991. Relocation, repatriation, and translocation of amphibians and reptiles: are they conservation strategies that work? Herpetologica 47:336-350.

Ernst, C. H. and E. M. Ernst. 2003. Snakes of the United States and Canada. The Smithsonian Institution. Washington, D.C., USA and London, England.

McDuffie, J. 1968. See education as solution to state's rattler problem. Foster's Daily Democrat, January 13, 1968.

Meffe, G.K and C. R. Carroll. 1998. Principles of Conservation Biology, 2nd ed. Sinauer, Sutherland MA. Oliver, J. A. and J. R. Bailey. 1939. Amphibians and Reptiles of New Hampshire. in Biological Survey of the Connecticut Watershed. Survey Report no.4. New Hampshire Fish and Games Department, Concord NH.

Reinert, H. K. and R. R. Rupert, Jr. 1999. Impacts of translocation on behavior and survival of timber rattlesnakes, *Crotalus horridus*. Journal of Herpetology 33:45-61.

Reinert, H. K. and R. T. Zappalorti. 1988. Field observation of the association of adult and neonatal timber rattlesnakes, Crotalus horridus, with possible evidence for conspecific trailing. Copeia. 1988:1057-1059.

Sealy, J. B. 1995. Movements and management of nuisance rattlesnakes in a state park in North Carolina, Abstract, 38th Meeting of the Society for the Study of Amphibians and Reptiles, Boone NC.

Society for the Protection of New Hampshire Forests. 2005. New Hampshire's Changing Landscape. Population growth and land use changes: what they mean for the Granite State. Executive Summary. Concord, New Hampshire, USA.

Therres, G. D., Chairman of the Northeast Endangered Species and Wildlife Diversity Technical Committee. 1999. Wildlife species of regional conservation concern in the northeastern United States. Northeast Wildlife 54:93-100.

Tyning, T.F. (editor). 1992. Conservation of the timber rattlesnake in the Northeast-a symposium held December 1, 1991 in Northhampton, MA, published by the Massachusetts Audubon Society.

SPECIES PROFILE

Wood Turtle

Glyptemys insculpta

Federal Listing: Not listed
State Listing: Special Concern
Global Rank: G4
State Rank: S3
Authors: Heidi Holman and Michael Marchand, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Wood turtles (*Glyptemys insculpta*) are associated with rivers and streams with hard sand or gravel substrate (Ernst et al. 1994) but make extensive use of surrounding uplands during the summer (Compton et al. 2002, Tuttle and Carroll 2003). Turtle terrestrial activity often is within 300 m of streams and rivers (Kaufmann 1992, Arvisais et al. 2002). Habitat use and home range may vary among individuals of a local population (Kaufmann 1992, Compton 2002).

A mosaic of river or stream, forest, dense shrub thicket, and bare sandy substrate may attract turtles and provide habitat for a higher density of turtles (Kaufmann 1992). In Maine, wood turtles were near streams and rivers that had moderate forest cover (Compton et al. 2002). Within activity areas, wood turtles in Maine selected areas that were near water, were non-forested, and had low canopy cover (Compton et al. 2002). Compton et al. (2002) attributed this difference in selection at the 2 spatial scales to a preference for forest edges, where basking and feeding opportunities are abundant. Some disturbances (e.g., agriculture, hayfields, gravel pits) may provide habitat heterogeneity that wood turtles prefer.

Wood turtles can be found closer to the river after emerging from hibernation in late April and May (Tuttle 1995). At this time, and throughout the summer, dense riparian and early successional shrub thickets are extremely important cover (Kaufmann 1992, Compton 2002, Arvisais et al. 2004). Alder (*Alnus spp*.), dogwoods (*Cornus spp*), and arrowwood (*Viburnum spp*.) are good cover plants along riparian areas and other edges (D. Carroll, personal communication). A mixture of herbs and grasses (e.g., meadow-sweet, *Spiraea latifolia*, goldenrod *Solidago* spp.), shrubs (e.g., dogwoods), and vines (e.g., woodbine *Parthenocissus quinquefolia*, grape *Vitis* spp.) reduce detection by humans and other predators and provide abundant food for the turtles (D. Carroll, personal communication). Food includes green leaves, earthworms, fruit, fungi, insects, and carrion (Ernst et al. 1994, Niederberer and Siedel 1999). Emergent marshes, swamps, and vernal pools may be used during spring and summer (Hunter et al. 1999, Arvisais et al. 2004), and at night wood turtles enter shallow forms under grass, leaves and brush, fallen logs, and flood debris (Harding and Bloomer 1979, Ernst 1986, Farrell and Graham 1991).

Female wood turtles lay eggs during late May and early July in sparsely vegetated, sandy-gravelly, well-drained soils, often near water (Harding and Bloomer 1979, Klemens 1993, Buech et al.1997). Nests may be excavated in natural (e.g., sandbars, sandy banks) and anthropogenic (e.g., gravel and sit pits, railroad beds) sites (Brooks et al. 1992, Tuttle and Carroll 1997, Buech et al. 1997). Hatchlings emerge from the nest chamber between mid August and early October (Ernst et al. 1994).

Turtles return to the river daily in September and October before settling into hibernation before mid November (Tuttle 1995). Hibernation sites include undercut banks, submerged tree snags, and woody debris in rivers, wildlife burrows, and deep pools (Garber 1989, Ernst and McBreen 1991). Most wood turtles hibernate in the same location annually (Garber 1988) and may hibernate communally (Harding and Bloomer 1979).

1.2 Justification

The wood turtle is a species of concern in the northeast that warrants federal endangered or threatened species listing considerations (Therres 1999). Though many states across the species range have reported declines, population structures with a disproportionate number of adults, or local extirpations (Ross et al. 1991, Garber and Burger 1995, Ernst 2001a). The wood turtle is listed as a species of special concern in Maine (Hunter et al. 1999), Massachusetts (Massachusetts Natural Heritage and Endangered Species Program 2004), Connecticut, and New Hampshire, and is listed as a species at risk in Vermont (Vermont Nongame and Natural Heritage Program 2000). Wood turtles were once one of the most common turtle species in New Hampshire (Oliver and Bailey 1939).

Life history traits including late sexual maturation (Ontario: 17-18 years, Brooks et al. 1992) and limited fecundity (Garber 1989, Farrell and Graham 1991, Ross et al. 1991, Brooks et al. 1992) make wood turtles extremely vulnerable to increased adult mortality. Wood turtles depend on high rates of adult survival to compensate for large mortality in the early stages of life. A model developed by Compton (1999) predicted that the annual removal of only 2 adult wood turtles from a stable population of 100 individuals would result in the extirpation of the population in fewer than 80 years.

As human populations expand in New Hampshire, development and disturbance will likely harm the wood turtle (Tuttle and Carroll 1997; M.N. Marchand, personal observation.)

1.3 Protection and Regulatory Status

- Convention on International Trade of Endangered Species (CITES) Appendix II restricts the import and export of the species from the country.
- A petition to list the wood turtle as threatened under the Endangered Species Act by the Federal government was refused in the mid 1990s, when the United States Fish and Wildlife Service (USFWS) stated the petition did not present "substantial scientific or commercial information indicating that listing the species is warranted" (USFWS 1995).
- New Hampshire Fish and Game (NHFG) Rule Fis 803.02. Wood turtles shall not be imported to New Hampshire.
- NHFG Rule Fis 804.02. Wood turtles shall not be possessed in New Hampshire.
- NHFG Rule Fis 811.01. No person shall sell wood turtles in New Hampshire.
- Fill and Dredge in Wetlands; New Hampshire Department of Environmental Services (NHDES, RSA 482-A, Wt 302). Projects that propose to impact jurisdictional wetlands or the banks or channel of rivers or stream are reviewed by NHDES and NHFG.
- Comprehensive Shoreland Protection Act; NHDES (RSA 483-B). Applies to waterbodies larger than 4.05 ha (10 acres). Restricts work conducted within 76.2 m (250ft) from fourth order or greater streams (e.g., tree, shrub and groundcover removal) and requires primary structure setback of 15.24 m (50 ft). Individual towns have the authority to extend these regulations to lower order streams and smaller bodies of water.
- Rivers Management and Protection Program; NHDES (RSA 438) designates rivers in New Hampshire for protection of cultural or natural resources. Established to protect public uses and includes habitat protection. No channel alteration activities shall be allowed in rivers designated as "natural". No dams will be built on rivers designated as natural, rural, or rural community rivers. A protected instream flow level shall be established for each designated river. No motorized watercraft are allowed on designated natural rivers. Within 15.24 m (50ft) of a stream, 50% of basal area of trees cannot be cut. For fourth order streams and higher this extends to within 45.72 m (150 ft).

1.4 Population and Habitat Distribution

Wood turtle range extends from Maine to Minnesota, south to Virginia and Iowa in the United States, as well as from Nova Scotia to Ontario (Ernst et al. 1994). The northeast United States comprises a significant portion of the wood turtle's global range (Therres 1999). Wood turtles appear to be distributed throughout New England but are less common in coastal zones (Klemens 1993).

In New Hampshire, wood turtles likely occur throughout much of the state, excluding higher altitudes such as the White Mountains Region (Taylor 1993, New Hampshire Natural Heritage Bureau (NHNHB) 2005). High elevation records for southern New England include 442 m (1,450 ft) at Norfolk, Connecticut, 497 m (1,630 ft) Becket, Massachusetts, and 518 m (1,700 ft) Plainfield, Massachusetts (Klemens 1993). Scarcity of deep, low gradient streams, as opposed to altitude, may be the limiting factor at high elevation (Klemens 1993). Historical town locations identified by Oliver and Bailey (1939) included 12 towns with no recent records (before 1985).

1.5 Town Distribution Map

1.6 Habitat Map

Wood turtle habitat was mapped at 2 scales: known occupied sites and watersheds. Known wood turtle records (Element Occurrences, New Hampshire Natural Heritage Bureau Rare Species Database) were assigned to the closest point in a river or stream. These stream locations were then expanded to include areas 0.5 km up and downstream (Inferred Extent, NatureServe Element Occurrence specifications) as well as 300 m of adjacent uplands. These areas were considered occupied habitat patches.

A second scale was created using the 12-digit watersheds (HUC-12) to map potential habitat. Non-tidal rivers and streams below 550 m elevations were buffered by 300 m, marsh and shrub wetlands partially within this buffer were included in entirety. Because use of deep, open water habitat by wood turtles has not been observed, lakes were removed from the potential habitat model. The potential habitat map was meant to be inclusive rather than exclusive. Therefore, over prediction of potential habitat is likely, and this map will be refined based on field inventory and updated Geographic Information System (GIS) data layers.

1.7 Sources of Information

Habitat information came from peer-reviewed literature and a wood turtle species viability report conducted by the White Mountain National Forest (unpublished document, originally prepared by K. Marchowsky 2001; revised by M. Marchand 2002). The Reptile and Amphibian Reporting Program (RAARP) and NHNHB databases were used to assess distribution. Neighboring state websites were consulted for recent distribution information. Habitat maps were produced by NHFG using available GIS data layers from various sources (metadata available upon request).

1.8 Extent and Quality of Data

Observations from RAARP were reviewed for quality before inclusion. However, distribution information is not complete, and new town records are likely. Information has been collected on a few populations by researchers conducting mark-recapture studies, and Tuttle and Carroll (1997, 2003) conducted an intensive population study for NHFG in the early 1990s.

1.9 Distribution Research

Potential wood turtle habitat within watersheds will be evaluated by GIS analysis to identify and prioritize future survey efforts. Multiple RAARP observations in a particular section of a watershed may indicate high priority areas for surveying efforts. Surveys would verify if a watershed provides likely habitat.

Element 2: Species/Habitat Condition

2.1 Scale

Habitat condition was assessed based on occupied and potential habitat patches with HUC-12 watersheds.

2.2 Relative Health of Populations

Conditions of most populations are not known. Wood turtles were reported in 78 towns at 108 various locations. Sixteen records reported more than 1 individual. Nine dead individuals were reported (2 males, 3 females, 3 juveniles and 1 unidentified). Sixteen reports were near roadsides; 6 of 9 deaths were among these (2 males, 1 female, 3 juveniles). Nesting has been observed in 9 reports; this included actual nesting or behavior indicative of nesting.

2.3 Population Management

There is no management of wood turtles by the NHFG. Independent researchers (e.g., David Carroll) and universities (St. Anselm's, Plymouth State) in the state are conducting local monitoring, mark-recapture, and radio telemetry studies.

2.4 Relative Quality of Habitat Patches

There are 327 12-digit watersheds in New Hampshire. Ninety-three watersheds had known wood turtle habitat, and potential habitat occurred in the 93 occupied watersheds as well as 226 additional watersheds (table 1). Only 8 watersheds were not mapped as potential wood turtle habitat; these watersheds were all in northern New Hampshire and continued into Maine. Most attributes measured were similar among occupied and potential watershed units. However, only 1 occupied watershed lacked any state routes and interstates in potential or known wood turtle habitat, compared to 23 potential watersheds.

2.5 Habitat Patch Protection Status

The total area of known and potential wood turtle habitat protected in occupied watersheds ranged from 0 to 2,193 ha (mean = 518 ha). Only 29% (27 of 93) of occupied watersheds had more than 20% protection of wood turtle habitat (table 2), though a number of watersheds where wood turtles have not been documented have a greater degree of protection. The actual habitat quality of these protected areas is not known and should be ascertained. Also, areas listed as conservation land may not be protecting wood turtles because of permitted land or recreational uses. Therefore, protection status for wood turtles may be much lower than what is represented in the conservation lands data layer used for these analyses.

2.6 Habitat Management Status

There is no habitat management being conducted for the wood turtle by NHFG, although recommendations pertaining to wood turtles have been made to private landowners by NHFG.

2.7 Sources of Information

Condition information was obtained from the NHNHB Element Occurrence database. Additional GIS data layers were used to analyze habitat quality.

2.8 Extent and Quality of Data

Wood turtle may occupy many of the available watersheds in the state, but only portions of watersheds have been documented (93 known of 319 potential), and only a few populations have been studied in detail through mark-recapture and radio telemetry.

2.9 Condition Assessment Research

Surveys should be conducted in areas that most likely support large remnant populations (vis-à-vis historical and current observation, lack of threats, adequate nesting and hibernation sites, undeveloped upland habitat). A multivariate analysis could be conducted to determine watershed characteristics associated with wood turtle occupancy. Long-term studies should be conducted on a few populations to assess and monitor viability. These studies should be coordinated with universities and other researchers and be consistent with other regional efforts.

Element 3: Species Threat Assessment

Additional threats specific to habitats used by wood turtles can be found in relevant Habitat Profiles (e.g., Watersheds, Marsh and Shrub Wetlands, and Floodplain Forests). See form 2: Threat Ranking for details on all threats considered.

3.1.1 Development (Fragmentation, Habitat Loss and Conversion)

A) Exposure Pathway
Residential and commercial development results in loss of upland habitat for wood turtles. Conversion of disturbed sites (e.g., gravel pits) to impervious surfaces or manicured lawns reduces the quality of nesting habitat. Increased recreation (e.g., hiking and water sports) along streams and rivers can result in removal of dense riparian vegetation and trampling of sandbars and other potential nesting areas.

B) Evidence
Habitat loss and fragmentation are the main threats to wood turtles throughout their range (Kaufmann 1992, Ernst 2001a). In New Hampshire, large wetland systems are being bisected by development, especially in the southern portion of the state (Tuttle 1995) and the human population and associated development is rapidly expanding (Society for the Protection of New Hampshire Forests 2005).

Wood turtles use upland habitats extensively during the summer (Ernst 1986, Kaufmann 1992, Tuttle and Carroll 2003, Arvisais et al. 2004). Development and other alterations within the summer activity range of wood turtles may result in mortality and injuries to wood turtles (Harding and Bloomer 1979, Saumure and Bider 1998, Marchand and Litvaitis 2004), as well as loss of protective vegetative cover.

3.1.2 Transportation Infrastructure

A) Exposure Pathway
Increasing human population is associated with increasing road densities and traffic volume, as well as with road widening. Turtles are relatively slow when traveling through upland habitat, and individual turtles are extremely vulnerable when crossing moderate to high traffic roads. Small annual losses of only a few adult wood turtles may result in population extirpation.

B) Evidence
Roads located near local turtle populations can lead to mortality of individual and altered population structures, including skewed age or sex ratios (Ernst and McBreen 1991, Klemens 1989, Garber 1989, Marchand and Litvaitis 2004, Steen and Gibbs 2004).

Sixty-seven percent (6 of 9) of dead wood turtles reported in New Hampshire were located on roads (New Hampshire Natural Heritage Bureau 2005). There are 23 watersheds with no major roads in potential wood turtle habitat, but only 1 known occupied watershed without major roads. The mean number of stream road crossings per occupied watershed is 30.

3.1.3 Recreation

A) Exposure Pathway
Converting abandoned railways to active hiking and biking trails (i.e., Rails to Trails) may reduce nesting habitat available to turtles and increase human-wood turtle encounters, leading to collection of individuals. The construction of parking lots at recreation areas may increase injuries or mortality of individual wood turtles, and injuries or morality resulting from domestic dogs could be a factor in recreation areas with walking trails. Canoeists may harm nest sites on beaches, and Off –Highway Recreational Vehicle (OHRV) use in riparian corridors could result in collision with individuals and destruction of nests.

B) Evidence
Most recreational threats to wood turtles are anecdotal. However, a long-term study in Connecticut documented the extirpation of 2 wood turtle populations following an increase in human recreation (Garber and Burger 1995).

3.1.4 Unregulated Take

A) Exposure Pathway
Commercial collection is a major threat to wood turtles. Wood turtles often hibernate in groups, making them easy for collectors to find.

B) Evidence
Illegal collection has eliminated entire populations of wood turtles in some areas (NatureServe 2005), though the NHFG has no evidence of commercial collection of wood turtles in New Hampshire. However, reptile dealers have advertised wood turtles in New Hampshire in the past (Levell 2000). In 1992 a wood turtle sold for $75, and in 1994 a pair sold for $275 (RESTORE: The North Woods et al. 1994). Adults, which are crucial to population stability, are collected most often because they are easy to find (Ernst 2001b).

3.1.5 Altered Hydrology

A) Exposure Pathway
Dams alter the flow of a stream, and the impoundment of water and regulated release may reduce natural erosion processes that create nest sites, and may flood any nests that are laid when water levels are low. Also, turtles hibernating in the undercut banks of streams may freeze when water discharge is stopped. Dams or ineffective culverts under roadways

may impede the movement of turtles, fragmenting populations and reducing gene flow. Channelization of streams may also alter stream flow by increasing water velocity, causing sections of river to be unusable for the wood turtle. Dredging may cause sediment loading in rivers, degrading water quality. The use of riprap along shorelines reduces availability of food and cover vegetation.

B) Evidence
At a dam site in Maine, female wood turtles delayed nesting and eventually relocated their nest sites due to lack of water flow needed to maintain nesting areas (Compton 1999). Water releases resulted in the flooding of 25% of nests at the site each year. Flooding later in the season could result in a higher mortality rate of developing wood turtle embryos.

3.1.6 Agriculture

A) Exposure Pathway
The maintenance of agricultural crops and hayfields may result in injury to adult turtles using the area during the summer. The loss of individuals, especially adult females, can have a severe impact on the population due to the low recruitment of juveniles into the breeding population.

B) Evidence
Observed effects of agriculture on a wood turtle population include lower numbers of juveniles, decreased growth during the second decade of life, and increased shell injury (Saumure and Bider 1998). Numerous wood turtles in New Hampshire have been found in hay pastures dead from apparent collision (M. Marchand, personal observation). Female wood turtles have been observed nesting in agricultural fields (Kaufmann 1992), which increases the risk of collision and nest loss.

3.2 Sources of Information

Reviewing literature identified threats to wood turtles throughout the species' range. Threats were ranked based on databases, survey reports, literature reviews, and personal experiences by the authors.

3.3 Extent and Quality of Data

There is a lack of information about commercial and casual collection occurring in the state. Without knowing the location of large populations, threats are difficult to monitor. Potential threats such as disease, invasive plants, genetic isolation, and effects of forestry activities in New Hampshire are also less understood.

3.4 Threat Assessment Research

Identify and assess threats (e.g., trails, agricultural areas, and gravel pits) to specific populations, including those in conservation land, and develop local conservation actions.

Element 4: Conservation Actions

- Use occupied habitats to prioritize conservation of land through acquisition, development restrictions, and mitigation, and work with towns to protect critical habitat through land acquisition, prime wetland designation, and wetland buffer regulations.
- Evaluate protection status and develop guidelines for regulatory review of threats to known potential habitat.
- Design and place roads and other transportation networks to reduce impacts to wood turtles and other rare wildlife.
- Identify dams and alterations to water flows that occur near wood turtle populations.
- Educate public about rules and regulations pertaining to wood turtles and other reptiles and amphibians (e.g., sale and possession) through updated and improved NHFG website and other media. More inquiry into local pet stores and traders in the region needs to be conducted. Critically evaluate all possession permits in the state.
- Reduce anthropogenic food sources for predators.

Wood Turtle Actions

4.1.1 Raise mower level and time mowing appropriately, Restoration and Management

(A) Direct Threats Affected: Agriculture, Development (Habitat Loss and Conversion)

(B) Justification:
- Raising mower height will decrease the risk of turtle injury caused by collision with machinery.
- The ecological response to raising mower height will be a decrease in turtle mortality.
- Wood turtles rely on habitat that includes open meadows and fields. The mowing of any field could have a large impact on a particular population.
- The action can be adapted if it is found that the mower height should be adjusted for decreased mortality or increased economic benefit, without accidental take occurring

(C) Conservation Performance Objective
The objective of raising the mower height is to decrease the number of collisions with adult wood turtles.

(D) Performance Monitoring
The success of raising mower height will be indicated by a decrease in wood turtle carcasses found in fields. Monitoring of fields that are mowed at a variety of heights could indicate the level that is required for protection of individuals and is most cost effective for the landowner.

(E) Ecological Response Objective
The desired ecological response to raising mower height is to maintain population viability by decreasing additive adult mortality.

(F) Response Monitoring
A long-term, mark-recapture study could determine if the action is successful. Conduct surveys during the early spring or nesting period to find individuals that are coming out of hibernation (this is the easiest time to find them). Information on the age of individuals captured over time will reveal if the average population age were increasing, indicating a declining population size.

(G) Implementation
Identify landowners with fields that are maintained along segments of river that support wood turtle populations. Produce a flyer with information regarding the effect that 1 adult wood turtle death has on the health of a population, and indicate the benefits to raising the height of mower blades before this can be done, the blade height at which turtles become safe must be established. Discuss the possibility of performing mowing and other maintenance after mid-September, when wood turtles are more likely to be near or in the river. The Landowner Incentive Program (LIP) or the Wildlife Habitat Incentives Program (WHIP) could be used to compensate farmers who choose to enroll.

Alternatively, an unmowed buffer could be left at the edge of hayfields while turtles are active; research would need to determine an appropriate width. Reducing the economic impact that this action has on the cooperative landowner is imperative to its success.

(H) Feasibility
Long-term monitoring is labor intensive and so can only be initiated at several priority sites. Remaining agricultural land in New Hampshire is important to landowners, so it may be difficult to engage them.

4.1.2 Divert recreational activities to avoid wood turtle areas, Education and Outreach

(A) Direct Threats Affected: Unregulated Take, Transportation Infrastructure, Development (Habitat Loss and Conversion)

(B) Justification
- Reducing human use in an area that supports a wood turtle population would prevent destruction of nests, injury or mortality of individuals due to collision with OHRV, and the removal of individuals from a population.
- Diverting trails and access points away from areas that support wood turtle populations would ensure greater protection for a population. All populations that are identified should be protected.
- The conservation action may be adjusted if wood turtle populations increase

(C) Conservation Performance Objective
The objective of redirecting recreational access away from wood turtle habitat on public lands is to reduce the collection of individuals from the wild and reduce

destruction of nest sites and risk of collision with vehicles.

(D) Performance Monitoring
A long-term population study in a conservation land, such as a state park, would identify primary wood turtle habitat. Long-term mark-recapture and radio telemetry monitoring would indicate where individuals are affected (e.g., by injury, mortality, and collection) by ongoing recreational uses.

(E) Ecological Response Objective
The desired ecological response to isolating areas that support wood turtle populations is to stabilize existing wood turtle populations by preventing the loss or removal of individuals.

(F) Response Monitoring
These data could be obtained by a long-term, mark-recapture study. The stability of populations over time would be measured by population size, age and sex structures, and reproductive success.

(G) Implementation
Identify conservation land where wood turtles are likely to occur. Communicate with land managers regarding wood turtle habitat needs and vulnerability to recreational activities. Monitor several wood turtle populations that are affected by recreational activities.

(H) Feasibility
Managers of state lands may be seeking guidance to ensure development has minimal impact on the resources in their areas. The implementation of this action would be most successful in areas where recreation is currently limited.

4.2 Conservation Action Research

Use GIS models created for the comprehensive management plan to prioritize areas to be targeted for these conservation actions. Monitor long-term effects to determine if they are successful.

Element 5: References

5.1 Literature Cited

Arvisais, M., E. Levesque, J.-C. Bourgeois, C. Daigle, D. Masses, and J. Jutras. 2004. Habitat selection by the wood turtle (*Clemmys insculpta*) at the northern limit of its range. Canadian Journal of Zoology 82: 391-398.

Brooks, R.J., C.M. Shilton, G.P. Brown, and N.W.S. Quinn. 1992. Body size, age distribution, and reproduction in a northern population of wood turtles (*Clemmys insculpta*). Canadian Journal of Zoology. 70: 462-469.

Buech, R.R., and M.D. Nelson. 1991. How to create wood turtle nesting areas. Draft final report to Minnesota Department of Natural Resources. St. Paul, Minnesota, USA.

Buech, R.R., L.G. Hanson, and M.D. Nelson. 1997. Identification of wood turtle nesting areas for protection and management. Proceedings: Conservation, Restoration and Management of Tortoises and Turtles – An international Conference. New York Turtle and Tortoise Society, pp. 383-391.

Compton, B.W. 1999. Ecology and conservation of the wood turtle (*Clemmys insculpta*) in Maine. Master's Thesis. Univeristy of Maine. Orono, Maine, USA.

Compton, B.W., J.M. Rhymer, and M. McCollough. 2002. Habitat selection by wood turtles (*Clemmys insculpta*): an application of paired logistic regression. Ecology 83:833-843.

Ernst, C.H. 1986. Environmental temperatures and activities in the wood turtle, *Clemmys insculpta*. Journal of Herpetology 20:222-229.

Ernst, C. and McBreen, J.F. 1991. Virginia's endangered species: proceedings of a symposium. McDonald and Woodward. Blacksburg, Virginia, USA.

Ernst, C.H. 2001a. Some ecological parameters of the wood turtle, *Clemmys insculpta*, in southeastern Pennsylvania. Chelonian Conservation and Biology 4:94-99.

Ernst, C.H. 2001b. An overview of the North American genus Clemmys Ritgen, 1828. Chelonian Conservation and Biology 4:211-216.

Ernst, C.H., R.W. Barbour, and J.E. Lovich.1994. Turtles of the United States and Canada. Smithsonian Institution Press, Washington, D.C., USA.

Farrell, R.F. and T.E. Graham. 1991. Ecological notes on the turtle *Clemmys insculpta* in northwestern New Jersey. Journal of Herpetology 25:1-9.

Garber, S.D. 1988. Migratory behavior in turtles. Plastron Papers 19: 15-21.

Garber, S.D. 1989. Turtle hibernation. In: Proceedings of the 13th International Herpetological Symposium. Phoenix, Arizona. June 20-24 1989. Editor: Michael J. Uricheck.

Garber, S.D., and J. Burger. 1995. A twenty year study documenting the relationship between turtle decline and human recreation. Ecological Applications 5: 1151-1162.

Gibbs, J.P. and W.G. Shriver. 2002. Estimating the effects of road mortality on turtle populations. Conservation Biology 16:1647-1652.

Harding, J. H. and T.J. Bloomer. 1979. The wood turtle, (*Clemmys insculpta*): a natural history. Herpetolgical Bulletin New York Herpetological Society 15: 9-26.

Hunter, M.L., A.J.K. Calhoun, and M. McCollough. 1993. Maine amphibians and reptiles. University of Maine Press. Orono, Maine, USA.

Kaufmann, J.H. 1992. Habitat use by wood turtles in central Pennsylvania. Journal of Herpetology 26: 315-321

Klemens, M.W. 1989. The methodology of conservation: Pages 1-4 *in* Swingland, I.R. and M.W. Klemens eds. The Conservation biology of tortoises. Occasional papers of the IUCN Species Survival Commission no.005. University of Kent, United Kingdom.

Klemens, M.W. 1993. Amphibians and reptiles of Connecticut and adjacent regions. Connecticut Department of Environmental Protection. Hartford, Connecticut, USA.

Kolbe, J.J. and F.J. Janzen. 2002. Impact of nest-site selection on nest success and nest temperature in natural and disturbed habitats. Ecology 83:269 –281.

Levell, J.P. 2000. Commercial exploitation of Blanding's turtle, *Emydoidea blandingii*, and the wood turtle, *Clemmys insculpta*, for the live animal trade. Chelonian Conservation and Biology 3:665-674.

Marchand, M.N. and J.A. Litvaitis. 2004. Effects of habitat features and landscape composition on the population structure of a common aquatic turtle in a region undergoing rapid development. Conservation Biology 18:758-767.

Massachusetts Natural Heritage and Endangered Species Program. 2004. Massachusetts List of Endangered, Threatened and Special Concern Species. Massachusetts Division of Fisheries and Wildlife, Westborough, Massachusetts, USA.

NatureServe. 2004. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: January 4, 2005).

Niederberger, A.J., and M.E. Seidel. 1999. Ecology and status of a wood turtle (*Clemmys insculpta*) population in West Virginia. Chelonian Conservation and Biology 3: 414-418.

Oliver, J.A., and J.R. Bailey.1939. Amphibians and reptiles of New Hampshire exclusive of marine forms: Pages 195-217 *in* H.E.Warfel, editor, Biological Survey of Connecticut watershed. New Hampshire Fish and Game Department. Concord, New Hampshire, USA.

RESTORE: The North Woods, S.D. Garber, J. Burger, J.H. Harding, C. Ernst, S.E. Tuttle, J. Davis, and Biodiversity Legal Foundation. 1994. Petition for a rule to list the North American Wood turtle (Clemmys insculpta) as threatened under the Endangered Species Act. Unpublished manuscript submitted to the U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC.

Ross, D.A., Brewster, K.N, Anderson, R.K., Ratner, N. and Brewster, C.M. 1991. Aspects of the ecology of wood turtles, *Clemmys insculpta*, in Wisconsin. Canadian Field Naturalist. 105:363-367.

Saumure, R.A., and J.R. Bider. 1998. Impact of agricultural development on a population of wood turtles (*Clemmys insculpta*) in southern Quebec, Canada. Chelonian Conservation and Biology 3: 37-45.

Society for the Protection of New Hampshire Forests. 2005. New Hampshire's Changing Landscape. Population growth and land use changes: what they mean for the Granite State. Executive Summary. Concord, New Hampshire, USA.

Sperduto, D.D., and W.F. Nichols. 2004. Natural Communties of New Hampshire. New Hampshire Natural Heritage Bureau. Concord, New Hampshire, USA.

Steen, D.A., and J.P. Gibbs. 2004. Effects of roads on the structure of freshwater turtle populations. Conservation Biology 18: 1143-1148.

Therres, G.D. 1999. Wildlife Species of regional conservation concern in northeastern United States. Northeast Wildlife 54: 93-100.

Tuttle, S.E. 1995. The ecology and natural history of the wood turtle (Clemmys insculpta) in southern New Hampshire, final report. Concord, New Hampshire, USA.

Tuttle, S.E., and D.M. Carroll. 1997. Ecology and natural history of the wood turtle (*Clemmys insculpta*) in southern New Hampshire. Chelonian Conservation and Biology 2:447-449.

Tuttle, S.E., and D.M. Carroll. 2003. Home range and seasonal movements of the wood turtle (*Glyptemys insculpta*) in southern New Hampshire. Chelonian Conservation and Biology, 4 (3): 656-663.

U.S. Fish and Wildlife Service (USFWS). 1995. 90-day finding for a petition to list the wood turtle (*Clemmys insculpta*) as threatened. Federal Registrar 60(102): 27954-27955.

Vermont Nongame and Natural Heritage Program. 2000. Rare and Uncommon Native Animals of Vermont. Vermont Fish and Wildlife Department. Waterbury, Vermont, USA.

5.2 Data Sources

New Hampshire Natural Heritage Bureau. 2005. Database of Rare Species and Exemplary Natural Community Occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

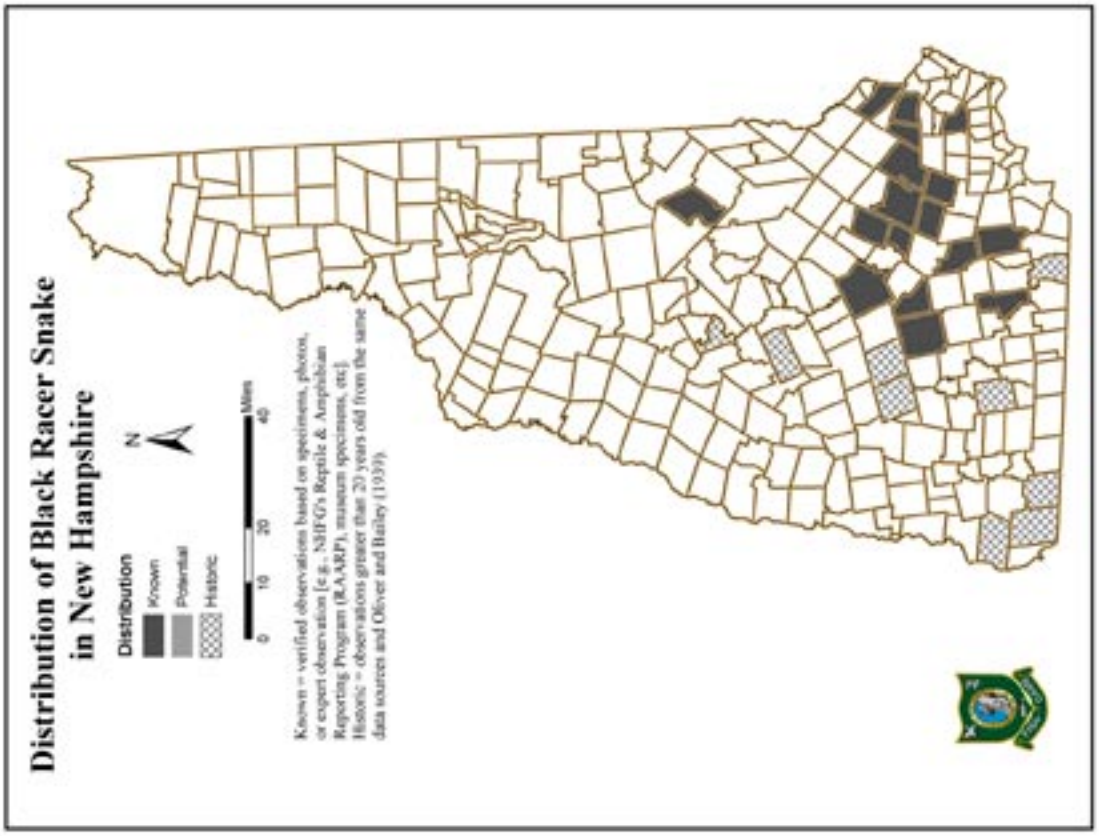
Element 6: List of Figures

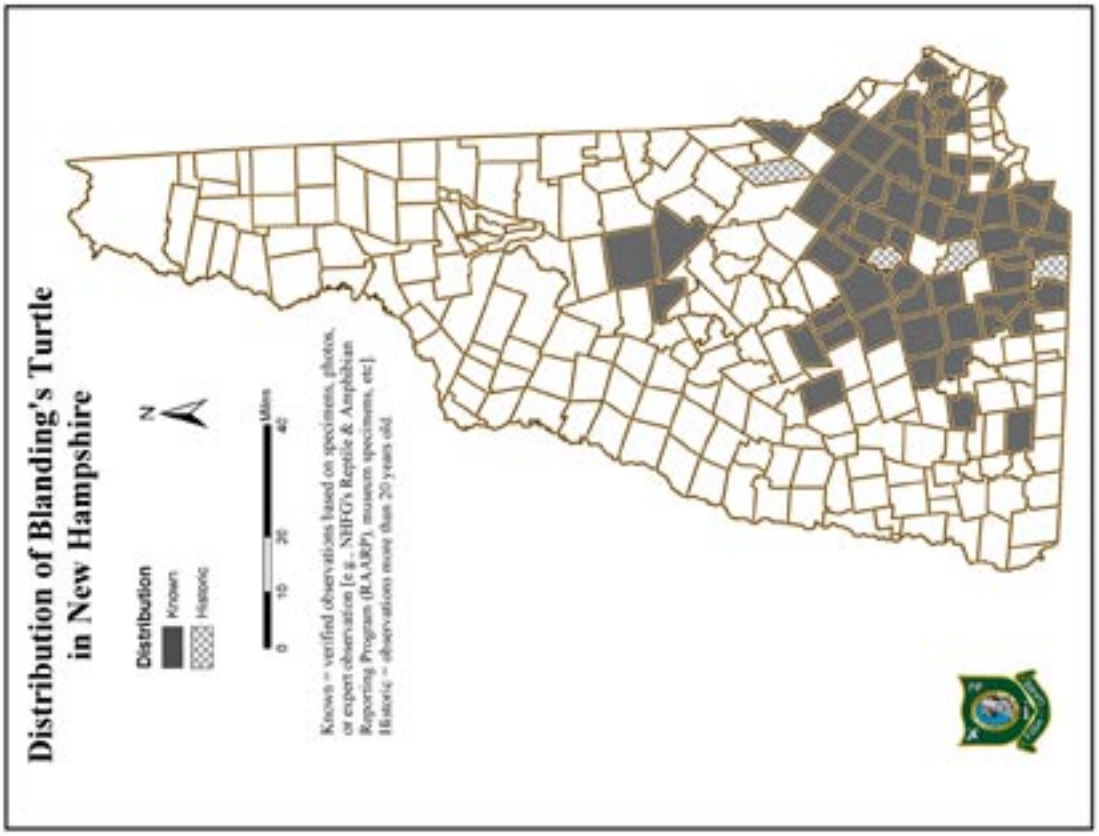
Table 1. Habitat quality attributes for New Hampshire HUC-12 watersheds that were known to be occupied by wood turtles ('Watershed Occupied') and watersheds that were mapped as potential habitat but where wood turtles have not been verified ('Watershed Potential'). Metadata is available that describes how variables were calculated.

Table 2. Protection status for New Hampshire HUC-12 watersheds that were known to be occupied by wood turtles ('Watershed Occupied') and watersheds that were mapped as potential habitat but where wood turtles have not been verified ('Watershed Potential'). Protection status was assessed for all mapped wood turtle habitat (known and potential) within watersheds. The conservation lands data layer from the University of New Hampshire Complex Systems (GRANIT) was used to calculate protection status.

Table 1. Habitat quality attributes for New Hampshire HUC-12 watersheds that were known to be occupied by wood turtles ('Watershed Occupied') and watersheds that were mapped as potential habitat but where wood turtles have not been verified ('Watershed Potential'). Metadata is available that describes how variables were calculated.

Reptile and Amphibian Maps


Distribution of Black Racer Snake
in New Hampshire
Distribution
Known
Potential
Historic
N
0
10
20
40
Miles
Known = verified observations based on specimens, photos, or expert observation [e.g., NHFG's Reptile & Amphibian Reporting Program (RAARP), museum specimens, etc]
Historic = observations greater than 20 years old from the same data sources and Oliver and Bailey (1939).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Historic
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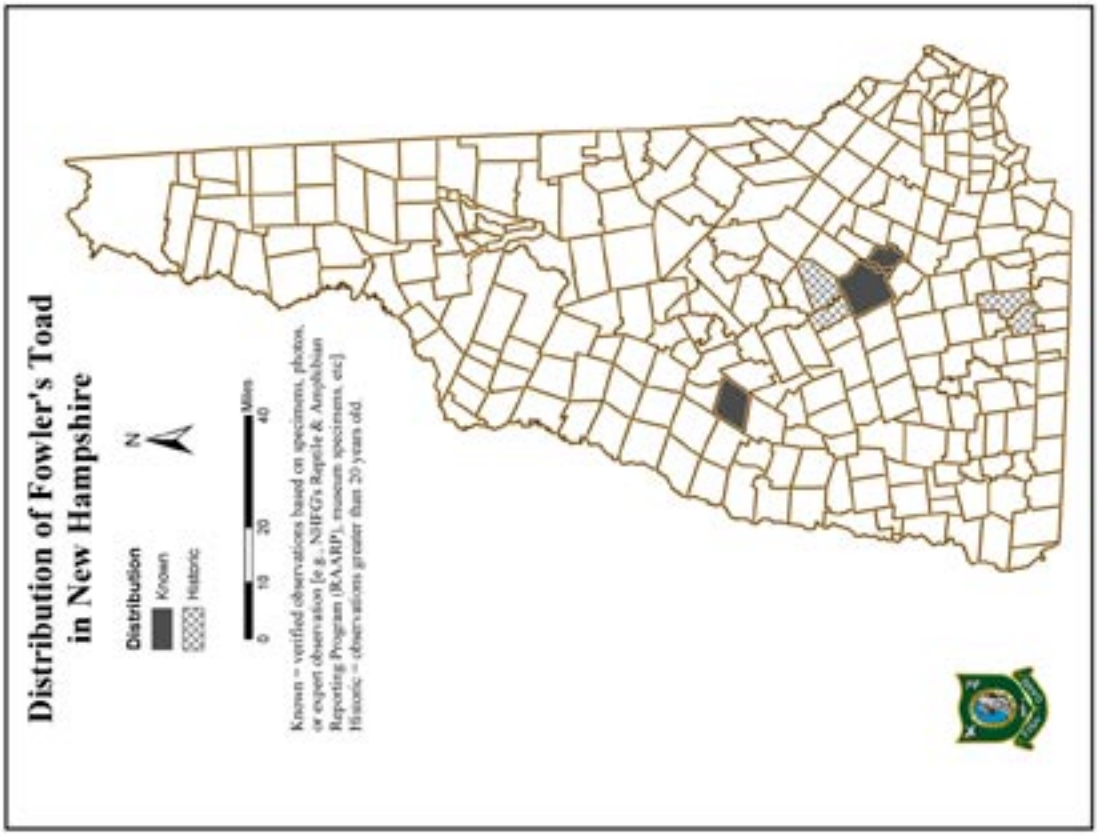
20
40
Miles
Knows = verified observations based on specimens, photos, or expert observation [e.g., NHFG's Reptile & Amphibian Reporting Program (RAARP), museum specimens, etc]
Historic = observations more than 20 years old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Historic
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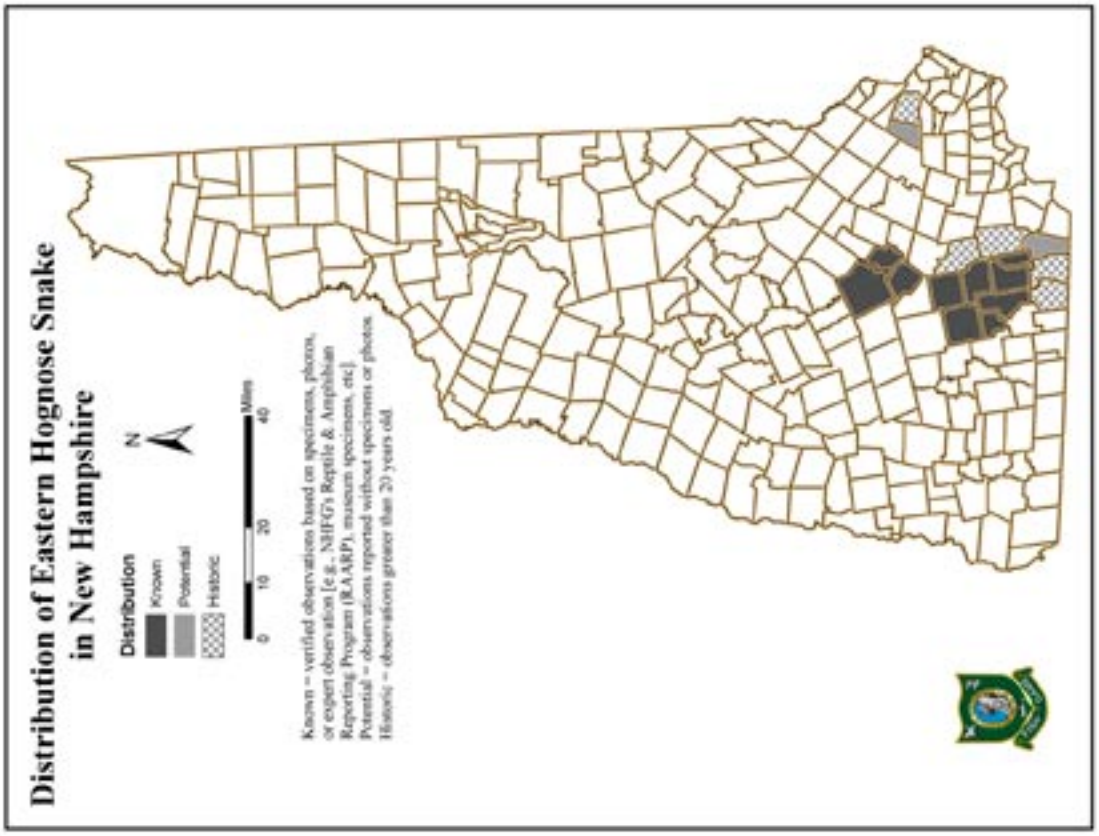
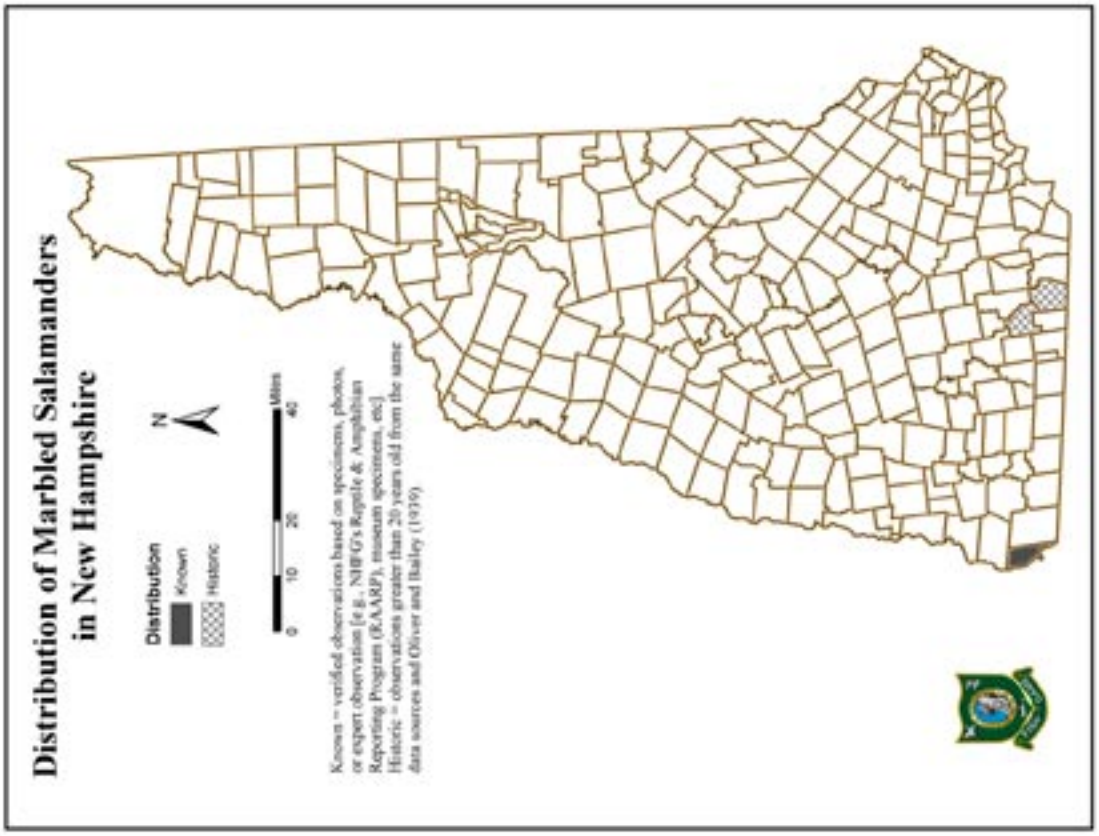
Miles
Known = verified observations based on specimens, photos, or expert observation [e.g., NHFG's Reptile & Amphibian Reporting Program (RAARP), museum specimens, etc]
Historic = observations greater than 20 years old.


Distribution of Eastern Hognose Snake
in New Hampshire
Distribution
Known
Potential
Historic
N
0 10 20 40
Miles
Known = verified observations based on specimens, photos, or expert observation [e.g., NHFG's Reptile & Amphibian Reporting Program (RAARP), museum specimens, etc]
Potential = observations reported without specimens or photos.
Historic = observations greater than 20 years old.

Distribution of Jefferson & Blue-spotted Salamanders, and hybrids in New Hampshire
Legend
Jefferson Salamanders
Blue-spotted Salamanders
Hybrids
N
0 10 20 40 Miles
Known Jefferson and blue-spotted salamander records from Bogart and Klemens (1997). Hybrids are records reported to the NH Reptile and Amphibian Reporting Program that could not be verified as pure Jefferson or blue-spotted salamanders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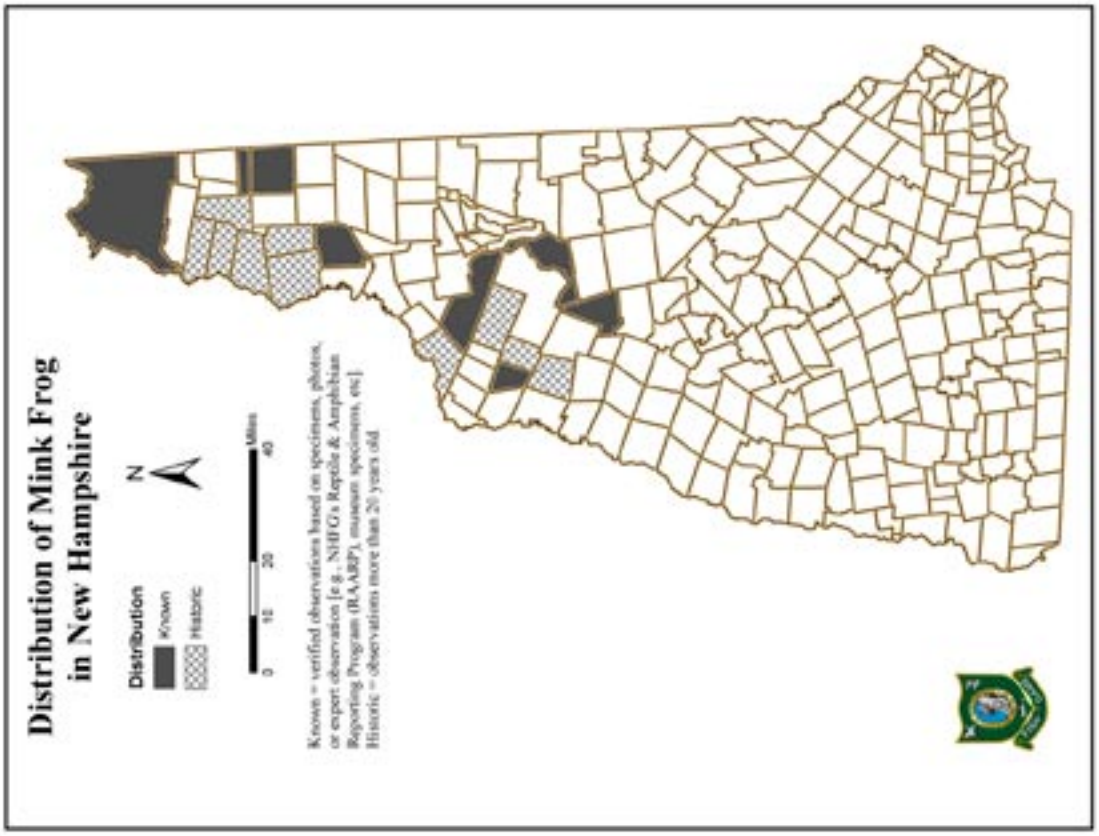
Known = verified observations based on specimens, photos, or expert observation [e.g., NHFG's Reptile & Amphibian Reporting Program (RAARP), museum specimens, etc]
Historic = observations greater than 20 years old from the same data sources and Oliver and Bailey (1939)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Historic
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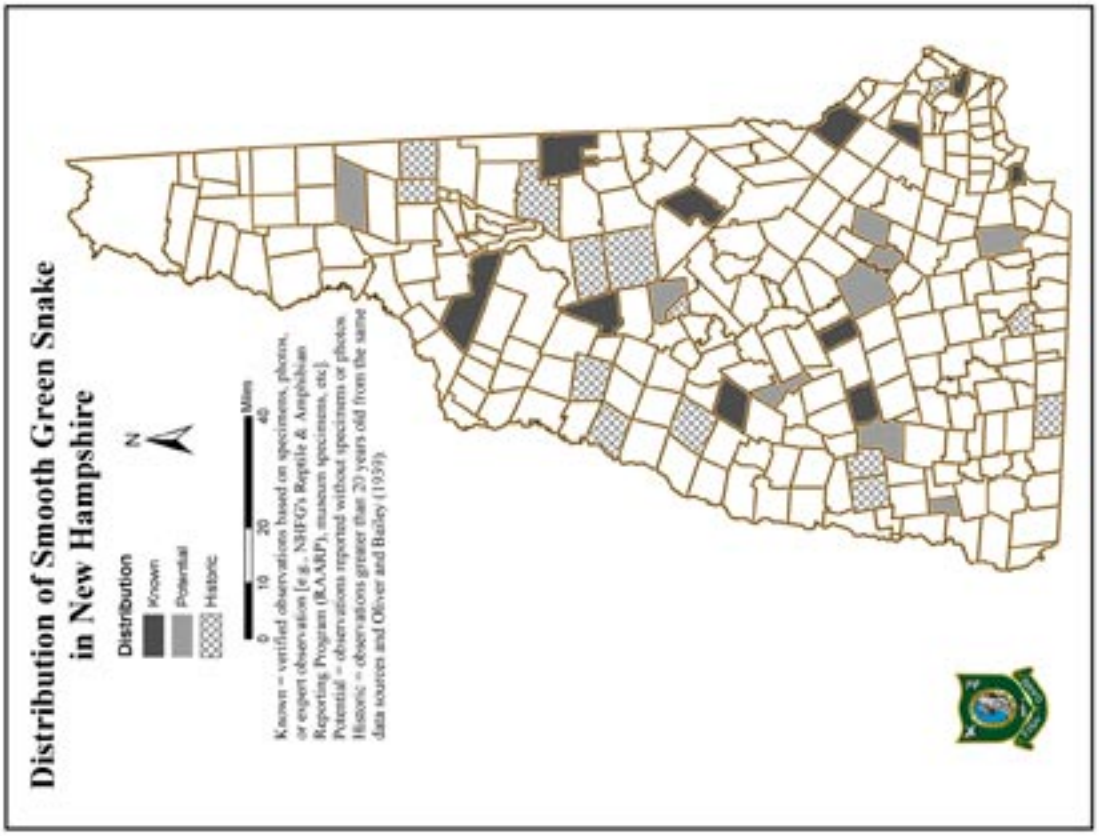
Miles
Known = verified observations based on specimens, photos, or expert observation [e.g., NHFG's Reptile & Amphibian Reporting Program (RAARP), museum specimens, etc]
Historic = observations more than 20 years old

Distribution of Northern Leopard Frog
in New Hampshire
Distribution
Known
Historic
N
0
10
20
40
Miles
Known = verified observations based on specimens, photos, or expert observation [e.g., NHFG's Reptile & Amphibian Reporting Program (RAARP), museum specimens, etc]
Historic = observations greater than 20 years old (from the same data sources and Oliver and Bailey (1939)

Distribution of Ribbon Snake
in New Hampshire
Distribution
Known
Historic
N
0 10 20 40
Miles
Known = verified observation based on specimens, photos, or expert observation [e.g., NHFG's Reptile & Amphibian Reporting Program (RAARP), museum specimens, etc]
Historic = observations more than 20 years old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Distribution
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Potential
Historic
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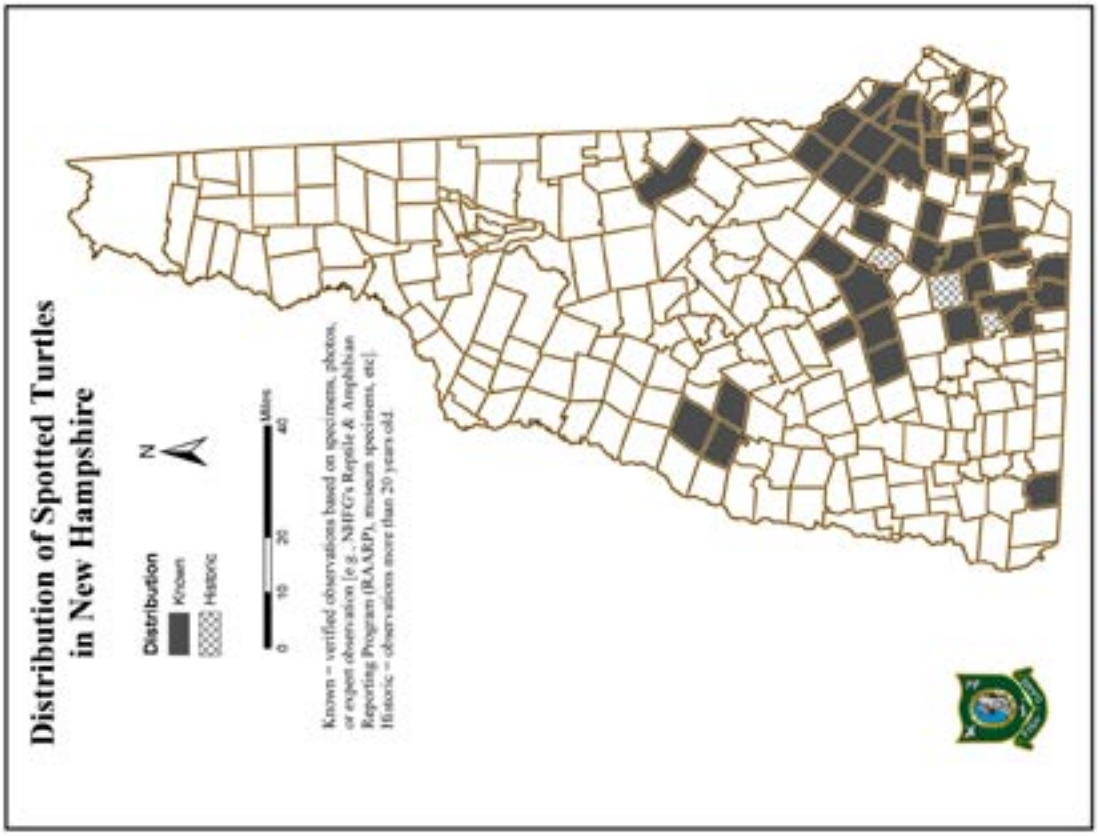
Miles
Known = verified observation based on specimens, photos, or expert observation [e.g., NHFG's Reptile & Amphibian Reporting Program (RAARP), museum specimens, etc]
Potential = observations reported without specimens or photos
Historic = observations greater than 20 years old from the same data sources and Oliver and Bailey (1939).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Distribution
Known
Historic
N
0 10 20 40 Miles
Known = verified observations based on specimens, photos, or expert observation [e.g., NHFG's Reptile & Amphibian Reporting Program (RAARP), museum specimens, etc]
Historic = observations more than 20 years old.

Distribution of Wood Turtle in New Hampshire
Distribution
Known
Historic
N
0 10 20 40 Miles
Known = verified observations based on specimens, photos, or expert observation [e.g., NHFG's Reptile & Amphibian Reporting Program (RAARP), museum specimens, etc]
Historic = observations more than 20 years old.

APPENDIX B

Habitat Profiles

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HABITAT PROFILE

Alpine

Associated Species: White Mountain Arctic Butterfly (Oeneis Melissa semidea), White Mountain Fritillary (Boloria titania montinus)

Global Rank: Not ranked
State Rank: Alpine herbaceous snowbank/rill (S1)
Moist alpine herb-heath meadow (S1)
Alpine ravine shrub thicket (S1S2)
Diapensia shrubland (S1)
Alpine heath snowbank (S1S2)
Bigelow's sedge meadow (S1)
Sedge-rush-heath meadow (S1)
Dwarf shrub-bilberry-rush barren (S2)
Labrador tea heath-krummholz (S2)
Sheep laurel-labrador tea heath-krummholz (S2)
Wet alpine/subalpine bog (S1)
Wooded subalpine bog/heathsnowbank (S1S2)
Subalpine sliding fen (S1)
Felsenmeer (S2)
Alpine cliff (S2)
Authors: Celine T. Goulet and Steven G. Fuller, New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

In New Hampshire, alpine habitat occurs above treeline (trees taller than 6 ft) at approximately 4,900 ft, primarily within the Franconia and Presidential Ranges. This region endures high winds, precipitation, cloud cover, and fog, resulting in low annual temperatures and a short growing season (Bliss 1963, Sperduto and Crowley 2001). The interaction between severe climate and geologic features—such as bedrock, exposure, and aspect—determine the distribution and structure of alpine systems (Antevs 1932, Bliss 1963, Harries 1996, Sperduto and Crowley 2001). Alpine habitat is comprised of low, treeless tundra communities embedded in a matrix of bedrock, stone, talus, or gravel, with or without thin organic soil layers, and interspersed with krummholz. Soils are well drained, highly acidic, nutrient poor, and weakly developed (Sperduto and Cogbill 1999).

Alpine systems are comprised of 5 broad groups of communities: diapensia shrublands, alpine herbaceous snowbank/wet-mesic alpine communities, alpine/subalpine bogs, heath-krummholz communities, and dwarf shrub-sedge-rush meadow communities (Sperduto and Cogbill 1999). Diapensia shrublands occur on exposed windblown ridges above 4,300 ft and are characterized by a high abundance of *Diapensia lapponica* supported on a rock or gravel substrate. Alpine herbaceous snowbank/wet-mesic alpine communities are typically sloped, have shallow organic soils, and associated with late-melting snowpacks, seeps, rills, and ravine settings. They are by dominated by *Geum peckii, Solidago macrophylla,* and *Calamagrostis canadensis* and occur between 4,400 and 5,500 ft. Alpine/subalpine bogs occur at elevations ranging from 2,900 to 4,900 ft within concavities and are dominated by *Vaccinium uliginosum* and *Empetrum nigrum*.

In parts of the White Mountain National Forest (WMNF), these communities form a mosaic with heath-krummholz communities composing structures referred to as "heath balds." Heath-krummholz communities are composed of wind-dwarfed thickets of trees, primarily *Picea mariana* or *Abies balsamea*, distributed as a continuous zone between 3,800 and 4,800 ft or intermixed with heath shrubs, primarily bilberry, cranberry, and blueberry. Dwarf shrub-sedge-rush meadow communities dominate much of the vegetated portion of the alpine zone at elevations ranging from 4,600 to 5,600 ft. *Carex bigelowii*, *Juncus trifidus*, bilberry heaths, and cranberry heaths characterize this habitat.

1.2 Justification

Alpine habitat is a rare community throughout the Northeast, occurring mostly as isolated "islands" on high peaks. Unique alpine plant communities, extreme climate, and isolation lead to rare and endemic insect communities. White Mountain fritillary and artic butterflies are known to occur only on the Presidential Range, and their host plants may be sensitive to disturbance and climate change. Human impacts exist in almost every alpine zone, with the highest concentration occurring on ridges and summits (Harvey 2003). The impacts of human presence on alpine birds and mammals are not known. Alpine vegetation and soils are not well adapted to heavy recreational traffic.

There is widespread consensus that alpine habitat is extremely susceptible to climate change (Kimball and Weihrauch 2000). Climatic changes documented within the WMNF (Climate Change Research Center 1998, Harvey 2003, Grant and Pszenny 2004) are expected to cause interdependent shifts in species distribution and phenology as demonstrated in other alpine areas, and may eventually result in irreversible changes to the composition and structure of alpine plant communities (Halloy and Mark 2003, Lesica and McCune 2004). Isolated populations of low vagility alpine-dependent wildlife, especially insects, will be heavily influenced by the extirpation of climate-sensitive plants, rising treeline, and increasing woody plant cover.

1.3 Protection and Regulatory Status

The majority of New Hampshire alpine habitat is within the boundaries of the WMNF. The WMNF is part of the National Wilderness Preservation System (16 U.S.C. 1131-1136, 78 Stat. 890). This system is comprised of federally owned areas designated by Congress as "Wilderness Areas." Three Wilderness Areas in the WMNF (Great Gulf, Presidential-Dry River, Pemigewasset) contain alpine habitat.

1.4 Population and Habitat Distribution

In New Hampshire, alpine habitat occupies 0.13% (7,717 acres) of the state, with the highest concentration occurring in the Presidential Range. The Presidential Range distribution includes Alpine Garden (5,175 to 5,575 ft), Bigelow's Lawn (5,500 ft), Great Gulf (4,228 to 5,828 ft), Huntington Ravine (4,075 to 5,475 ft), Tuckerman's Ravine (4,525 to 5,125 ft), Monroe Flats (5,075 ft), Oakes Gulf (4,400 to 5,000 ft), Washington Summit (6,288 ft), and Lakes of the Clouds (5,012 ft) on Mt. Washington (6,288 ft); Edmunds Col (4,938 to 5,100 ft) on Mt. Madison (5,367 ft); Bumpus Brook (5,799 ft) on Mt. Adams; Monticello Lawn (5390 ft); Mt. Clay (5533 ft); King's Ravine (3825-5000 ft) on Mt. Jefferson; Mt. Franklin (5001 ft); Mt. Monroe (5,384 ft); and Mt. Eisenhower (4,760 ft) (Harvey 2003). The remaining New Hampshire alpine habitat includes: North Baldface, South Baldface, Mt. Davis (3,819 ft), Mt. Bond (4,690 ft), Mt. Bondcliff (4,265 ft), Mt.Guyot (4,580 ft), South Twin (4,902 ft), Mt. Lafayette (5,260 ft), Mt Lincoln (5,089 ft), and Mt Moosilauke (4,802 ft) (Harvey 2003).

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

The definition of alpine habitat used in this analysis was areas with vegetation 8 ft in height that graduated down to bare rock. Alpine habitat was identified by isolating patches larger than 5 ac containing both krummholz and open rock per Hale and Rock's (2003) landcover classification for the WMNF. The resulting cover was appended with the Appalachian Mountain Club's (AMC) data depicting alpine areas in the Presidential Range and Franconia Ridge as well as New Hampshire Natural Heritage Bureau's (NHNHB) data depicting exemplary alpine communities. The NHNHB natural communities that were omitted included the following (with the exception of South Twin Mountain, Mt. Clinton, and Baldface): NHNHB alpine communities smaller than 5 ac; NHNHB alpine communities below 3,400 ft elevation, despite the appearance of diagnostic features; NHNHB peripheral/occasional alpine communities above 3,400 ft but greater than one quarter mile from a diagnostic community; and NHNHB peripheral/occasional alpine communities above 3,400 ft but greater than one quarter mile from the results of the other data sources. Other lower elevation habitat types will absorb alpine communities excluded in this analysis.

1.7 Sources of Information

Current distribution, historic distribution, and status of alpine habitat is synthesized from expert review and consultation, management plans, technical field reports, scientific journals, and plant and community records in the New Hampshire Heritage Biological and Conservation Data System (BCD). Habitat maps were generated utilizing Hale and Rock (2003) landcover analysis for the WMNF, AMC alpine habitat polygons for the Presidential Range and Franconia Ridge, and NHNHB exemplary alpine natural communities.

1.8 Extent and Quality of Data

The vegetation of New Hampshire's Presidential Range has been the subject of considerable study over the past 150 years. Plant and community databases, herbaria records, published reports, regional hiking guides, and articles on early exploration provide relatively thorough historical and current information about the Presidentials, but outlying occurrences in the state have received relatively little attention (Sperduto and Cogbill 1999). Although invertebrates dominate alpine-dependent fauna, very little is known about their distribution. Strong altitudinal and landform relationships make predicted alpine habitat occurrences reliable, and model validation should emphasize predicted habitat at marginal elevations.

1.9 Distribution Research

Surveys need be conducted to delineate alpine habitat outside the Presidential Range. Alpine invertebrate distributions need study.

Element 2: Species/Habitat Condition

2.1 Scale

Alpine habitat polygons derived from the mapping process were clustered by mountain range in which they occurred to facilitate conservation planning. Clustering helped define 6 conservation-planning units.

2.2 Relative Health of Populations

New Hampshire's largest expanse of alpine habitat occurs in the Presidential Range (6,931 ac), followed by Franconia Ridge (379 ac) and Baldface (247 ac). The remaining alpine habitat units comprise 160 ac.

2.3 Population Management Status

N/A

2.4 Relative Quality of Habitat Patches

The Presidential Range supports the largest and most ecologically diverse alpine community, containing more susceptible plants than any other habitat type (Kimball and Weihrauch 2000). It also supports the highest level of recreational use, containing the largest trail (50 mi), road (3.3 mi), and rail (1.4 mi) systems. Highly sensitive communities (e.g., snowbank) occur in Tuckerman's, Huntington, and King ravines, the Alpine Garden, Lakes of the Clouds, and Red Pond on Mt. Eisenhower.

2.5 Habitat Patch Protection Status

Alpine habitat within the WMNF is protected by the United States Forest Service (USFS) as designated by the National Wilderness Preservation System. National scenic trails bisecting alpine habitat throughout these Wilderness Areas will be protected and regulated in accordance with the Appalachian Trail regulations delineated in the Appalachian National Scenic Trail Comprehensive Plan (ATPO 1981). Further protection will be granted upon approval of the Proposed Land and Resource Management Plan for the White Mountain National Forest: Standards and Guidelines for Management Area 8.1- Alpine Zone.

2.6 Habitat Management Status

The Wilderness Areas in the WMNF containing alpine habitat (Pemigewasset, Presidential-Dry River, and Great Gulf Wilderness Areas) are managed according to the guidelines and standards delineated in the Land and Resource Management Plan for the White Mountain National Forest. Natural processes are allowed to continue with minimal impediment, effects and impacts of human use will be minimized, primitive recreation opportunities will be provided, appreciation of the qualities of wilderness landscapes will be fostered, and utilization for educational and scientific purpose will be continued (USDA Forest Service 2004).

National scenic trails bisecting alpine habitat will be administered in accordance with the Wilderness Act (ATPO 1981) and are under the management authority of the Cooperative Management System (1984 memorandum of understanding (MOU) USFS and Appalachian Trail Conference), composed of the AMC, Dartmouth Outing Club (DOC), New Hampshire Department of Environmental Resources (DES), and WMNF. In addition, an MOU between the New Hampshire Fish and Game (NHFG), United States Fish and Wildlife Service (USFWS), and the USFS was established in 1996 delegating authority to develop, maintain, and manage all of the fish and wildlife resources and their habitats within the WMNF to NHFG. Further management guidance of alpine habitat will be granted upon approval of the Proposed Land and Resource Management Plan for the White Mountain National Forest: Standards and Guidelines for Management Area 8.1- Alpine Zone.

2.7 Sources of Information

Information regarding the management and protection of alpine habitat was obtained from the Proposed Land and Resource Management Plan for the White Mountain National Forest; 2001 MOU between the Bureau of Land Management (BLM), National Park Service (NPS), USFS, United States Department of Transportation (USDOT), and National Endowment for the Arts (NEA); 1996 MOU between NHFG, USFWS, and USFS; Appalachian National Scenic Trail comprehensive management plans; and documents delineating the Wilderness Act. Habitat patch identification and quality were determined utilizing WMNF landcover analysis, Presidential Range and Franconia Ridge alpine habitat polygons, NHB, and Vermont Institute of Natural Sciences (VINS) alpine natural community delineations.

2.8 Extent and Quality of Data

See Species/Habitat Condition Technical Assessment

2.9 Condition Ranking

See Species/Habitat Condition Technical Assessment

2.10 Condition Assessment Research

Data on alpine habitat condition need to be compiled. Parameters for relative condition, including extent of recreational impacts and rare natural communities, need to be identified and measured.

Element 3: Species and Habitat Threat Assessment

3.1.1 Recreation

(A) Exposure Pathway
Recreational use of alpine habitat is high. Structures, designated trails, undesignated trails, climbing routes, popular ski areas, and viewpoints co-occur with some of the most sensitive alpine communities, such as ravines and snowbanks. Disturbance from snow compaction and trampling may result in vegetative stress, mortality, and erosion, thereby reducing recolonization within these sensitive communities.

(B) Evidence
The alpine zone throughout the Presidential Range is highly recreated, enduring high levels of foot traffic and snow compaction (USDA Forest Service 2004). Magnitude of response is strongly correlated with trampling intensity (Cole 1995, USDA Forest Service 2004). While robust in their ability to withstand severe environmental conditions, alpine communities and soils have low tolerances for trampling. Trampling substantially reduces vegetation cover and height and increases soil erosion. Communities dominated by dwarf heath shrubs and erect forbs are the least resistant to trampling (Cole 1995, Cole and Monz 2002). Despite varying tolerances of trampling resistance and resiliency among alpine communities, they all have a threshold beyond which impacts become irreversible (D. Sperduto, New Hampshire Natural Inventory Bureau, personal communication).

3.1.2 Climate Change

(A) Exposure Pathway
The composition of the earth's atmosphere is changing, altering temperature, precipitation, air quality, and frequency of extreme weather (Climate Change Research Center 1998). Climate change could significantly alter the phenology and distribution of alpine vegetation (Kimball and Weihrauch 2000). Alpine communities could be further disrupted by alterations in snow cover and ice extent, causing stress or mortality to snowbank vegetation (Ingersoll et al.

1995, Walther et al. 2002, Sperduto and Nichols 2004).

(B) Evidence
Alpine communities are strongly influenced by edaphic and microclimatic gradients, increasing their vulnerability to climate change (Grabherr and Pauli 2000, Kimball and Weihrauch 2000, Harvey 2003). Climate change has been extensively demonstrated regionally and locally (Harvey 2003). In New Hampshire, temperatures have increased by 0.7 °F, 2 to 3 times the regional average, (NERA 2001, Harvey 2003). This same trend has been documented on the summit of Mt. Washington, where a 69-year temperature record has demonstrated a 0.3+/-0.08°C increase for the period 1935 to 2003, with a sharper rise in minimum temperatures than in maximum temperatures (Grant and Pszenny 2004). In response, freeze-free periods in many subalpine/alpine regions are lengthening, decreasing snow cover and ice extent (Walther et al. 2002). Alterations in annual snowpack in the alpine zone negatively impacts the herbaceous snowbank/rill communities which depend on these late-melting snowbanks to abbreviate their growing season and limit exposure to extreme conditions (Ingersoll et al. 1995, Sperduto and Nichols 2004). Additionally, Walther (2002) has documented poleward and upward shifts of species ranges including treeline advancement toward higher altitudes, elevation shift of alpine plants, and northward range shifts of 39 butterfly species, each of which is linked to global warming (Gottfried et al. 1998; Grabherr et al. 1994, Pauli et al. 1996, Harvey 2003). Changing climatic regimes will ultimately alter species distributions and composition, disrupting community structure and function (Walther et al. 2002).

3.1.3 Acid Deposition

(A) Exposure Pathway
In alpine communities, acid deposition may change community structure, spatial distribution of ecosystems, soil properties, and soil fauna (Rusek 1993). These reactions are compounded by similar reactions to climate change (Rusek 1993). The reactions of alpine grassland communities precede changes in the lower elevation subalpine zone and mountain forests (Rusek 1993). Bioaccumulation of contaminants (such as mercury) and other interactive chemical impacts may be high in wet, high-elevation environments with reduced pH.

(B) Evidence
Exposure to acid deposition is high at high elevation and in areas with frequent direct exposure to clouds. Extensive studies have demonstrated the detrimental consequences of acid deposition on alpine communities. Data have linked acid deposition to decreased soil pH, increased range of acidophilic species, disappearance of calciphilic species, and changes in plant community distribution (Rusek 1993). Methylation of abiotic mercury is accelerated in acidic environments. The communities most sensitive to acid deposition were found in locations with snow accumulation and water runoff gullies (Rusek 1993).

3.1.4 Mercury
(See Threats, Mercury)

3.2 Sources of Information

Information regarding alpine threats was compiled from expert review and consultation, management plans, technical field reports, and scientific journals. AMC, WMNF, and DRED trail data were used to assess recreational impacts.

3.3 Extent and Quality of Data

Recreational impacts, climate change, and acid deposition are fairly well documented.

3.4 Threat Assessment Research

Further research should focus on range shifts of alpine flora and fauna, phenological changes, and pollution-induced wildlife stress/mortality. Measuring the effects of local alpine point sources of pollution, such as the cog railway, is a high priority. Responses of invertebrate and avian foodwebs to interactions among atmospheric pollutants and among pollutants and climate change need to be assessed.

Element 4: Conservation Actions

4.1.1 Advise Land Managers on Mitigating Trail Impacts, Regulation, and Policy

(see also Strategies, Inter-Agency Regulation and Policy)

(A) Trails in Sensitive Areas/ Trampling

(B) Justification

1. Restricting trail use, placement, and width in sensitive areas will reduce the area of exposure.
2. Alpine communities have historically responded positively to scree-walls and other trail design modifications.
3. Trail advisories will be designated for high-use trails through delineated sensitive areas.
4. Advisories will be provided immediately upon entry into trail management agreements (see G: Implementation).
5. Trail use and design will be modified based on habitat response indicators.

(C) Conservation Performance Objective

Eliminate the co-occurrence of trail impacts with delineated S1-ranked natural communities and rare alpine lepidopteran habitats. Performance will be indicated by entry into trail management agreements, modification of trails, and adoption of trail advisories.

(D) Performance Monitoring

Advisories will include trail use and design modification reporting protocols.

(E) Ecological Response Objective

Restore S1-ranked natural communities and rare alpine lepidopteran habitats to delineated areas. Advisories will include restoration and monitoring recommendations.

(F) Response Monitoring

Cover of alpine vegetation and soils will be measured in delineated areas prior to implementation of advisories and in subsequent years. Responses will be used to revise advisories.

(G) Implementation

NHFG will delineate sensitive areas and provide trail advisories to all managing agencies to mitigate trail impacts to wildlife and wildlife habitats. NHFG will become a recognized participant of the Appalachian Trail Conference (ATC) Cooperative Management System. Participants include AMC, DOC, NHDES, and WMNF formalized through a series of Cooperative Agreements at both the state-level and local level (New Hampshire is one of the only states that does not have a wildlife agency as a partner). NHFG will be involved in the development, review, and approval of the Appalachian Trail Local Management Plan. NHFG will enter a MOA with DRED to maintain and manage trails in accordance with the health of wildlife and wildlife habitats. NHFG will review the 1996 MOU between the Department, USFWS, and the USFS.

(H) Feasibility

Given that NHFG is one of the only New England states not party to the ATC, the ATC's success and trail maintenance resources, and the Department's regulatory authority, it is highly feasible for the Department to enter the ATC and assert that trail managers adopt activities to mitigate wildlife impacts.

- Advise IAFWA Regional Coordination Team on Climate Change and Acid Deposition Impacts, Regulation and Policy (see Strategies: Regional Coordination)
- Engage in Inter-Agency Risk Assessments for Climate Change and Acid Deposition, Regulation and Policy (see Strategies: Inter-Agency Regulation and Policy)
- Identify High Risk Areas, Conservation Planning (see Strategies: Conservation Planning)
- Monitor Indicator Species for Climate Change and Acid Deposition, Monitoring (see Strategies: Monitoring)
- Restrict Access to Sensitive Areas, Regulation and Policy (see Strategies: Inter-Agency Regulation and Policy)
- Cultivate Recreational User Stewardship, Education and Outreach (see Strategies: Education and Outreach)

4.2 Conservation Action Research

Baseline surveys need to be conducted to better identify diagnostic species for sensitive alpine habitat areas and indicators of climate change and acid deposition. A permanent monitoring scheme needs to be developed and implemented in order to assess habitat changes across space and time.

Element 5: References

5.1 Literature

Bliss, L.C. 1963. Alpine plant communities of the Presidential Range, New Hampshire. Ecology 44(4):678-697.

Climate Change Research Center. 1998. New England's changing climate, weather and air quality. Institute for the study of Earth, Oceans, and Space, Durham, New Hampshire, USA.

Cole, D.N. 1995. Recreational Trampling Experiments: Effects of Trampler Weight and Shoe Type. Research Note INT-RN-425 Ogden, UT USDA, Forest Service, Intermountain Research Station, USA.

Cole, D.N., and C.A. Monz. 2002. Trampling disturbance of high-elevation, Wind River Mountains, Wyoming, USA. Arctic, Antarctic, and Alpine Research 34(4):365-376.

Gottfried, M., H. Pauli, and G. Grabherr. 1998. Prediction of vegetation patterns at the limits of plant life- a new view of the Alpine nival ecotone. Arctic and Alpine Research 30:207-221.

Grabherr, G., M. Gottfried, and H. Pauli. 1994. Climate effects on mountain plants. Nature 369: 448.

Hale, S.R., and B.N. Rock. 2003. Impact of topographic normalization on land-cover classification accuracy. Photogrammetric Engineering and Remote Sensing 69:785-791.

Halloy, S.R., and A.F. Mark. 2003. Climate-change effects on alpine plant biodiversity: a New Zealand perspective on quantifying the threat. Arctic, Antarctic, and Alpine Research 35(2):248-254.

Harvey, R.J. 2003. Using the Northeastern Alpine Zone as a bio-monitor of climate change. Paul Smith's College, New York, USA.

Huntington, T.G., and G.A. Hodgkins. 2004. Changes in the proportion of precipitation occurring as snow in New England. Journal of Climate 17:2626-2636.

Kimball, K.D., and D.M. Weihrauch. 2000. Alpine vegetation communities and the alpine-treeline ecotone boundary in New England as biomonitors for climate change. USDA Forest Service Proceedings 3:93-101.

Lesica, P., and B. McCune. 2004. Decline of arctic-alpine plants at the southern margin of their range following a decade of climatic warming. Journal of Vegetation Science 15:679-690.

McCarty, J.P. 2001. Ecological consequences of recent climate change. Conservation Biology 15(2): 320-331.

National Park Service. 1981. Comprehensive Plan for the Protection, Management, Development and Use of the Appalachian National Scenic Trail. National Park Service, Appalachian Trail Project Office, Harpers Ferry, West Virginia, USA.

---------2000. Strategic Plan for the Appalachian National Scenic Trail. National Park Service, Appalachian Trail Project Office, Harpers Ferry, West Virginia, USA.

---------2001. Memorandum of Understanding for the Administration and Management of National Historic and National Scenic Trails. National Park Service, Appalachian Trail Project Office, Harpers Ferry, West Virginia, USA.

New England Regional Assessment (NERA). 2001. Preparing for a changing climate: the potential consequences of climate variability and change. New England Overview, U.S. Global Change Research Program, University of New Hampshire, Durham, New Hampshire, USA.

HABITAT PROFILE

Appalachian Oak Pine Forest

Associated Species: Timber rattlesnake, eastern hognose snake, whip-poor will, veery, eastern pipistrelle, eastern red bat, northern myotis, silver haired bat, bobcat, black bear

Global Rank: Not ranked
State Rank: Not ranked
Author: Carol R. Foss, Audubon Society of New Hampshire

Element 1: Distribution and Habitat

1.1 Habitat description

Appalachian oak pine forest systems are found mostly below 900 ft elevation in southern New Hampshire south of and at lower elevations than the hemlock-hardwood-pine forest system. The southern-most portions of the state are associated with the warmer and drier climatic conditions and apparently more fire-influenced landscapes that prevail south of New Hampshire in lower New England. Substrates in these forests include nutrient-poor, dry to mesic sandy glacial tills, and some large areas of sand plain or shallow-to-bedrock tills, particularly in the seacoast and lower Merrimack and Connecticut River valleys. Sand plains in these areas that have a frequent fire history correspond to pitch pine sand plain; those with a less frequent fire regime (i.e., more than 50 to 100 years) are classified as oak pine forest or sometimes hemlock hardwood pine forest systems depending on the composition of trees. More isolated patches of oak pine forest systems are found to the north in central New Hampshire associated with dry rocky ridges or sand plains with a historic fire regime.

1.2 Justification

Appalachian oak pine forest currently has a limited distribution in New Hampshire, covering less than 10% of the state's land area. Available data indicate that only 7.3% of the state's potential Appalachian oak pine forest is on permanently protected lands. This forest type supports 104 vertebrate species in New Hampshire, including 8 amphibians, 12 reptiles, 67 birds, and 17 mammals. Threatened and endangered wildlife species occurring in this forest type include osprey, Cooper's hawk, timber rattlesnake, and eastern hognose snake. In New Hampshire, intense development has dramatically reduced the area of this forest type influenced by natural disturbance regimes, resulting in a preponderance of the forest currently in older age classes. A full range of age classes well distributed on the landscape is important to support the diversity of wildlife species that depend on this forest type.

1.3 Protection and Regulatory Status

Most of New Hampshire's Appalachian oak pine forest occurs on small, privately owned parcels. Less than 15% of this forest type occurs on conservation lands. Forestry on state lands is covered by RSAs 216, 217, and 218. RSA 227 stipulates requirements for residual basal area in riparian areas. The manuals "Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire" (Cullen 1996) and "Good Forestry in the Granite State" (FSSWT 1996) provide recommended management practices for sustainable forestry in New Hampshire.

1.4 Distribution

Appalachian oak pine forest occurs primarily in southern New Hampshire, with more than 40%

by area in Rockingham County and approximately 20%, 15%, and 10% in Hillsborough Strafford, and Cheshire counties, respectively.

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

To develop a map of Appalachian oak pine forest in New Hampshire, a model was developed for each ecoregion subsection of the state based on the 2001 New Hampshire Land Cover Assessment, elevation, landform, and soils. The model was developed by experts from The Nature Conservancy (TNC), the New Hampshire Natural Heritage Bureau (NHNHB), and New Hampshire Fish and Game (NHFG).

First, relevant forested 2001 New Hampshire Land Cover Assessment grid values were combined with elevation ranges from sea level to 900' (CSRC 2001, USGS 2003). Ecological Land Units, created by The Nature Conservancy's Conservation Science Support, were then added to capture additional areas likely to have geo-physical conditions favorable to Appalachian oak pine, or remove areas likely to have geo-physical conditions unfavorable to Appalachian oak pine (TNC 2003). Specifically, north-facing side slopes and north-facing coves were removed from some land cover/elevation classes, and some land cover/elevation classes were restricted to only south-facing sideslopes and south-facing coves.

During previous fieldwork, NHNHB mapped exemplary Dry Appalachian oak-hickory forest, Mesic Appalachian oak-hickory forest, Appalachian oak-mountain laurel forest, and Semi-rich Appalachian oak-sugar maple forest systems in the state. These areas were added to ensure that known Appalachian oak pine locations were captured (NHNHB 2005). These data do not capture all existing locations of these communities, only those that have been mapped by NHNHB.

To further refine the model, soil types associated with Appalachian oak pine were identified by Natural Resource Conservation Service scientists and selected from digitized county soil data, where available (e.g., Merrimack county soils have not been digitized) (NRCS 2002, Homer 2005). The soils were selected, and then clipped to only include forested areas based on the New Hampshire Landcover Assessment, and added to the existing model information. The same was done for hemlock-hardwood-pine, and then Appalachian oak pine was used to erase areas from hemlock-hardwood-pine where there was overlap, so that Appalachian oak pine takes precedence over hemlock-hardwood-pine. NHFG then applied a filter to determine the majority forest type between neighboring polygons in the TNC model, and smoothed the boundaries to generalize the transition between matrix forest types. This process is expected to somewhat over-predict current locations of Appalachian oak pine, but it captures better broad distribution patterns of the type.

Model results were reviewed by experts from TNC, NHFG, and NHNHB, who agreed that the broad patterns depicted by the model align with reasonable expectations. No ground truthing was conducted.

1.7 Sources of Information

The Appalachian oak pine map was developed based on expert input from scientists from the NHNHB, NHFG, and the New Hampshire Chapter of The Nature Conservancy. The results were reviewed by additional scientists from NHFG and the Audubon Society of New Hampshire. A variety of GIS data was used to generate the map including elevation data from the United States Geological Survey, landform data from The Nature Conservancy's eastern regional office, landcover data from the New Hampshire Landcover Assessment, and soils data from the Natural Resource Conservation Service, among others.

1.8 Extent and Quality of Data

The Appalachian oak pine habitat map is a depiction of broad landscape patterns with limited fine-scale accuracy. Additional refinements will likely be necessary based on ground truthing of the existing map. The Natural Resource Conservation Service provided a table of soil series that were believed to be strongly correlated with Appalachian oak pine and other forest types (Homer 2005). Soil series were provided by ecoregional subsection and elevation ranges. There was considerable overlap between series outlined for Appalachian oak pine and other forest types, especially hemlock-hardwood-pine. The transition between Appalachian oak pine and hemlock-hardwood-pine

was especially difficult to delineate, as disturbance is a driving factor in the distribution of Appalachian oak pine. The soil series considered to be most strongly correlated with Appalachian oak pine that did not overlap with hemlock-hardwood-pine were used in mapping Appalachian oak pine. Additional review of soils data, as well as land use history and paleoecology information, are necessary for future iterations.

1.9 Distribution Research

Additional fieldwork is needed to evaluate correlations between soil series and forest type as outlined in Homer (2005). County soil surveys outline soils suitable for forestry from an economic perspective. However, little has been done to evaluate soils from an ecological perspective (e.g., if left unmanaged, an area with a particular soil would eventually succeed to Appalachian oak pine forest).
Fieldwork is also needed to ground truth the Appalachian oak pine map.
Research is needed to identify human-created disturbance regimes that can maintain and regenerate Appalachian oak pine forest.

Element 2: Species/Habitat Condition

2.1 Scale

County

2.2 Relative Health of Populations

An approximately 5% decrease in forest area occurred between 1992 and 1993 and 2001 in the 4-county area where approximately 90% of New Hampshire's potential Appalachian oak pine forest occurs. An additional approximately 5% decrease is projected to occur between 2001 and 2025 (calculated from data in SPNHF 2005).

2.4 Relative Quality of Habitat Patches

Analysis pending

2.5 Habitat Patch Protection Status

Approximately 10% of potential Appalachian oak pine forest in the 4-county area where approximately 90% of this forest type occurs is in conservation ownership (calculated from TNC data). Approximately 14% of this type occurs on lands with some form of conservation protection (calculated from NHFG data).

2.6 Habitat Management Status

Approximately 25% of the 4-county area in which approximately 90% of potential Appalachian oak pine forest area occurs is in certified Tree Farms (calculated from TNC data and data in Thorne and Sundquist 2001).

2.7 Sources of Information

See 1.7

2.8 Extent and Quality of Data

See 1.8 regarding extent and quality of data associated with the TNC matrix forest map. Tree farm data from Thorne and Sundquist 2001 are based on a New Hampshire Tree Farm program database issued in August 2000. Data regarding changes in forest area from SPNHF 2005 include information from the New Hampshire Land Cover Assessment, 2001 and results of predictive modeling.

2.9 Condition Assessment Research

- Research is needed to determine the extent of this forest type that occurs in large unfragmented blocks.
- Research is needed to determine the age class distribution of this forest type on the landscape.

Element 3: Species and Habitat Threat Assessment

3.1.1 Transportation Infrastructure

(A) Exposure Pathway
Transportation infrastructure fragments forest blocks, creating edge effects from light penetration and exposure to wind and pollutants such as road salt and hydrocarbons. Transportation infrastructure and its use by vehicles also create dispersal barriers, edge effects, and increased mortality for matrix forest wildlife (Forman et al. 2003).

(B) Direct Evidence
Large carnivores may be unable to maintain sustainable populations in landscapes with road densities exceeding 1 mi/ mi^2 (Forman and Alexander 1998). Roads affect forest and habitat conditions well beyond the actual edge of the forest (Ranney et al. 1981). Roads can negatively affect landscape permeability for black bears, bobcats, and lynx (Forman et al. 2003).

3.1.2. Development (Habitat Loss and Conversion)

(A) Exposure Pathway
Development reduces matrix forest habitat by converting natural forest to landscaped lawns and impermeable surfaces (e.g., buildings, roads). Development also contributes to forest fragmentation by directly reducing habitat, increasing traffic on existing roads, and requiring construction of new transportation infrastructure.

(B) Direct Evidence
A study of 10 New Hampshire communities found that their populations increased by an average of 70.9% (range 9.7 to 189.7%) between 1974 and 1992, while developed land increased by an average of 137.2%. In the community with 9.7% population growth, developed land increased by 15.9% (New Hampshire Office of State Planning (NHOSP) 2000).

3.1.3. Development (Land Use Planning)

(A) Exposure Pathway
In New Hampshire, land use decisions are made at the municipal scale by volunteer planning boards with little or no training in natural resource issues. In cities and some of the larger towns, professional planning staff evaluate proposed developments and provide input to the planning board, but this is the exception rather than the rule. Most professional planners lack training in ecology or natural resources. Decisions are typically based on engineering and aesthetic considerations, with no recognition of direct or cumulative impacts on the underlying ecological functions of the affected lands or on impacts to wildlife habitat.

(B) Direct Evidence
A Growth Management Advisory Committee convened by the New HOSP in 1999 concluded that:

- Impacts of growth and development are cumulative over decades
- Development in New Hampshire has occurred incrementally, resulting in fragmentation and loss of important and environmentally sensitive areas, including forestlands and wildlife habitat
- Communities seldom evaluate the potential impacts of their zoning ordinance or land use regulations (NHOSP 2000)

3.1.5 Altered Natural Disturbance (Succession)

(A) Exposure Pathway
Extinction of the passenger pigeon, fire suppression, development, and accompanying land-use policies have essentially eliminated the major historical natural disturbances for this forest type. Parcelization and extensive residential development now preclude forest management in much of New Hampshire's Appalachian oak pine forest. Habitat for wildlife species requiring early successional stages of this forest type has been substantially reduced.

(B) Direct Evidence
Forest inventory data for New Hampshire show major deficits in the 2-inch diameter class for hickory and the 4-inch diameter class for white oaks (Miles 2005).

3.2 Sources of Information

Threat information was derived from a work session with forestry professionals and stakeholders, available data, published literature, and personal experience.

3.3 Extent and Quality of Data

Threats to Appalachian oak pine forest resulting directly or indirectly from land conversion and development are well documented.

3.4 Threat Assessment Research

The major threats are adequately documented. Re-

search should be directed to condition assessment and conservation actions.

Element 4: Conservation Actions

4.1.1 Incorporate Habitat Conservation into Local Land Use Planning

See Strategies: Local Regulation and Policy

4.1.2 Advise Conservation Commissions and Open Space Committees

See Strategies: Local Regulation and Policy, Education and Outreach

4.1.3 Promote Role of the Regional Planning Commissions in Landscape-Scale Conservation

See Strategies: Local Regulation and Policy

4.1.4 Protect unfragmented blocks and other key wildlife habitats

See Strategies: Land Protection

4.1.5 Develop a comprehensive land protection support program

See Strategies: Land Protection

4.1.6 Advocate adoption of sustainable forestry

See Strategies: Education and Outreach

4.2 Conservation Action Research

Research is needed to provide a sound scientific basis for new tools to help municipalities maintain large forest blocks and significant wildlife habitat in the face of development. Such research could include:

- Road noise effects on forest bird distribution and breeding status
- Behavior and land use of mesocarnivores in relation to development and road densities
- Bear use of mast stands relative to proximity of development
- Effects of residential lot sizes on habitat suitability and landscape permeability for selected wildlife species

Element 5. References

5.1 Literature

Forman, R.T.T., D. Sperling, J.A. Bissonette, A.P.Clevenger, C.D. Cutshall, V.H. Dale, L. Fahrig, R. France, C.R. Goldman, K. Heanue, J.A. Jones, F. S. Swanson, T. Turrentine, T.C. Winter. 2003. Road Ecology. Island Press, Washington.

Forman, R.T.T. and L.E. Alexander. 1998. Roads and their major ecological effects. Annual Review of Ecology and Systematics 29:207-231.

Homer, J. 2005. Soil types corresponding to the NH Natural Heritage Bureau forest systems classification. U.S. Department of Agriculture, Natural Resource Conservation Service, Lancaster, NH, U.S.A., Unpublished Report to New Hampshire Fish and Game Department.

Keys, J.E. and C.A. Carpenter. 1995. Ecological units of the eastern United States: first approximation. U.S. Department of Agriculture, Forest Service.

NHOSP. 2000. Managing Growth in New Hampshire: Changes & Challenges. New Hampshire Office of State Planning in conjunction with The Growth Management Advisory Committee, Concord, New Hampshire,

Ranney, J.W., M.C. Bruner, and J.B. Levenson. 1981. The importance of edge in the structure and dynamics of forest islands. Pp.67-92 in R.L. Burgess and D.M. Sharpe, eds. Forest Island Dynamics in Man-Dominated Landscapes. Springer-Verlag, New York.

Thorne, S. and D. Sundquist. 2001. New Hampshire's Vanishing Forests: Conversion, Fragmentation and Parcelization of Forests in the Granite State. Report of the New Hampshire Forest Land Base Study. Society for the Protection of New Hampshire Forests, Concord.

5.2 Data sources

Complex Systems Research Center. 2001. New Hampshire land cover assessment – 2001. 30m raster data. Available from GRANIT, University of New Hampshire.

Homer, J. 2005. Soil types corresponding to the NH Natural Heritage Bureau forest systems classification. U.S. Department of Agriculture, Natural Resource Conservation Service, Lancaster, NH, U.S.A., Unpublished Report to New Hampshire Fish and Game Department.

Miles, P.D. May 11, 2005. Forest inventory mapmaker web-application version 1.7, St. Paul, MN: U.S.

Departmetn of Agriculture, Forest Service, North Central Research Station [www.ncrs2.fs.fed.us/4801/fiab/index.htm]

Natural Resources Conservation Service. Date varies, in progress with last revision in 2002. Soil Units of Rockingham, Sullivan, Cheshire, and Strafford Counties. Automated by and available from GRANIT, University of New Hampshire.

New Hampshire Natural Heritage Bureau. January 2005. Exemplary Natural Community Data. Scale varies, vector data. Available with permission from the NH Natural Heritage Bureau.

Sperduto, D, and M. Zankel. 2005. Distribution of matrix forest systems in New Hampshire by subsection, elevation, slope, and aspect. NH Department of Resources and Economic Development, Division of Forests and Lands, Natural Heritage Bureau, and The Nature Conservancy, Concord, NH, U.S.A. Unpublished Report to New Hampshire Fish and Game Department.

The Nature Conservancy, Conservation Science Support. 2003. Ecological Land Units. 30m raster data. Available from TNC, Eastern Resource Office, Boston, MA.

United States Geological Survey. Date varies, complete by 2003. National Elevation Dataset. 30m raster data. Projected by Complex Systems Research Center in January 2005, available from GRANIT, University of New Hampshire.

HABITAT PROFILE

Caves and Mines

Associated Species: Northern Myotis, Eastern Small-Footed Bat, Myotis sodalis, , Eastern Pipistrelle
Global Rank: G5
State Rank: S1
Authors: Jacques Veilleux and Scott Reynolds, Franklin Pierce College; St. Paul's School

Element 1: Distribution and Habitat

1.1 Habitat Description

Caves and mines are distinguished from all other New Hampshire habitats by being located below ground. Cave and mine habitat does not represent an ecosystem, but rather an abiotic habitat type. Prior to the 1800s, no underground cave or mine habitat existed in New Hampshire other than the small fracture "caves" located in tourist areas such as Lost River and The Polar Caves; such structures are not true caves.

1.2 Justification

Six of New Hampshire's 9 bat species overwinter in the state, hibernating in thermally stable underground caves or mines. A small number of mines in New Hampshire are known to provide habitat for hibernating bats, although historic mining data suggest that there could be additional mines that provide suitable winter habitat. For conservation, it is necessary to maintain mines with attributes (e.g., temperature, airflow, low disturbance) that are required by hibernating bats. Some individuals, such as *Eptesicus fuscus*, undoubtedly hibernate in buildings (Whitaker and Gummer 1992). Managers need better knowledge of hibernacula sites to conserve overwintering animals.

3.3 Protection and Regulatory Status

The Bureau of Land Management and Office of Surface Mining provide no data regarding use of abandoned mines. They may provide public service announcements indicating the danger of entering abandoned mines, but no specific federal law appears to regulate non-commercial use of mines.

At the state level, under the Revised Statutes Annotated (RSA), Title I (the State and its Government), Chapter 12-E regulates mining and reclamation activities in New Hampshire. Section 12-4:V discusses the requirements of post-mining reclamation, and states "post-mining uses may include agricultural, recreational, residential, commercial, industrial, forestry or open space land use." This post-mining reclamation appears to relate to the habitat surrounding the mine, but not the mine itself. Chapter 12-E does not provide regulations pertaining to use of the mine after commercial mining activities have ceased.

1.4. Population and Habitat Distribution

There are 7 known abandoned mines that serve as winter hibernacula in New Hampshire. Within the Northeast region, approximately 198 hibernacula have been documented to date (approximate numbers per state are: Connecticut = 2, Maine = 3, Massachusetts = 16, New York = 150, Rhode Island = 0, and Vermont = 27), with just 55 in New England.

New Hampshire's hibernacula are concentrated in Grafton County (5 of 7 sites), with one site located in each of Coos and Merrimack Counties. Additionally, *potential* hibernacula are located in Grafton County (6 mines), Sullivan County (2 mines), and Cheshire County (1 mine). Mean minimum distance between nearest neighbor mine sites was 20.7 km (range 1.7 – 61.8 km).

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

Profile authors visited each mine during the summer of 2004 and GPS coordinates were gathered using a Garmin 12XL receiver. Map coordinates were provided to the habitat mapper. Coordinates provide accurate localities of each mine.

1.7 Sources of Information

The main source of information pertaining to mine locations was the New Hampshire Natural Heritage Inventory: Bat Hibernaculum Records for abandoned mines. Existing GPS coordinates were found to be inaccurate for some mines (e.g., Mt. Kearsarge Mine) and therefore only the coordinates provided to the habitat mapper from the 2004 field work (section 1.6) should be used.

Several sources were used to identify potential hibernacula including databases, published literature, and consultation with state agencies, local spelunkers, historical societies, and landowners. The main database used to determine historical mine sites was the United States Bureau of Mines, Minerals Availability System Domestic Deposit Listing (maintained by the Utah State Historical Society). Morrill (1960; New Hampshire Mines and Mineral Localities) provided more detailed information about potential mines.

Authors consulted with the state geologist (David Wunsch, New Hampshire Department of Environmental Services) and a land manager (Bill Carpenter, New Hampshire Department of Resources and Economic Development, Land Management Bureau). For each mine identified as a potential hibernacula, the local historical society was contacted about mine ownership, condition, etc. Two active New Hampshire spelunkers (Michele Tremblay and Steven Landry) were consulted about the presence of additional mines that we had not identified, as well as data about the condition of known mines. Finally, local landowners near potential sites were consulted during the survey to gather additional data on mine location and condition.

1.8 Extent and Quality of Data

Trends in the habitat quality of New Hampshire's mines are unknown. In addition, the lack of data on caves/mines in New Hampshire precludes an accurate assessment of the statewide or regional significance of New Hampshire's mines.

1.9 Distribution Research

It is important to survey all known mines for use by bats. Sites should be described in terms of microclimate and disturbance regimes; this will allow managers to determine the potential of a mine to serve as a hibernaculum.

Element 2: Species/Habitat Condition

2.1 Scale

Due to the relatively small number of New Hampshire mines that are known to provide habitat or potentially provide habitat, each mine is treated individually as a conservation planning unit.

2.2 Relative Health of Populations

The 7 mines that have been surveyed for bats in New Hampshire have hibernating populations ranging in size from 12 bats (Beebe River Mine) to 1,579 bats (Mascot Lead Mine). Species diversity within these mines ranges from 2 species (Carter Mine) to 5 species (Mascot Mine). Although Bristol Mine was only surveyed once (1989), the remaining 6 mines have been surveyed at least three times since 1986. From these data, it appears that hibernating populations of bats are generally stable, with 5 of the mines having larger populations in recent surveys. The only mine to see a decline was the Beebe River Mine, which saw a 79% reduction from 1988 to 1991.

A *Hibernacula of Special Concern* is defined as any cave or mine that contains at least four species of bats, at least 1,000 individuals, or any threatened or endangered species (Butchkowski 2003). New Hampshire has two Hibernacula of Special Concern: Mascot Lead Mine and the Red Mine.

To estimate the hibernating population of bats in New Hampshire, we assumed changes in population size between surveys were a linear function of

time and conducted a smoothed-line interpolation of data between surveys. We took two approaches to estimate the current population of bats in hibernacula. The first approach assumed all populations would remain stable since the last survey; because all but one of the mines had increasing population trends, this was considered a conservative estimate. The second method involved extrapolating data from the last survey date using the rate of increase estimated from prior surveys; this was considered the potential estimate. The conservative estimate was 2,928 bats and the potential estimate was 3,283. Because the largest mine (Mascot Lead Mine) was surveyed in 2004, the potential estimate is only 12% higher than the conservative estimate.

The little brown bat (*Myotis lucifugus*) is the dominant hibernating bat in New Hampshire, being found in all seven mines and representing 86.5% of all bats. Northern myotis (*Myotis septentrionalis*) are also found in each of the known mines and represent 12.5% of the total hibernating population. Northern myotis is the only species that appears to be declining, with the 2004 estimate reflecting a 36% decrease from 1989 estimates. This decline may be due to population pressures outside the hibernacula, but may also reflect differences in survey methods and misidentification of little brown bats as northern myotis. Big brown bats (*Eptesicus fuscus*) represent 0.3% of the current hibernating population and are currently known from two hibernacula (Red Mine and Beebe River Mine), although they were found in the Paddock Copper Mine as recently as 1991. Similarly, eastern pipistrelle bats (*Pipistrellus subflavus*) represent 0.3% of the current hibernating population and are currently known from two hibernacula (Dodge Mine and Mascot Lead Mine), although they were found in the Mt. Kearsarge Mine as recently as 1991. Eastern small-footed bats (*Myotis leibii*) represent 0.3% of the current hibernating population and are only known from Mascot Lead Mine. The 2004 population estimate of eastern small-footed bats (9 animals) reflects an increase from the previous survey, but a 43% reduction from the peak estimate in 1987.

2.3 Population Management Status

2.4 Relative Quality of Habitat Patches

Several physical characteristics are predictive of hibernacula. These include cool and stable interior temperatures (Hall 1956, McManus 1974, Harmata 1987, Jones et al. 1995, Tuttle and Kennedy 2002, Tuttle 2003), low air flow (Jones et al. 1995, Kath 2002), long or complex adits (Lopez-Gonzalez and Torres-Morales 2004), and a high degree of protection from human disturbance and vandalism (Martin et al. 2002, Tuttle and Kennedy 2002). Updates on population information and physical attributes of known hibernacula suggest that New Hampshire Natural Heritage ranks need revision.

2.5 Habitat Patch Protection Status

Mascot Lead Mine is the only mine that currently contains (state) endangered species. Mascot Lead Mine, Paddock Copper Mine, and Mt. Kearsarge Mine are the three largest hibernacula in the state. Five of the seven known mines (Carter's Mine, Beebe River Mine, Bristol Mine, Paddock Copper Mine, and Red Mine) are located on private land. Two mines (Mascot Lead Mine and Mt. Kearsarge Mine) are managed by the Department of Resources and Economic Development (DRED). Each mine identified as potential habitat is located on private land. The exact location of one mine (Keyes Mine) could not be determined, and therefore protection status is unknown.

2.6 Habitat Management Status

The only ongoing habitat management action occurring in New Hampshire is the maintenance of a bat gate at Mascot Lead Mine. Bat gates have been installed at hibernacula for the last 35 years to reduce or eliminate disturbance (Tuttle 1976). These gates are steel-welded structures installed at the entrance to a mine or cave that restrict human access while producing minimal impact on air flow and flight behavior of bats. Because many caves and mines are found in remote locations, bat gates have been described as "the only means available for protecting these [colonies]" (Pierson et al. 1991). Some states, such as Pennsylvania, have installed bat gates hibernacula that contain Indiana bats (Butchkoski 2003)

Despite the increased use of gates as a conserva-

tion tool, there has been little attempt to quantify the effectiveness of gating (Currie 2002). In fact, there are several instances of mines and caves experiencing population declines or complete abandonment following construction of bat gates (Tuttle 1976, Johnson et al. 2002).

Two bat gates were installed at the Mascot Lead Mine in 1992—one on the lower adit (Level 1) and another on the upper adit (Level 2). Prior to installation, a census of bats in the mine estimated a hibernating population of 874 bats representing five species. A 1993 survey (1,504 bats representing five species) strongly suggests that the bat gate has not negatively impacted the microclimate of Mascot Lead Mine nor has it impeded the flight behavior or hibernacula preferences of the bats. Given the design of the gate and the security of the access door, it is reasonable to assume these bat gates have been highly effective at minimizing human disturbance.

2.7 Sources of Information

The physical attribute information on four of the known bat hibernacula (Mt. Kearsarge Lead Mine, Paddock Copper Mine, Carter's Mine, and Red Mine) were collected by Durham (2000). Measured variables included temperature, relative humidity, shaft height, shaft width, bat cluster temperature, species composition, roost height, and roost depth. These data were used to generate mine maps and look at species-specific thermal preferences.

2.8 Extent and Quality of Data

The quality and extent of data collected varies between the mines. There have been four winter surveys at Mascot Lead Mine since 1987; two were conducted since installation of the bat gate in 1992. Red Mine has been surveyed four times since 1986 and the Mt. Kearsarge Lead Mine and Paddock Copper Mine have been surveyed five times since 1986. The smaller hibernacula have generally been surveyed less frequently, including Carter's Mine (three surveys since 1989), Beebe River Mine (three surveys since 1988), and Bristol Mine (one survey in 1989). With the exception of data collected in 1999 and 2000 at Red Mine, Paddock Copper Mine, Carter's Mine, and Mt. Kearsarge Lead Mine (Durham 2000), no microclimate data have been collected at any of these sites. Furthermore, bats have not been surveyed at Ruggle's Mine.

2.9 Condition Assessment Research

It is important for the conservation of bats in the Northeast to identify and determine the importance of mines as winter roost habitat (Ellison et al. 2002). This requires establishing a monitoring program that will assess the physical attributes of a mine to determine its' potential suitability as a hibernacula, document the population status of hibernating bats using non-intrusive monitoring techniques, and evaluate the need for, and effectiveness of, mine gates to minimize disturbance.

One priority should be to continue to seek additional mines that may contain hibernating bats. Previous surveys across the country have shown that approximately half of abandoned mines show some evidence of bat use (Tuttle 1995). In New Hampshire, a small fraction of the summer bat population can be accounted for by existing hibernacula. Therefore, it is likely that additional surveys will discover new hibernacula.

For each potential hibernaculum, it is important to measure the physical characteristics of the mine and key microclimate conditions that influence bat occupancy. Foremost of these microclimate variables is core mine temperature (Tuttle and Kennedy 2002). Most bats prefer mines that maintain a stable winter temperature slightly above freezing (1°C - 10°C: Tuttle 2003). This is consistent with the temperatures recorded in Red Mine near hibernating bats (6°C - 9°C; Durham 2000). Most rigorous surveys now rely on battery-operated data logger probes (such as the Hobo Pro ™ series) to record mine temperature throughout the hibernation period (Tuttle and Kennedy 2002). These devices can be installed in the autumn and programmed to record temperature each hour during the winter. Devices can be recovered in the spring without disturbing the bats. Air flow can also be important in larger mines because it indicates air exchange within the mine and may be the result of chimney-effect air flow that is produced by a secondary opening. Chimney-effect air flow maintains cool air in mines and often enhances temperature stability (Tuttle and Kennedy 2002).

For mines with hibernating bats, periodic monitoring is essential to assess population stabil-

ity. Surveys involving Species of Concern should be conducted every second or third year (Johnson et al. 2002, Tuttle 2003). Hibernacula surveys should be conducted during December through February when bats are most abundant. Details of the survey protocol are available from Veilleux and Reynolds (2005). Technical climbing support may be required to access the habitats. Microclimate needs to be measured to determine a mines' suitability as hibernacula.

For mines subject to vandalism and disturbance, it may be necessary to install bat gates across the mine entrance. Well-designed bat gates can protect bats from disturbance without impacting cave microclimate. Although gates can be expensive to install, they appear to be the only effective method of reducing human disturbance. Research into the value of chain-link fences and signage suggests they do not deter vandalism at all (Johnson et al. 2002). Johnson et al. (2002) did find, however, that a motion-activated alarm reduced human entrance into a mine in Indiana.

Element 3: Species and Habitat Threat Assessment

3.1.1 Recreation

(A) Exposure Pathway
Humans that enter New Hampshire mines during winter may disturb hibernating bats and cause individual bats to arouse from hibernation. These disturbances may expend a portion of an individual's energy reserve that is required for successful hibernation. If human disturbance of wintering bats and the subsequent arousals from hibernation occur too frequently, energy reserves may be depleted and individuals may die before spring emergence. As evidence of this, Johnson et al. (1998) documented lower body masses in Indiana bats hibernating in caves that were subject to human disturbance.

(B) Evidence
Thomas (1995) examined whether non-tactile disturbance by humans (i.e. disturbance by light and sound, rather than direct physical contact with bats) visiting hibernacula during the hibernation period affected winter arousal rates of bats. Data indicated that the presence of humans in hibernacula causes a dramatic increase in arousal of bats (little brown bats and northern myotis) and an increase in flight activity. Thomas (1995) suggested that non-tactile disturbance may cause bats to attempt to copulate (males) with hibernating females, and attempt to reposition themselves within a hibernating cluster of non-aroused bats. Aroused bats may arouse others due to tactile disturbance.

Costs for normal metabolic functions during hibernation and natural periodic arousals likely consume the majority of available fat reserves during winter. Each time human disturbance causes arousal by bats in a hibernaculum, limited energy supplies are exhausted, and this may lead to mortality. This is particularly important for juvenile bats that enter hibernation with limited fat reserves.

3.1.2 Development (Habitat Loss and Conversion)

(A) Exposure Pathway
Landowners with abandoned mines on their property may try to reduce risk of litigation by backfilling (closing) the mine entrance. If backfilling occurs in the fall or early spring, hibernating bats may be trapped in the mine and experience direct mortality from the mine closure. If backfilling occurs during summer, it is unlikely that bats would be trapped in the mine, but bats returning to the mine in the fall would not be able to gain entrance. Natural again also contributes to mine collapse, which may trap bats within mines, exclude them entirely, or merely disturb them during the winter.

(B) Evidence
Five of the known mine hibernacula and each mine identified as a potential hibernaculum are located on private land, and therefore may be at risk of landowner modification in the form of backfilling. Some of these mines have vertical shafts that present a potential hazard. Limited investigation yielded no information on serious injury or death of individuals entering New Hampshire mines for recreational purposes. Other Northeast states with more intensive mining histories have had injuries or deaths at abandoned mines. For example, in Pennsylvania, at least 45 deaths and 19 injuries at abandoned mines sites have been reported in the past 30 years (<www.doi.gov/news/040206d>, accessed 7 April 2005).

It is difficult to estimate the likelihood of a land-

owner backfilling a hibernaculum, but if the threat materializes, it may have severe consequences for bat populations. Conservation efforts should be pro-active. By identifying important hibernacula on private lands and initiating a protection program for the mine (for example, bat gating), wildlife management agencies can work to mitigate this threat.

3.2 Sources of Information

Sources of information on threats to cave/mine habitat included peer-reviewed scientific articles, gray literature, expert review by John O. Whitaker of Indiana State University, and information from New Hampshire residents familiar with local mines.

3.3 Extent and Quality of Data

The threats described under element 3.1 and their potential impact on bat populations are well documented, both for caves/mines in general, and for New Hampshire mines. The available data for the severity and likelihood of the threats for the mines located in New Hampshire are moderately well understood, but more data are required to fully realize the impact of each threat.

3.4 Threat Assessment Research

It is important to document the level of human disturbance at mines that serve as hibernacula A potential indicator of the threat could be a system (e.g. infrared monitoring devices) that would document human visitation rates at each non-gated hibernaculum. Such data could be correlated with costs of arousal for hibernating bats (see Element 3.1.1 B) to generate a probability of mortality to hibernating bats (and the corresponding decrease in habitat suitability) resulting from disturbance. This analysis would provide managers with criteria for aiding management decisions, such as whether to construct a bat gate.

It is important to assess the structural stability of each hibernaculum. A potential indicator of stability could be the degree of fissuring at mine entrances and other areas within the mine (Fig. 1). Such data could be used to determine which mines contain structural components (entrance, wall, or ceiling) that may be stressed and eventually collapse. This would provide managers with specific locations within mines that may require support structures.

The probability of a landowner blocking mine access by backfilling should be assessed. It is not recommended that state (or other) agencies inform landowners of the potential for litigation if a person was to be injured in a mine located on their property. Such action is likely outside the purview of state wildlife agencies. Rather, if a mine was to be documented as a high priority site for conservation, such information may be useful in convincing landowners of the utility of installing bat gates at their mines (e.g. excluding humans but allowing bats to utilize the mine).

Element 4: Conservation Actions

4.1.1 Gating, Habitat Protection

(A) Direct Threats
Human disturbance at mines, Landowner backfilling of mines

(B) Justification

1. Installing bat gates at high priority hibernacula will restrict human access to the mine during the winter. Therefore, the immediate threat of human disturbance causing arousals will be eliminated at the gated site. Convincing private landowners to install bat gates at high priority hibernacula will also remove the threat of potential litigation for personal injury, as cavers and spelunkers will be unable to enter the mines.

2. Too few data exist on historical bat populations to know whether gating will have a measurable impact on the number of hibernating bats present at a hibernaculum. Pre-gating surveys during winter at each hibernaculum will provide a current estimate of the number of species and individuals utilizing the mine. Post-gating surveys will allow managers to determine whether the gate has had a positive, negative, or neutral impact on hibernating bat populations. In addition, pre-gating measurements of mine microclimate will help determine whether gate construction significantly alters microclimate.

3. Several hibernacula in New Hampshire are currently experiencing human disturbance during winter. For example, Paddock Copper Mine (containing several hundred hibernating bats) was recently determined to be a popular site for "geocaching" activity. Geocaching involves placing an object at a specific GPS (latitude/longitude) location. The location is posted on the Internet for other individuals to locate. A cache was placed within the Paddock Copper Mine (approximately 70 m into the mine) and it appears that several individuals are entering the mine during winter. Carter Mine and Beebe River Mine also show signs of human activity during the winter.
4. Once a gate is constructed, it may be difficult to adapt the gate if new information arises about the effects of gating on bats. The gate could be removed if the gate was found to be a strong negative influence on the hibernating bats within a particular mine.

(C) Conservation Performance Objective
Construct bat gates that will restrict human access to the mine during winter and remove the threat of personal injury litigation against landowners from unauthorized humans entering at privately owned mine. A measurable performance indicator for this conservation action is periodic monitoring of the gate during the winter to ensure that the gate is not vandalized or opened by humans (this has been observed at the Roxbury Mine in Roxbury, CT, J. Veilleux personal observation).

(D) Performance Monitoring
During the first winter after a gate is installed, visit the mine three times (one visit every 2 months beginning in November and ending in April). If a gate shows signs of tampering, or the mine has been entered, personnel could enter the mine to assess evidence of disturbance (presence of trash, evidence of fire, etc.). Subsequently, the gate could be assessed every 2-3 years for evidence of tampering.

(E) Ecological Response Objective
The habitat protection response objective is to maintain or increase the current number of bats hibernating in each mine that is gated (conservation action). The minimal ecological response should be to maintain the current population size. An increase in population size at a hibernaculum following gate construction may suggest that gating has restored habitat quality (lower disturbance rate).

(F) Response Monitoring
A suggested long-term monitoring protocol for determining whether bat populations are being maintained or enhanced following gate construction is to survey gated mines every three years. This will provide detailed demographic data for each species of bat hibernating in the mine.

(G) Implementation
After high priority hibernacula are identified (see Section 2.5), the state should coordinate gaining landowner permission to construct the gate if the mine is on private land, purchasing gating materials, hiring a contractor (welder) to construct the gate, and delivering gate materials to the mine site. Gates should be constructed at each hibernaculum where bats are at risk.

Preliminary survey work to document current species distribution and abundance at known and potential hibernacula, as well as the documentation of human visitation rates at the hibernacula during winter, should be initiated as soon as possible.

The Office of Surface Mining (under the Bureau of Land Management) offers grant opportunities for the construction of bat gates at abandoned hibernacula. Additional funding opportunities may be available through the Nature Conservancy and other NGOs. Bat Conservation International provides construction specifications for the design of bat gates.

(H) Feasibility
Two bat gates have been constructed in New Hampshire (both at Mascot Lead Mine), and several bat gates have been constructed in other Northeast states (e.g. Connecticut, Vermont, and New York). Therefore, the technical competence to complete the construction of bat gates is available. The overall feasibility of gating hibernacula is limited by the availability of funding for pre-gating hibernacula surveys and gate construction.

4.1.2 Mine Condition Assessment, Habitat Protection

(A) Direct Threats
Shaft/adit collapse due to weathering

(B) Justification

1. One historic hibernaculum (North Woodstock Silver Mine) is known to have experienced at least one adit collapse. Nancy Mine No. 2, a potential hibernaculum, shows evidence of structural compromise at the main entrance.
2. Assessing the structural integrity of mine walls and ceilings will allow managers to determine the mines, and the sections of a particular mine, that are structurally compromised. Managers can then develop strategies for constructing physical support structures for protecting an area, thereby reducing the threat of collapse.
3. Maintaining the structural integrity of hibernacula will preserve the hibernating population of bats within the mine.
4. Once a mine is assessed for structural integrity, periodic assessments (perhaps once per 10 years) for structural integrity, as well as general assessments of integrity during hibernacula surveys, should allow managers to continually gather new information about the integrity of hibernacula.

(C) Conservation Performance Objective
Assessing hibernacula for structural integrity will determine whether sections of a mine are structurally compromised. A method to reinforce structural weaknesses must be developed to ensure structural integrity and long-term habitat protection. There is no definite endpoint of the conservation action, since the threat level can change as a mine system modifies over time. A partial endpoint goal is to assess each known and potential hibernacula and develop a plan for addressing any high priority breach in the mine structure.

(D) Performance Monitoring
Following the initial assessment, surveys to assess changes in structural integrity could be completed every ten years. A general bat survey could be conducted every three years. If a reinforcement action was required and completed, the action should be assessed at least once during the winter following construction, and then during each general assessment as described above.

(E) Ecological Response Objective
The habitat protection response objective is to maintain current number of bats hibernating in the mine by maintaining the structure stability of the mine. Populations would not be expected to decrease or increase due to the implemented conservation action, since the action is only maintaining habitat.

(F) Response Monitoring
A suggested (long-term) monitoring protocol for determining whether bat populations are being maintained is to perform hibernacula survey every three years at affected hibernacula. Such monitoring efforts will provide detailed demographic data for each species of bat hibernating within the mine as they respond to the action.

(G) Implementation
High priority sites for receiving reinforcement will have a combination of presence of rare/listed species, high population numbers, and high threat level to habitat/bats. After high priority sites are identified, the state should coordinate gaining landowner permission to modify the mine structure if the mine is on private land, purchasing reinforcement materials, hiring a contractor to construct the reinforcement structure, and delivering reinforcement materials to the mine site.

(H) Feasibility [Categorical Rank]
The technical competence to assess the structural condition of New Hampshire mines should be available within state agencies (e.g. USGS) and in colleges and universities (geology faculty). The overall feasibility of reinforcing hibernacula is limited by funds to purchase materials and construct the reinforcement structure.

4.2 Conservation Action Research:

Element 5: References

5.1 Literature

Butchkoski, C. 2003. Indiana bat hibernacula surveys. Unpublished report submitted to the Pennsylvania Game Commission.

Currie, R.R. 2002. Response to gates at hibernacula. Pages 86-99 *in* A. Kurta and J. Kennedy, editors. The Indiana Bat: Biology and Management of an Endangered Species. Bat Conservation International. Austin, Texas.

Durham, H.C. 2000. Microclimate and roost selection in four New Hampshire bat hibernacula. Thesis, Antioch New England Graduate School, Keene, New Hampshire, USA.

Ellison, L.E., M.B. Wunder, C.A. Jones, C. Mosch, K.W. Navo, K. Peckham, J.E. Burghardt, J. Annear, R. West, J. Siemers, R.A. Adams, and E. Brekke. 2004. Colorado Bat Conservation Plan, unpublished.

Ewing, W.G., E.H. Studier, and M.J. O'Farrell. 1970. Autumn fat deposition and gross body composition in three species of *Myotis*. Comparative Biochemistry and Physiology 36:119-129.

Hall, J. S. 1956. Life history studies of the eastern pipistrelle bat (*Pipistrellus subflavus*) in Massachusetts. Thesis, University of Massachusetts. Amherst, Massachusetts, USA.

Harmata, W. 1987. The frequency of winter sleep interruptions in two species of bats hibernating in limestone tunnels. Acta Theriologica 32:331-332.

Johnson, S.A., V. Brack, and R.E. Rolley. 1998. Overwinter weight loss of Indiana bats (*Myotis sodalis*) from hibernacula subject to human visitation. American Midland Naturalist 139:255-261.

Johnson, S.A., V. Brack, and R.K. Dunlap. 2002. Management of hibernacula in the state of Indiana. Pages 100-109 *in* A. Kurta and J. Kennedy, editors. The Indiana Bat: Biology and Management of an Endangered Species. Bat Conservation International. Austin, Texas.

Jones, G., P.L. Duvergé, and R.D. Ransome. 1995. Conservation biology of an endangered species: field studies of greater horseshoe bats. Symposium of the Zoological Society of London 67:309-324.

Kath, J. 2002. An overview of hibernacula in Illinois, with emphasis on the Magazine Mine. Pages 110-115 *in* A. Kurta and J. Kennedy, editors. The Indiana Bat: Biology and Management of an Endangered Species. Bat Conservation International. Austin, Texas.

Lopez-Gonzalez, C. and L. Torres-Morales. 2004. Use of abandoned mines by long-eared bats, genus *Corynorhinus* (Chiroptera: Vespertilionidae) in Durango, Mexico. Journal of Mammalogy 85: 989-994.

Martin, C.O., W.A. Mitchell, and M.S. Wolters. 2002. Eastern cave- and crevice-dwelling bats potentially impacted by USACE reservoir operations. EMRRP Technical Notes Collection (ERDC TN EMRRP-SI-24). U.S. Army Engineer Research and Development Center, Vicksburg, MS.

McManus, J. 1974. Activity and thermal preference of the little brown bat, M*yotis lucifugus*, during hibernation. Journal of Mammalogy 55:844-846.

Morrill, P. 1960. New Hampshire Mines and Mineral Localities. Second edition. Dartmouth College Museum, Hanover, New Hampshire, USA.

Pierson, E., W.E. Rainey, and W.M. Koontz. 1991. Bats and mines: experimental manipulation for Townsend's big-eared bat at the McLaughlin Mine in California. Proceedings of the Thorne Ecological Institute: 31-42.

Speakman, J.R., P.I. Webb, and P.A. Racey. 1991. Effects of disturbance on the energy expenditure of hibernating bats. Journal of Applied Ecology 28: 1087-1104.

Thomas, D.W. 1995. Hibernating bats are sensitive to nontactile human disturbance. Journal of Mammalogy 76:940-946.

Thomas, D. W., M. Dorais, and J. Bergeron. 1990. Winter energy budgets and cost of arousals for hibernating little brown bats, *Myotis lucifugus*. Journal of Mammalogy 71:475-479.

Tuttle, M.D. 1976. Gating as a means of protecting cave-dwelling bats. Pages 77-82 *in* T. Ale and D. Rhodes, editors. Proceedings of the National Cave Management Symposium. Speleobooks, Albuquerque, New Mexico, USA.

Tuttle, M.D. 1995. Saving North America's beleaguered bats. National Geographic 1995: 37-57.

Tuttle, M.D. 2003. Estimating population sizes of hibernating bats in caves and mines. Pages 31-39 *in* T.J. O'Shea and M.A. Bogan, editors. Monitor-

ing trends in bat populations of the United States and Territories: Problems and Prospects. U.S. Geological Survey, Biological Resources Discipline, Information and Technology Report, USGS/BRD/ITR-2003-0003. National Technical Information Service, Springfield, VA.

Tuttle, M.D., and J. Kennedy. 2002. Thermal requirements during hibernation Pages 68-78 *in* A. Kurta and J. Kennedy, editors. The Indiana Bat: Biology and Management of an Endangered Species. Bat Conservation International. Austin, Texas.

United States Bureau of Mines Collection. 1981, 1988. OVERSIZE Mss B 1033. Utah State Historical Society.

Veilleux, J.P., and S.D. Reynolds. 2005. Survey of known and potential mine habitat in New Hampshire. Unpublished report to New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

Walsh, A.L., C.M.C. Catto, T.M. Hutson, S. Langton, and P.A. Racey. 2003. The United Kingdom National Bat Monitoring Programme: turning conservation goals into tangible results. Pages 103-118 *in* T.J. O'Shea and M.A. Bogan, editors. Monitoring trends in bat populations of the United States and Territories: Problems and Prospects. U.S. Geological Survey, Biological Resources Discipline, Information and Technology Report, USGS/BRD/ITR-2003-0003. National Technical Information Service, Springfield, VA.

Whitaker, J.O., and S.L. Gummer. 1992. Hibernation of the big brown bat, *Eptesicus fuscus*, in buildings. Journal of Mammalogy 73:312-316.

5.2 Data Sources

1) Database: Minerals Availability System Domestic Deposit Listings located within the United States Bureau of Mines Collection: A register of the collection of at the Utah State Historical Society. Collection Call Number: OVERSIZE Mss B 1033. The collection can be accessed at http://history.utah.gov/FindAids/B01033/b1033.html

HABITAT PROFILE

Cliffs

Associated Species: American peregrine falcon (Falco peregrinus anatum), Golden Eagle (Aquila chrysaetos)
Global Rank: Not ranked
State Rank: Montane acidic (S5), Montane circumneutral (S2S3), Lowland acidic (S4), Lowland circumneutral (S2), Cliff seep (S3S4), Calcareous
Authors: Alina J. Pyzikiewicz and Steven G. Fuller, New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

Cliffs are steep rocky outcrops greater than 65° in slope and 3 m in height. They are more fractured and limited in soil accumulation than other types of rocky outcrops (Sperduto and Nichols 2004). Cliffs are exposed to the elements, do not accumulate significant amounts of snow pack, and may be protected from runoff by overhangs. Vegetation is sparse and is usually restricted to cracks and crevices where soil accumulates (NatureServe 2004). Although cliffs are generally dry, seeps do occur and may influence vegetation, pH, and nutrients (Sperduto and Nichols 2004).

Vegetation of acidic cliffs commonly includes three-toothed cinquefoil (*Potentilla tridentata*), fragile fern (*Cystopteris fragilis*), mountain cranberry, (*Vaccinium vitis-idaea*), sheep laurel (*Kalmia angustifolia*), and stunted trees such as red oak (*Quercus rubra*) and paper birch (*Betula papyrifera* var. *papyrifera*) (Sperduto and Nichols 2004). Circumneutral cliffs—which are rare in New Hampshire—are often vegetated with the state endangered smooth woodsia (*Woodsia glabella*) and creeping juniper (*Juniperus horizontalis*), state threatened fragrant fern (*Dryopteris fragrans*), and rare bryophytes such as *Distichium capillaceum, Gymnostemum aeruginosum*, and *Tortella tortuosa* (Sperduto and Nichols 2004). Calcareous cliffs are even more rare than circumneutral cliffs and support species such as bulblet bladder fern (*Cystopteris bulbifera*), zig-zag goldenrod (*Solidago flexicaulis*), and small trees and shrubs, such as eastern red cedar (*Juniperus virginiana*) and downy arrow-wood (*Viburnum rafinesquianum*) (Edinger et al. 2002).

1.2 Justification

Cliffs are primary nesting sites for the state endangered American peregrine falcon (*Falco peregrinus anatum*). Cliffs are used by many other species as well, including the state endangered golden eagle (*Aquila chrysaetos*), common raven (*Corvus corax*), state endangered timber rattlesnake (*Crotalus horridus*), long-tailed shrew (*Sorex dispar*), rock vole (*Microtus chrotorrhinus*), state endangered eastern small-footed bat, (*Myotis leibii*), gray fox (*Urocyon cinereoargenteus*), and bobcat (*Lynx rufus*) (DeGraff and Yamasaki 2001). The extreme range in chemical and physical factors (e.g., pH, temperature, moisture) found on cliffs may be important to endemic invertebrates and plants. Although often viewed as isolated or inaccessible, the popularity of cliffs and cliff tops as recreational destinations is rapidly increasing. Cliffs will also likely be targeted for wind energy development.

1.3 Protection and Regulatory Status

There are no laws explicitly protecting cliffs in New Hampshire. Areas occupied by state endangered and threatened plants and animals are protected under RSA 217-A and RSA 212-A respectively. Under the 1979 Peregrine Falcon recovery plan, the United States Fish and Wildlife Service (USFWS) protects peregrine falcon nests. Areas within 20 m of peregrine falcon nests are closed to hikers and climbers during the nesting season, typically April to August (United

States Forest Service (USFS) 2004).

The White Mountain National Forest (WMNF) prohibits rock defacement, including "chipping to create foot and hand holds, gluing to stabilize features, and attaching permanent artificial handholds. Route cleaning is prohibited where federal-listed threatened, endangered, and sensitive species occur. Removing, altering, or manipulating vegetation, soils, or other natural features at the cliff edge, talus slope, or cliff base is prohibited. To protect natural features, the use of mechanical or motorized devices, explosives, or chemicals for cleaning or developing climbing routes is prohibited" (WMNF Proposed Land and Resource Management Plan 2004). The Department of Resources and Economic Development (DRED) has no regulations for rock climbing on state lands, with the exception that hikers must register before climbing any routes on Cannon Cliff (Webster 1996). The USFWS (1979) established a landowner agreement to protect peregrine nesting sites.

1.4 Population and Habitat Distribution

Cliffs occur throughout the mountainous and lowland regions of New Hampshire. Montane acidic cliffs are found in northern areas at elevations of 360 to 1,000 m (1,200 to 3,500 ft). Montane circumneutral cliffs are found in the northern White Mountains at elevations of 275 to 1,000 m (900 to 3,500 ft). Lowland acidic and lowland circumneutral cliffs are found south of the White Mountains below elevations of 300 m (1,000 ft). Calcareous cliffs are restricted to western New Hampshire along the Connecticut River (Sperduto and Nichols 2004). Seeps can occur in any of these cliff types.

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

The 10-m Digital Elevation model provided by the Society for the Protection of New Hampshire Forests was analyzed to identify areas greater than 65% slope and was combined with the cliff landforms identified by The Nature Conservancy's (TNC) Ecological Landunit datalayer and the New Hampshire Natural Heritage Bureau's (NHB) exemplary cliff communities. A 200-m buffer was placed around these cliff polygons since research indicates the area within 200 m of a peregrine falcon nest (the primary species using cliff habitats) is the zone of predator defense (Cade 1960, White et al. 2002).

1.7 Sources of Information

Guides to the natural communities of New Hampshire and the NatureServe database were used as sources regarding habitat and distribution of cliffs. Field guides were used to identify species that utilize cliffs. The WMNF management plan was used to gather information regarding climbing rules and regulations. The NHNHB (is this right?) Element Occurrence Database (2004) listed endangered, threatened, or rare animal species associated with cliffs, including known breeding sites of peregrine falcons. In addition, a peregrine falcon assessment produced by the Audubon Society of New Hampshire (ASNH) was used to identify potential breeding sites. Rock climbing guides were used to locate recreational cliffs and assess use levels.

1.8 Extent and Quality of Data

NHB??? field surveys are the only known source of field data for cliff communities. The relative inaccessibility and remoteness of cliff habitats has prevented biologists from fully documenting cliff communities (Farris 1995). Predicted cliff polygons need field verification; however, aerial photographic interpretation may be a viable alternative.

1.9 Distribution Research

Research is needed to relate the patterns of plant and animal diversity to the chemical and physical attributes of cliffs. Surveys and long-term monitoring may be needed to determine species composition, trends, and conservation targets. Surveys should be designed to include all taxa, including invertebrates.

Element 2: Species/Habitat Condition

2.1 Scale

Habitat planning units were delineated primarily by mountain ridges, roads, and proximity to other cliffs, which resulted in 51 distinct units.

2.2 Relative Health of Populations

According to New Hampshire Fish and Game (NHFG), the Crawford Notch (828 ac), Carter-Wildcat (551 ac), Presidential (524 ac), Franconia-Whaleback (512 ac), and Carrigain (467 ac) units contain the greatest amounts of cliff habitat. Patterns of decline or loss are unknown.

2.3 Population Management Status

N/A

2.4 Relative Quality of Habitat Patches

Of the 316 cliffs mapped by NHFG, 68 (26% of total cliff areal extent) contain known climbing routes. Of 74 (27% of total cliff areal extent) current or historic peregrine falcon nesting sites, 46 (84% of occupied areal extent) contain known climbing routes. Thirty-three percent of the total areal extent of cliffs has potential for commercial wind turbine development, and 35% has potential for small turbines.

2.5 Habitat Patch Protection Status

Of the mapped cliff polygons, 66% are federally owned (USFS, WMNF), 23% are state owned (DRED), 1% are owned by private organizations, and less than 1% are town or county owned. Nine percent are protected.

2.6 Habitat Management Status

The 1996 MOU between the NHFG, USFWS, and USFS gives NHFG authority to develop, maintain, and manage all of the fish, wildlife, and rare plant resources within the WMNF. The 1993 memorandum of understanding (MOU) between DRED and NHFG directs land management practices that offer opportunities to combine agency resources for the improvement of wildlife habitat, forest recreation, and forestry operations for public use and benefit. In areas where cliffs occur in the WMNF, habitat improvement is forbidden because habitat should only be a result of natural processes (USFS 2004).

Cliff habitat improvement is not known to be occurring anywhere else in New Hampshire, although some cliff-dwelling species are being managed. Climbing routes that are fewer than 20 m from known peregrine falcon nesting sites are closed during the breeding and nesting seasons. ASNH posts cliff closure signs to protect peregrine falcons, WMNF has at least one PEFA-related display on the Kancamaugus Highway, and the Appalachian Trail Conference (ATC) and National Park Service (NPS) created an interpretive sign about cliff ecology that has been installed at Holts Ledge in Lyme, New Hampshire.

Informal agreements exist with Appalachian Mountain Club (AMC), EMS, and IME (1986) regarding posting cliff closure signs (for rare bird nesting) in stores and clubhouses to steer hikers away from Franconia Notch, Willard, and Frankenstein. Under an MOA between Rumney Climbers Association and WMNF, "The Rumney Climber's Association has the sole responsibility for overseeing fixed anchors, erosion control, new route activity, trail maintenance, posting peregrine falcon closures, and monitoring the status of rare plants at this popular New Hampshire climbing area."

2.7 Sources of Information

Information on management and regulations was obtained from the WMNF Protection Plan. GIS datalayers were used to identify key habitat areas and determine the quality of habitat patches.

2.8 Extent and Quality of Data

Peregrine falcon breeding and nesting is well documented by the ASNH peregrine falcon monitoring program, but is lacking for other bird species. Little is known about habitat use by other taxa, especially invertebrates.

2.9 Condition Assessment Research

- Establish baseline data regarding habitat quality
- Identify indicator species of high quality habitat, and survey for the existence of these species in potential habitat
- Determine the climbability of different cliffs, the impact of climbing at critical habitat areas, and the presence and location of rare species on cliffs used for recreational activity
- Assess the intensity of recreational use including infrastructure on cliff tops

Element 3: Species and Habitat Threat Assessment

3.1.1 Recreation

(A) Exposure Pathway
Cliffs, especially in the White Mountains, are often heavily used for hiking and rock climbing. Rare plants, soil, and sensitive communities may be trampled or removed to create new routes, or displaced by non-native species. Climbers and sight-seeing tours that repeatedly get too close to nesting birds can frighten birds off nesting sites, potentially causing nest abandonment.

(B) Evidence
New Hampshire has a long climbing history, dating back to 1910 (Webster 1996). In a 1969 rock climbing guidebook, 18 climbing routes were described for Cathedral Ledge, an area where peregrine falcons have nested for the past 10 years (ASNH unpublished data). By 1996, 222 new routes were established (Webster 1996). Statewide, New Hampshire has 106 cliffs with over 2,000 established climbing routes (Webster 1996, Smith 2001, Sykes 2001).

A common result of increased climbing activity is the establishment of informal trails (Pyke 2001). Climbers hiking to climbing routes and assembling at cliff plateaus cause minimal damage to vegetation (McMillan and Larson 2002), although seed viability and productivity may be reduced (Maschinski et al. 1997). On the face of the Niagara Escarpment in Canada, the density and composition of vascular plants, bryophytes, and lichens were lower in climbed areas than in unclimbed areas (McMillan and Larson 2002). The removal of vegetation to create new climbing routes can cause wind and rain to wash away soil, slowing the establishment of new plants (Camp and Knight 1998). Rock climbing can introduce non-native species through seeds transported on climbing equipment, shoes, and clothing (McMillian and Larson 2002).

The presence of low flying aircraft can frighten cliff-nesting birds from their nests, inadvertently knocking eggs or chicks from the nest (White et al. 2002). Nest disturbance can expose eggs and chicks to unfavorable environmental conditions that may result in mortality, or complete nest abandonment (White et al. 2002).

3.1.2 Energy and Communication Infrastructure

(A) Exposure Pathway
Construction of cell towers or wind turbines could directly impact the cliff top and indirectly affect the cliff face via increased erosion. There is an increased risk of migratory bird mortality in areas with towers and turbines (Kerlinger 2000).

(B) Evidence
There were 60 known towers sited in New Hampshire as of 1998 (www.towerkill.com) and 475 towers currently mapped by NHFG. Kerlinger (2000) prepared an extensive literature review for the USFWS Office of Migratory Bird Management on avian mortality at towers and turbines. Birds that migrate along ridgelines at night are at greatest risk for tower collision by becoming disorientated when encountering lighted towers (Partners in Flight, unpublished data). Current estimates of the numbers of birds killed annually by communication towers range between 4 and 10 million (www.towerkill.com).

3.2 Sources of Information

Expert review and consultation provided input on identifying and ranking threats. Rock climbing guides provided information on recreational cliffs. Peer-reviewed journal articles provided evidence for threats.

3.3 Extent and Quality of Data

Extensive information is available regarding rock climbing and its impacts on cliff vegetation. Little is known about rock climbing impacts on animal species other than peregrine falcons. There is no documentation on avian mortality or habitat degradation resulting from wind turbine or telecommunications tower collisions/construction in New Hampshire.

3.4 Threat Assessment Research

Plant harvest, climate change, forestry operations, acid deposition, development, succession/revegetation, and mining operations were identified as low ranking threats to cliff habitat. More research is needed to determine whether these could become more significant in the future.

Element 4: Conservation Actions

4.1.1 Cultivate Recreational User Stewardship, Education and Outreach

(see also Strategies, Education and Outreach)

(A) Human disturbance

(B) Justification
Existing education and outreach programs have engaged recreational enthusiasts, especially rock-climbers, to support conservation and management designed to protect cliffs from recreational impacts. Stewardship activities will target high-use areas and specific audiences. Adverse human-wildlife interactions are expected to increase as the human population and recreational use of cliffs increases. Thus, stewardship programs need to be cultivated immediately. Stewardship programs can be modified to target new areas, audiences, and user groups.

(C) Conservation Performance Objectives
Eliminate the co-occurrence of adverse recreational impacts in delineated S1-ranked natural communities and rare cliff habitats.

(D) Performance Monitoring
Performance will be evaluated based on implementation of management and stewardship agreements and subsequent decreases in recreational impacts. Stewardship agreements will include recommendations for monitoring.

(E) Ecological Response Objective
Restore S1-ranked natural communities and rare wildlife to delineated cliff habitat areas. Increased native vegetation and wildlife use will indicate a beneficial response.

(F) Response Monitoring
Monitor cliffs for changes in vegetation and wildlife. Stewardship agreements will include recommendations for monitoring.

(G) Implementation
NHFG will delineate high-risk cliffs and cultivate user stewardship or support existing approaches. ASNH has successfully implemented stewardship programs. NHFG will review existing agreements with other agencies and planning entities, including WMNF, USFWS, DRED, SCORP, and ATC, and modify them or provide input to support stewardship. Recommended activities include the following:

- Install signs regarding cliff ecology along access routes and in New Hampshire and Massachusetts climbing shops
- Produce and distribute educational and outreach materials to delineated areas and target audiences
- Recruit stewards and volunteer outreach personnel
- Contribute material to guidebooks
- Develop and train volunteer group to assist with habitat mapping
- Develop a website on climbing and cliffs that is linked to existing rock-climbing websites

(H) Feasibility
Given that implementation will build on current ASNH methods and existing agreements, it is reasonable to expect these objectives can be accomplished.

4.1.2 Advise Land Managers on Mitigation of Recreational Impacts, Regulation and Policy

(see also Strategies, Inter-Agency Regulation and Policy)

(A) Human disturbance

(B) Justification
Restricting use, placement, and width of trails, rock-climbing routes, or other modes of access to sensitive areas will reduce disturbance. Cliff species benefit from efforts to restrict access to sensitive areas. Advisories will be designated for sensitive areas immediately upon entry into management agreements and may be modified based on habitat response indicators.

(C) Conservation Performance Objective
Eliminate recreational impacts on rare cliffs and wildlife. Performance will be assessed based on management agreements, modification of recreational management practices, and adoption of trail advisories.

(D) Performance Monitoring
Advisories will include reporting protocols to docu-

ment the modification of recreational management practices.

(E) Ecological Response Objective
Restore rare natural communities and cliff species to delineated areas. Advisories will include restoration and monitoring recommendations.

(F) Response Monitoring
Vegetative cover, soils, and presence of rare species will be measured prior to the implementation of advisories and in subsequent years. Responses will be used to revise advisories.

(G) Implementation
NHFG will delineate sensitive areas and provide advisories to all managing agencies and organizations to mitigate recreational impacts on cliffs and associated wildlife. Recreational users will be engaged to develop or provide input on advisories. NHFG will participate in the ATC Cooperative Management System. NHFG will help develop, review, and approve the Appalachian Trail Local Management Plan (see Alpine habitat profile for detail). NHFG will review existing agreements with other agencies and planning entities, including WMNF, USFWS, DRED, SCORP, and ATC, and modify them or provide input in accordance with the health of wildlife and wildlife habitats. In particular, NHFG will review or revise its 996 MOU with USFWS and the USFS, and the 1993 MOU with DRED.

(H) Feasibility
Given that implementation will build on current methods and existing agreements (see above), it is reasonable to expect these objectives can be accomplished. Limiting factors may include personnel to enforce climbing regulations and resistance of user groups to new regulations.

4.1.3 Engage in Inter-Agency Risk Assessment for Recreation and Wind Energy Development, Regulation and Policy
(see Strategies, Inter-Agency Regulation and Policy)

4.1.4 Identify High Risk Areas for Recreation and Wind Energy Development, Conservation Planning
(see Strategies, Conservation Planning)

4.1.5 Restrict Access to High Risk Areas, Regulation and Policy
(see Strategies, Inter-Agency Regulation and Policy)

4.1.7 Advise Wind Energy Developers on Best Management Practices for Construction, Regulation and Policy
(see Strategies, Inter-Agency Regulation and Policy)

4.1.8 Prioritize Cliffs for Protection, Land Protection
(see Strategies, Conservation Planning)

4.1.9 Protect Unfragmented Blocks, Land Protection
(see Strategies, Land Protection)

4.2 Conservation Action Research

Develop methods to monitor the response of cliff wildlife and natural communities to recreational pressures.

Element 5: References

5.1 Literature

Cade, T.J. 1960. Ecology of the Peregrine and Gyrfalcon populations in Alaska. University of California Published Zoology 63:151-290.

Camp, R.J., and R.L. Knight. 1998. Effects of rock climbing on cliff plant communities at Joshua Tree National Park, California. Conservation Biology 12:1302-1306.

DeGraaf, R.M., and M. Yamasaki. 2001. New England wildlife: habitat, natural history, and distribution. University Press of New England, Hanover, New Hampshire, USA.

Edinger, G.J., D.J. Evans, S. Gebauer, T.G. Howard, D.M. Hunt, and A.M. Olivero, editors. 2002. Ecological communities of New York State. Second edition. A revised and expanded edition of Carol Reschke's ecological communities of New York State. (Draft for review). New York Natural Heritage Program, New York State Department of Environmental Conservation, Albany, New York, USA.

Kerlinger, P. 2000. Avian mortality at communication towers: a review of recent literature, research,

and methodology. Curry & Kerlinger, L.L.C. Cape May Point, New Jersey, USA. repared for United States Fish and Wildlife Service Office of Migratory Bird Management.

Maschinski, J., R. Frye, and S. Rutman. 1997. Demography and population viability of an endangered plant species before and after protection from trampling. Conservation Biology 11: 990-999.

McMillan, M.A. and D.W. Larson. 2002. Effects of rock climbing on the vegetation of the Niagara Escarpment in southern Ontario, Canada. Conservation Biology 16:389-398.

Pyke, K. 2001. Climbing management: a guide to climbing issues and the production of a climbing management plan. The Access Fund. Boulder, Colorado, USA.

Smith, W. 2001. Rock climbing guide to Rumney New Hampshire. Vertical Brain Publications. Bishop, California, USA.

Sperduto, D.D., and K.F. Crowley. 2001. Overview of natural communities in New Hampshire. New Hampshire Natural Heritage Bureau, Concord, New Hampshire, USA.

Sperduto, D.D., and W.F. Nichols. 2004. Natural communities of New Hampshire. New Hampshire Natural Heritage Bureau, Concord, New Hampshire, USA.

Sykes, J. 2001. Secrets of the Notch: a guide to rock and ice climbing in Franconia Notch State Park and surrounding areas. Huntington Graphics. Burlington, Vermont, USA.

United States Forest Service. 2004. Proposed land and resource management plan, White Mountain National Forest. USDA Forest Service, Eastern Region, Milwaukee, Wisconsin, USA.

Webster, E. 1996. Rock Climbs in the White Mountains of New Hampshire. Third Edition. Mountain Imagery. Eldorado Springs, Colorado, USA.

White, C.M., N.J. Clum, T.J. Cade, and W.G. Hunt. 2002. Peregrine falcon (*Falco peregrinus*). *In* A. Poole and F. Gill, editors. The birds of North America, No 660. The Birds of North America, Inc, Philadelphia, Pennsylvania, USA.

http:// www.towerkill.com accessed January 31, 2005.

5.2 Data Sources

NatureServe. 2004. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.1. NatureServe, Arlington, Virginia. <http://www.natureserve.org/explorer> (Accessed: 15 December 2004).

<http://www.towerkill.com/> Accessed 31 January 2005

Massachusetts Technology Collaborative. 2003. Developed by TrueWind Solutions, LLC under contract to AWS Scientific, Inc as part of a project jointly funded by the Connecticut Clean Energy Fund, Mass. Technology Collaborative, and Northeast Utilities System.

HABITAT PROFILE

Coastal Islands

Associated Species: roseate tern (Sterna dougallii dougallii), common tern (Sterna hirundo), Arctic tern (Sterna paradisaea), black guillemot (Cepphus grylle), purple sandpiper (Calidris maritima)
Global Rank: Not Ranked
State Rank: Not Ranked
Author: Alina J. Pyzikiewicz, Steven G. Fuller, Diane L. De Luca, and John J. Kanter, New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

Off the New Hampshire coast, islands are exposed to and battered by the maritime environment. Natural disturbances such as severe storms affect the rocky intertidal zones by causing mechanical weathering, disrupting succession, and influencing local levels of species diversity (Sousa 1979). Coastal islands have rocky shores, are usually remote, undisturbed, and free of predators (Percy 1997). Coastal islands are vegetated by grasses, herbaceous plants, and shrub thickets that grow among rocky outcrops, and have few to no trees (Nichols 2004). Historical accounts of the Isles of Shoals describe the islands as rocky and barren, and overgrown by grasses, herbaceous plants, and dense shrubs (Borror and Holmes 1990). The rocky intertidal areas are dominated by blue-green algae, lichens (Nichols 2004), and various mollusks and gastropods. The vegetation on mainland islands closely reflects the upland and wetland communities that are typical of the mainland near that island (B. Nichols, NHNHB, personal communication.).

1.2 Justification

Many species of colonial seabirds, water birds, waterfowl, shorebirds, and marine mammals use coastal islands as breeding grounds (DeGraaf and Yamasaki 2001, Kushlan et al. 2002). The Isles of Shoals group serves as a major premigratory staging area and migratory stopover for many Neotropical birds and provides wintering habitat for land birds (Borror and Holmes 1990). Numerous species of invertebrates (amphipod crustaceans, periwinkles, barnacles, mussels) and rockweeds reside in the rocky intertidal areas.

Several of these islands were home to large breeding colonies of terns (*Sterna* sp.), but a loss of habitat and an increase in numbers of herring gull (*Larus argentatus*) and great black-backed gulls (*Larus marinus*) preying on and displacing the terns resulted in their decline (USFWS 1998). Since 1997, Seavey Island has been the site of an intense tern restoration project. Efforts to restore breeding colonies of the federally endangered roseate tern (*Sterna dougallii dougallii*), state endangered common tern (*Sterna hirundo*), and state threatened Arctic tern (*Sterna paradisaea*) have been successful through gull control measures before and during the tern breeding seasons (NHFG 2004). Islands increase the productivity of waters by agitating currents, sediments, and nutrients, and increase the amount of shoreline available for use by plant and animal species (Percy 1997).

1.3 Protection and Regulatory Status

Islands that serve as breeding grounds for federal and state listed species are protected through the Endangered Species Act and the State Endangered Species Act respectively. Marine mammals are protected under the Marine Mammal Protection Act. Islands located in Great Bay National Wildlife Refuge are

protected under the National Wildlife Refuge System, along with the Great Bay National Estuarine Research Reserve (Short 1992). Various laws and agreements exist that protect marine waters such as the Clean Water Act, the MARPOL Act, the Rivers and Harbors Act, Marine Mammal Protection Act, and the Marine Protection, Research, and Sanctuaries Act (Boesch et al. 2001).

1.4 Population and Habitat Distribution

Within the Gulf of Maine watershed, New Hampshire has 40-60 coastal islands that are all located in the southeast corner of the state (USGS 2001). They occur in four main waterbodies: Little Bay, Great Bay, Portsmouth Harbor, and the Atlantic Ocean. Offshore islands include the Isles of Shoals group located roughly 10 miles off the coast of New Hampshire. Mainland islands are scattered throughout Portsmouth harbor, the Piscataqua River and its tributaries, and Little and Great bays in Great Bay National Wildlife Refuge.

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

GRANIT was accessed to identify coastal islands. Very small islands were grouped to their nearest adjacent neighboring island. In total, 96 polygons were grouped into 48 islands,

1.7 Sources of Information

Information on habitat and distribution of coastal islands in New Hampshire was taken from the New Hampshire natural communities guide, scientific literature, conservation plans, field guides, databases, and technical reports.

1.8 Extent and Quality of Data

There is no defined coastal island natural community type in New Hampshire. However, the presence of Shoals Marine Lab has led to extensive research on the Isles of Shoals. Changes in bird species composition and abundance have periodically been documented (Borror and Holmes 1990). Other smaller islands have been surveyed irregularly to determine presence of nesting common terns. An ongoing island ownership debate between New Hampshire and Maine has added to the uncertainty of the number of coastal islands that are under New Hampshire jurisdiction.

1.9 Distribution Research

A formal assessment and classification of New Hampshire coastal island natural communities and intertidal communities is needed.

Element 2: Species/Habitat Condition

2.1 Scale

The 48 islands were clustered into 15 conservation units based on geographic location.

2.2 Relative Health of Populations

The Isles of Shoals have been identified as key habitats for nesting and migrating birds. The islands also serve as haul-outs for harbor and other seal species. Historical habitats for nesting colonial birds include unnamed islands of Back Channel/New Castle, Colony Cove and Hen Island in Little Bay, and Footman and Nannie islands in Great Bay (New Hampshire Audubon Society unpublished data). Little is known about the health of other islands due to their remoteness or small size.

2.3 Population Management Status

N/A

2.4 Relative Quality of Habitat Patches

The 9 islands (4 of which are in New Hampshire) that comprise the Isles of Shoals provide the highest quality of coastal habitat. Nevertheless, large colonies of herring and great black-backed gulls that were established between 1950 and 1970 have reduced habitat values for other species. Gull management on White and Seavey Islands has restored their function as tern nesting areas. The islands in the Portsmouth Harbor and Great Bay have more limited habitat value because of their small size and proximity to the mainland.

2.5 Habitat Patch Protection Status

- The Isles of Shoals have varying degrees of protection. White and Seavey Islands have been under the ownership of the DRED Parks Division as part of Odiorne State Park since 1993 (Appledore Engineering 1999). Seavey Island was deeded to the State of New Hampshire after the White Island Lighthouse was automated in 1987. A Memorandum of Agreement between DRED Parks Division and NHFG exists relative to tern restoration. Seavey Island is managed by NHFG as an endangered species nesting area and is afforded both state and federal protection under endangered species law.
- The Star Island Corporation privately owns Appledore and Star Island, and both are open to the public through various touring companies.
- The Coastal Islands National Wildlife Refuge purchased Duck Island in July 2003. This island will be managed for its wildlife resources, protected as a seabird colony, posted for closure during the breeding season, and evaluated for habitat management and restoration (B. Benedict, USFWS, personal communication).
- Lunging, Malaga, and Cedar Islands are privately owned. There is no protection status at these islands beyond current shoreline and wetland regulations.
- Smuttynose Island is privately owned but was protected in August of 2001 by a conservation easement held by the Coastal Islands National Wildlife Refuge. This conservation easement allows the refuge to manage the site for wildlife resources (B. Benedict, USFWS, personal communication).
- Hen Island is owned by the Town of Newington. Since the early 1990s, the town has worked with NHFG and ASNH to post signs to close the island during the breeding season. The area is used only by town residents, and they have acted as stewards for this colony. The proximity of the island to the mainland leaves the terns vulnerable to predation and the Hen Island tern colony has been disrupted by rats, Canada geese, great horned owl, and human disturbance.
- Islands in Great Bay National Wildlife Refuge have protection under the National Wildlife Refuge System and the Great Bay National Estuarine Research Reserve.
- The protection status of islands in Portsmouth Harbor and Piscataqua Rivers is unknown.

2.6 Habitat Management Status

A management program for Great Bay has been established by the Great Bay National Estuarine Research Reserve, the National Oceanic and Atmospheric Administration, and the Marine Division of the New Hampshire Fish and Game Department, whose goal is to preserve the estuarine resources for research and education. There is no organization for management of Little Bay or Piscataqua River. An MOA between the DRED and NHFG exists relative to tern restoration on White and Seavey Islands. The Marine Fisheries Division of NHFG has authority over management activities of coastal natural resources. Various governmental and nongovernmental programs collaborate (e.g., Gulf of Maine Council on the Marine Environment and Gulf of Maine Seabird Working Group) work to protect and restore coastal island habitats.

2.7 Sources of Information

Habitat maps were examined to identify key habitats. Information on protection and management status was found in management and conservation plans.

2.8 Extent and Quality of Data

Numerous studies have been conducted and published on the flora and fauna of the Isle of Shoals and the surrounding marine environment. Currently, the University of New Hampshire Jackson Estuarine Laboratory conducts long term monitoring of the health of the Great Bay estuary and Portsmouth Harbor. Due to their remoteness or small size, little is known about the relative condition of mainland coastal island habitat.

2.9 Condition Assessment Research

A formal assessment and classification of New Hampshire coastal island natural communities and intertidal communities is needed. Mainland island vegetation and wildlife use needs to be assessed to define priority habitats.

Element 3: Species and Habitat Threat Assessment

3.1.1 Non-Point Source Pollution, Mercury

(A) Exposure Pathway
Moderate forms of atmospheric pollution are widespread among coastal environments. Chemicals in the environment from industrial and municipal discharges, atmospheric deposition, and polluted runoff can accumulate in marine sediments at harmful levels and, accumulate in aquatic plants, invertebrates, fish, and mammals (Beckvar 1996). Accumulation of contaminated sediment in prey species may be transferred to higher trophic levels.

Once mercury is converted to methylmercury, it can be consumed by organisms. Methylmercury can then both accumulate and increase in concentration as it moves up the food chain. Seabirds are at risk for high levels of mercury as they feed relatively high on the ocean's food chain (Evers 2005).

(B) Evidence
The two basic routes of exposure are transport of dissolved contaminants through porous tissue and ingestion of contaminated prey or sediment particles. Metals are easily absorbed into the tissue of aquatic organisms and are not easily eliminated. Mercury has the highest potential of being biomagnified and transferred along the intertidal food chain (Blackmore and Wang 2004, Marsden and Rainbow 2004). Marine mammal tissues have some of the highest concentrations of mercury found in all marine organisms (Beckvar 1996).

Mercury Connections, a report that summarizes the findings of mercury patterns in northeastern North America, identified nine areas where mercury concentrations were significantly elevated in fish and wildlife. These locations were identified as "biological hotspots" where high levels of methylmercury pose an ecological risk (Evers 2005). The lower Merrimack River watershed that borders New Hampshire and Massachusetts was identified: Seavey Island is in close proximity to the outflow of this river. Mercury has been shown to have negative effects on individual seabirds, as well as the overall populations, through changes in reproduction, behavior, and physiology that result in lowered productivity and survival.

3.1.2 Recreation

(A) Exposure Pathway
An increase in recreational activities near or on coastal islands can cause nesting species to abandon nests causing eggs or chicks to become vulnerable to predators, or prevent species from returning to suitable nesting sites. Carelessly walking across islands could result in trampling of vegetation or destruction of bird nests. Pets may destroy nests and frighten nesting birds, resulting in nest abandonment.

The lighthouse renovations scheduled to take place on White Island in 2005 – 2006 will bring many more visitors to White and Seavey Islands. Preservation of the White Island Light Station is being supported, in part, by a grant under the Save America's Treasures program which stipulates that visitation to the island be permitted for a minimum number of days each year. The potential exists for an increased number of island visitors after the renovation is complete.

(B) Evidence
Boaters have been seen dumping garbage into the ocean, which eventually washes up onto island shores. Remains of illegal campfires have been found on White Island, Isles of Shoals, adjacent to the tern colony on Seavey Island. Vandalism on Higgins Beach, Maine resulted in a complete least tern (*Sterna antillarum*) colony failure (Kress and Hall 2004). Offshore boating activities (whale watching, fishing, tour boats) can cause species to be flushed from the islands causing them to use up energy (USFWS 1994). Studies that investigated the effects of recreation and trampling on rocky intertidal zones showed that species occupying these areas are under intense pressure and their populations fluctuate based on the intensity of the disturbance (Keough and Quinn 1998, Aleesa et al. 2003).

Beyond the direct impact that taking terns on the wintering grounds has on the survival of this species,

it is harder to correlate human disturbance with common and roseate tern productivity. Impacts from the intermittent disturbance of recreation and tourism are likely to cause some negative impacts to common tern productivity, but are unlikely to result in permanent disruption to nesting. Human disturbance at the inland colonies in New Hampshire has been known to cause abandonment in the past. Both Hen Island and the Hampton salt marsh colonies suffer negative impacts from human intrusion.

3.1.3 Climate Change

(A) Exposure Pathway
The melting of glacial ice and thermal expansion of ocean water is the main pathway for sea level rise (Gulf of Maine Council Habitat Restoration Subcommittee 2004). Low elevation habitats are important for nesting and loafing for seabirds and marine mammals and will be flooded by rising sea levels or overwashed more frequently by storm surges (Gulf of Maine Council Habitat Restoration Subcommittee 2004). These changes affect habitat availability and the timing of nesting and migration (Kushlan et al. 2002).

(B) Evidence
Sea levels are rising along mainland and island shores due to rising temperatures (Kushlan et al. 2002). Air temperatures are expected to rise 1.4 - 5.8 ° C in the twenty-first century (Church et al. 2001). Along much of the United States coast, the sea level is rising 2.5-3.0 mm/yr, and global warming, resulting from an increase in carbon dioxide and other gasses in the atmosphere, could raise the sea level 15 cm by 2050 and 34 cm by 2100, and increase storm frequency (Titus and Narayanan 1995, Titus 1990). According to Titus (1990), barrier islands respond to a rise in sea level by either washing over landward and remaining intact or breaking up and drowning in place.

3.1.4 Oil Spills

(A) Exposure Pathway
Oil can enter marine waters because of platform construction, drilling, shipping and spillage, and low-level seepage from surface runoff or subsurface sources (Boesch et al. 2001). Species can become coated in oil, resulting in direct mortality or reduced reproductive success, food can become contaminated, toxins can build up in upper trophic feeders, and oil can coat the shores resulting in habitat degradation (Kushlan et al. 2002).
Because coastal rocky shores are exposed to continuous wave action, any oil that is deposited is rapidly removed, however, contaminated waters that wash over tide pools could result in direct mortality of their inhabitants and heavy oil might remain on rocks over the high tide line. Any impacts usually do not last long except where heavy concentrations of light oil come ashore quickly (New Hampshire Estuaries Program and NHDES 2004).

(B) Evidence
The harmful effect of oil on birds has been well documented, both through contamination from chronic oil pollution and from major oil spills (Chardine 1990). Externally, even a small amount of oil contamination can destroy the weatherproofing and insulating properties of the plumage. This in turn can cause hypothermia and inability to fly, stay afloat, and forage. Internally, the ingestion of oil can be equally life threatening. Direct toxic effects on the gastrointestinal tract, pancreas, and liver have all been documented (Pierce 1991). Johnston (1984) has summarized various studies and reports regarding effects of oil spills on marine species and habitats:

- Plants, mollusks, and other invertebrates that are attached to rocks are initially impacted but quickly recover
- Birds suffer the greatest impacts, resulting in rapid death if they are coated in heavy oil and do not receive immediate assistance
- Internal organs are affected through ingestion of oil through preening, and oiled birds transfer oil to eggs causing a reduction in egg permeability and reduced productivity
- Marine mammals are not at great risk when encountering oil since it is usually washed off when diving, but when they come into contact with oil-coated shorelines, serious and possible life-threatening skin irritations occur
- Oil on rocks can last for as long as 8 years, particularly if the coated rock has been dried and warmed by the sun.

During a 1996 spill, the Hen Island tern colony in Little Bay was oiled as the birds were incubating eggs. Perhaps as disruptive was that the island was used to anchor containment booms and serve as point for cleanup activity. In addition to the direct disturbance, data from the New Hampshire Gulfwatch monitoring program documented high levels of polycyclic aromatic hydrocarbons in mussels immediately following the spill followed by a gradual recovery to baseline levels within 2 years (GOMC 2003).

Bird and Ram Islands, which support close to 50% of the northeastern roseate population, were especially affected by a 2003 spill. Ram Island was the most heavily oiled of the affected islands. According to Carolyn Mostello of the Massachusetts Division of Fisheries and Wildlife there were more than 20 birds found dead on Ram Island immediately following the spill and many more birds, including terns, were oiled to varying degrees. To limit further oiling of terns and their eggs, hazing was initiated on Ram to keep the birds off island.

3.1.5 Aquaculture

(A) Exposure Pathway

Marine aquaculture spreads over 26,000 hectares (100 mi^2) of marine waters and accounts for 1/3 of global seafood farming by weight (Goldburg et al. 2001). The production of marine finfish and shellfish has been the fastest growing portion of aquaculture (Goldburg et al. 2001). Aquaculture facilities attract seabirds that take advantage of new food sources. Distressed farmers may result to harassment and legal or illegal killing of these species to protect their stock (Kushlan et al. 2002, Goldburg et al. 2001). Fish can escape and harm wild populations by way of competition, interbreeding, spread diseases and parasites, and cause the displacement or extinction of native populations (Goldburg et al. 2001). Some aquaculture practices use wild fish as feed and can indirectly affect marine environments thousands of miles away (Goldburg et al. 2001). Aquaculture also contributes to nutrient pollution, primarily nitrogen pollution (through uneaten food and waste discharge), which can lead to eutrophication (Boesch et al. 2001, Goldburg et al. 2001).

(B) Evidence

In the southeastern United States, 108,000 waterbirds that feed at aquaculture sites were legally destroyed between 1987 and 1995 and more were probably illegally destroyed, which increases the impact of aquaculture-related mortality (Kushlan et al. 2002, Goldburg et al. 2001). Escapes of native species that are farmed can harm wild populations, especially when genetic differences exist between the farmed and wild populations (Goldburg et al. 2001). In Maine, a storm in 2000 resulted in the escape of 100,000 farmed Atlantic salmon of European origin (Goldburg et al. 2001).

Farmed mollusks, which are grown on the bottoms of bays along the East Coast, are sometimes harvested by dredging that can alter the bottom habitat and reduce biodiversity (Goldburg et al. 2001).

Organic wastes from aquaculture contribute to 80% of nitrogen released into the marine system (Goldburg et al. 2001). One finfish and shellfish aquaculture site in New Hampshire is less than 2 km south of White and Seavey Island. Two oyster aquaculture sites exist near Adams and Durham Points in Little Bay.

3.1.6 Energy and Communication Infrastructure

(A) Exposure Pathway

Three types of impacts to birds that may occur at offshore wind turbine facilities are short term disturbance and displacement during construction, long-term disturbance and displacement resulting from the presence of turbines and other structures, and mortality resulting from collision with moving turbine rotors (Kerlinger and Curry 2002). Waters may be disturbed and sediment released into the water column (Kerlinger and Curry 2002).

(B) Evidence

Few studies exist regarding impacts of offshore wind turbine facilities on birds. In the Netherlands and the United Kingdom, bird fatalities resulting from collision with turbines have been low to moderate (Kerlinger and Curry 2002). Other studies reveal that birds generally avoid sites within 100-200 m of the turbines (Kerlinger and Curry 2002). In some coastal situations, studies have observed water and shorebirds flying around turbines and not foraging beneath them (Kerlinger and Curry 2002). Even though the footprint of the wind turbine structure can take up

a small fraction of the project area, disturbance and displacement of birds has been known to occur (Kerlinger and Curry 2002).

3.2 Sources of Information

Information regarding threats was taken from peer-reviewed scientific studies, field observations, and technical reports from state and federal environmental agencies, and reports from non-governmental environmental organizations. Threats were compiled and ranked internally, and sent out for expert review. Known contamination sources, heliports, staging areas, recreational fishing, marinas, and aquaculture locations were provided by NHDES. Airport locations were provided by NHDOT.

3.3 Extent and Quality of Data

There is a vast amount of data pertaining to predator overpopulation, atmospheric deposition, recreation and tourism, climate change, aquaculture, and oil spills being major threats to marine environments, primarily resulting from scientific research studies and federal environmental agency programs. Little is known about the risks of offshore wind turbines. To date, there are few "best industry practices" for preventing and/or mitigating impacts to birds at wind power facilities (Kerlinger and Curry 2002).

3.4 Threat Assessment Research

- Better linkage of biological response to contaminants with exposure and dose (Luoma 1999) and evaluation of wildlife bioindicators for New Hampshire are priority research topics.
- Intense monitoring and reporting of recreational usage of coastal islands are needed to assess impacts and recreational tour boat effects on coastal island species (Kress and Hall 2004).
- Continue to monitor changes in sea level resulting from changes in air temperature. Study the effects of short and long-term climate change on ocean habitats and species (Kushlan et al. 2002).
- Long-term assessments and biodiversity surveys of coastal islands before and after oil spills to determine effects.
- Develop improvements to aquaculture facilities such as escape-proof pens, non-lethal predator control, and effluent treatment systems (Goldburg et al. 2001).
- Monitor legal/illegal seabird take.
- Studies showing how offshore wind turbines affect birds need to be conducted and should be designed to provide necessary information to assess risk, including flight patterns, frequency of use of the site, and seasonal population sizes (Kerlinger and Curry 2002).

Element 4: Conservation Actions

4.1.1 Advise Interagency Risk Assessment Team on climate change risks to marine wildlife

(see interagency regulation and policy strategy)

(A) Direct threats addressed: Predation and Herbivory, Non-Point Source Pollution (Chemical Contaminants)

(B) Justification
Evidence in the North Sea has shown that the warming of the ocean waters can have a drastic impact on the availability of seabird food resources. In 2004, the majority of the seabird nests along the coast of Scotland produced no chicks. Scientists believe that the shift in phytoplankton to colder waters caused a massive decline in the preferred seabird food. It will be important to collect adequate data in the Gulf of Maine to document changes in water temperature and food availability.

4.1.2 Coordinate with Oil Spill response team to update the oil spill response in proximity to Isles of Shoals including the purchase of survey and hazing equipment. Document habitat quality and food resources prior to spill to serve as baseline for assessing effects of spills.

(A) Direct Threats Affected: Oil spills, Habitat Loss, Predation and Herbivory

(B) Justification
With 99% of the common tern and 100% of the roseate tern population in New Hampshire nesting on Seavey Island it is critical to minimize the impacts

of a catastrophic event such as an oil spill. Through careful planning, the purchase of equipment, and enforcement of safe shipping and operational procedures, an oil spill may be more easily contained.

- Oil spill response planning will allow for more immediate and appropriate response to an oil spill in close proximity to the Seavey Island seabird colony. The purchase of appropriate equipment to contain and clean up an oil spill at this location will improve the chances for minimal impact to the colony.
- Oil spill response planning that is specific to the Isles of Shoals and seabird nesting areas will help to protect the Seavey Island colony.
- Oil spill response planning should be ongoing and year round. Plans should include breeding and non-breeding periods. Purchase of equipment is an immediate need.
- Baseline documentation of the habitat quality and available food resources will be important in assessing the impacts of an oil spill, responding to impacts, and improving the outcome of any future spill response.

(G) Implementation
Implementation of improved oil spill response to the waters surrounding the Isles of Shoals will require the collaboration and cooperation of Tern Restoration Project personnel from NHFG and ASNH with the Oil Spill Response team to ensure that information on tern nesting and habitat usage is incorporated into the plan. Purchase of the proper equipment to deal with an oil spill near Seavey Island will require dedicated funds. Baseline data collection will need coordination and input from all partners.

4.1.3 Coastal Predator Overpopulation Management Plan, Population Management

(see predation and herbivory strategy)

4.1.4 Protect Lunging Island as seabird nesting habitat by approaching landowners with land protection options including conservation easement, conservation tax abatements and incentives, fee acquisition or voluntary agreements, Habitat Protection

(A) Direct Threats Addressed: Habitat Loss

(B) Justification
Lunging Island provided the most important documented historical habitat for terns in New Hampshire. The future protection of this site is important to prevent any further habitat losses and for the expansion of tern nesting habitat at the Isles of Shoals.

4.1.5 Coordinate with the Coastal Islands Refuge in the protection of Duck and Smuttynose Islands as seabird nesting habitat, Habitat Protection

(A) Direct Threats Addressed: Habitat Loss

(B) Justification
Duck and Smuttynose Islands are both protected under the National Wildlife Refuge System as seabird nesting habitat. It is important to coordinate and support protection at these sites.

4.1.6 Endorse Research on Aquaculture Impacts Effluent guidelines, improved state oversight including wastewater discharges, and introduction of new species. Develop voluntary guidelines.

Element 5: References

5.1 Literature

Alessa, L, S. M. Bennett, and A. D. Kliskey. 2003. Effects of knowledge, personal attribution and perception of ecosystem health on depreciative behaviors in the intertidal zone of Pacific Rim National Park and Reserve. Journal of Environmental Management. 68: 207–218.

Appledore Engineering. 1999. Odiorne State Park and White Island master plan. Prepared for the State of New Hampshire, Department of Resources and Economic Development, Division of Parks and Recreation. Concord, New Hampshire, USA.

Beckvar, N., J. Field, S. Salazar, and R. Hoff. 1996. Contaminants in aquatic habitats at hazardous waste sites: mercury. National Oceanic and Atmospheric Administration, Hazardous Materials Response and Assessment Division. Seattle, Washington, USA.

Blackmore, G., and W. X. Wang. 2004. The transfer of cadmium, mercury, methylmercury, and zinc in

an intertidal rocky shore food chain. Journal of Experiemental Marine Biology and Ecology 307: 91-110.

Boesch, D. F., R. H. Burroughs, J. E. Baker, R. P. Mason, C. L. Rowe, and R. L. Siefert. 2001. Marine pollution in the United States: significant accomplishments, future challenges. Pew Oceans Commission, Arlington, Virginia, USA.

Borror, A. C. and D. W. Holmes. 1990. Breeding birds of the Isles of Shoals. Shoals Marine Laboratory, Ithaca, New York, USA.

Chardine, J.W. 1990. Newfoundland: Crossroads for Marine Birds and Shipping in the North Atlantic. Proceedings: The Effects of Oil on Wildlife. Newfoundland.

Church, J.A., J. M. Gregory, P. Huybrechts, M. Kuhn, K. Lambeck, M. T. Nhuan, D. Qin, and P. L. Woodworth. 2001. Changes in sea level. Pages 639-693 *in* Houghton, J. T., Y. Ding, D. J. Griggs, M. Noguer, P. J. van der Linden, X. Dai, K. Maskell, and C. A. Johnson, editors. Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, New York, USA.

DeGraaf, R. M. and M. Yamasaki. 2001. New England wildlife: habitat, natural history, and distribution. University Press of New England, Hanover, New Hampshire, USA.

Drury, W.H. 1973. Population changes in New England seabirds. Bird-Banding 44: 267-313.

Effects of Contaminated Sediments <http://www.epa.gov/aed/html/research/ecs.html> accessed 3 February 2005.

Fish tissue criterion for methylmercury to protect human health. Factsheet 2001 <http://www.epa.gov/waterscience/criteria/methylmercury/factsheet.html> accessed 3 February 2005.

Goldburg, R. J., M. S. Elliott, and R. L. Naylor. 2001. Marine aquaculture in the United States: environmental impacts and policy options. Pew Oceans Commission, Arlington, Virginia, USA.

GOseacoast Guides. 2004. How to visit the Isles of Shoals. <http://seacoastnh.com/Places_%26_Events/Isles_of_Shoals/How_to_Visit_the_Isles_of_Shoals/> accessed 22 February 2005.

Gulf of Maine Council Habitat Restoration Subcommittee. 2004. The Gulf of Maine habitat restoration strategy. Gulf of Maine Council on the Marine Environment.

Johnston, R. 1984. Oil pollution and its management. Pages 1433-1582 *in* O. Kinne, editor. Marine ecology: a comprehensive, integrated treatise on life in oceans and coastal waters. Volume 5, Part 3. John Wiley and Sons, Chichester, New York, USA.

Keough, M. J. and Quinn, G. P. 1998. Effects of periodic disturbances from trampling on rocky intertidal algal beds. Ecological Applications. 8: 141-161.

Kerlinger, P. and R. Curry. 2002. Desktop avian risk assessment for the Long Island power authority offshore wind energy project. Prepared for AWS Scientific, Inc. And Long Island Power Authority.

Kress, S. W. and C. S. Hall. 2004. Tern management handbook: Coastal Northeastern United States and Atlantic Canada. National Audubon Society. Ithaca, New York, USA.

Kushlan, J. A., M. J. Steinkamp, K. C. Parsons, J. Capp, M. Acosta Cruz, M. Coulter, I. Davidson, L. Dickson, N. Edelson, R. Elliot, R. M. Erwin, S. Hatch, S. Kress, R. Milko, S. Miller, K. Mills, R. Paul, R. Phillips, J. E. Saliva, B. Sydeman, J. Trapp, J. Wheeler, and K. Wohl. 2002. Waterbird conservation for the Americas: the North American waterbird conservation plan, Version 1. Waterbird Conservation for the Americas, Washington, DC, USA.

Luoma, S. N. 1996. The developing framework of marine ecotoxicology: pollutants as a variable in marine ecosystems? Journal of Experimental Marine Biology and Ecology. 200: 39-55.

Marsden, I. D. and P. S. Rainbow. 2004. Does the accumulation of trace metals in crustaceans affect their ecology—the amphipod example? Journal of Experimental Marine Biology and Ecology 300: 373-408.

Nedeau, E. and C. Finlayson. 2003. Gulfwatch. Monitoring chemical contaminants in Gulf of Maine coastal waters. Gulf of Maine Council on the Marine Environment.

New Hampshire Fish and Game Department. 2004. Summary of accomplishments achieved ending FY 2004, sea bird restoration: Isles of Shoals tern restoration project. New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

Nichols, B. 2005 Jan 4. Appledore Island survey report [personal e-mail]. Accessed 2005 Jan 5.

Percy, J.A. 1997. Land-based activities and their physical impacts on marine habitats of the Gulf of Maine. Final draft of a working paper prepared for the Global Programme of Action Coalition for the Gulf of Maine and the Secretariat of the Commission for Environmental Cooperation. Montreal, Quebec, Canada.

Pierce, V. 1991. Pathology of Wildlife following a #2 Fuel Oil Spill. The Effects of Oil on Wildlife: Research, Rehabilitation, and General Concerns. IBRRC, TSBR, IWR.

Short, F. T., editor. 1992. The ecology of the Great Bay estuary, New Hampshire and Maine: an estuarine profile and bibliography. Jackson Estuarine Laboratory. University of New Hampshire, Durham, New Hampshire, USA.

Sousa, W. P. 1979. Disturbance in marine intertidal boulder fields: the nonequilibrium maintenance of species diversity. Ecology. 60: 1225-1239.

Titus, J. G. 1990. Greenhouse effect, sea level rise, and barrier islands: case study of long beach island, New Jersey. Coastal Management. 18: 65-90.

Titus, J. G., and V. K. Narayanan. 1995. The probability of sea level rise. U. S. Environmental Protection Agency, Washington, D. C., USA.

United States Fish and Wildlife Service. 1994. Island ethics: Recognizing and protecting colonial nesting seabird and waterbird islands in the Gulf of Maine. Brocheure.

United States Fish and Wildlife Service. 1998. Roseate tern recovery plan - Northeast population, first update. Hadley, Massachusetts, USA.

U. S. Environmental Protection Agency. 2004. The Incidence and Severity of Sediment Contamination in Surface Waters of the United States. United States Environmental Protection Agency, Office of Science and Technology Standards and Health Protection Division. Washington, DC, USA.

5.2 Data Sources

United States Geological Service. 2001. Geographic names information system, query form for the United States and its territories. U.S. Geological Service. Reston, Virginia, USA. <http://geonames.usgs.gov> Accessed 12/29/04.

HABITAT PROFILE

Connecticut River Mainstem Watersheds

Associated Species: Alewife (Alosa pseudoharengus), American Eel (Anguilla rostrata), American Shad (Alosa sapidissima), Atlantic Salmon (Salmo salar), Atlantic Sturgeon (Acipenser oxyrhynchus), Blueback Herring (Alosa aestivalis), Brook Trout (Salvelinus fontinalis), Rainbow Smelt (Osmerus mordax), Sea Lamprey (Petromyzon marinus), Slimy Sculpin (Cottus cognatus), Tessellated Darter (Etheostoma olmstedi)
Federal Listing: Not listed
State Listing: Not listed
Global Rank: Not ranked
State Rank: Not ranked
Authors: New Hampshire Fish and Game and The Nature Conservancy

Element 1: Distribution and Habitat

1.1 Habitat Description

The unifying feature of the Connecticut River watershed group is the Connecticut River mainstem and its smaller tributaries on both sides of the Vermont-New Hampshire border. Bedrock geology is more calcareous in this watershed group than in any other in New Hampshire. Bedrock geology changes dramatically on the Vermont side, becoming even more enriched. This enriched bedrock extends into New Hampshire towns immediately adjacent to the Connecticut River. Despite the potentially distinct geologic difference between New Hampshire and Vermont, the aquatic species moving throughout the Connecticut River and its immediate tributaries are likely to be similar. Large-scale threats and land-use patterns are similar throughout the Connecticut River corridor.

Watersheds in this group have moderate elevations and moderate or gentle hill and side slopes. Every watershed in this group borders or encompasses the mainstem of the Connecticut River, and so there are also low floodplain terraces and wet flat landforms.

The Connecticut River mainstem, tributaries, and small headwater streams provide a wide range of aquatic habitats for both warm and coldwater species. Small coldwater streams that only support brook trout can occur in close proximity to larger, warmer streams. Rivers in this watershed group can have diverse habitats with moderate and slow moving sections and a variety of substrates and vegetation.

Connecticut River fine scale systems: 1, 2
Elevation is the dominant characteristic that splits the Connecticut River watershed group into two distinct systems. Fine scale system 1 is a more northerly, upstream collection of watersheds. It is higher in elevation with slightly more side slope and hilltop landforms. The Connecticut River mainstem meanders through large adjacent floodplains in this region. Fine scale system 2 has slightly more calcareous bedrock, more than any other watershed type in the state, which is mixed with acidic bedrock. In this area, the Connecticut River mainstem is more confined, flowing through deep coarse sediment rather than the deep fine sediment of wetlands and floodplains in fine scale system 1.

1.2 Justification

Like the Merrimack River, the Connecticut River represents one of the few large river habitats in the state or in the region that has the potential to support the full suite of diadromous fish species, such as Atlantic salmon (*Salmo salar*), American eel (*Anguilla rostrata*), river herring (*Alosa pseudoharengus* and *Alosa aestivalis*), American shad (*Alosa sapidissima*), and sea lamprey (*Petromyzon marinus*). Large rivers provide critical and unique habitats for wide-ranging species, and they require representation across wide geographies.

The Connecticut River watershed is the focus of rare species restoration and monitoring. For example, it is one of the few rivers in the world that still supports healthy and reproducing populations of the dwarf wedgemussel (*Alasmidonta heterodon*), a federally endangered species, and the cobblestone tiger beetle (*Cicindela marginipennis*), a state endangered species. The Ashuelot River, a tributary of the Connecticut River, also supports the dwarf wedgemmussel. The Connecticut River has been the subject of rare diadromous fish restoration, focusing on Atlantic salmon.

1.4 Habitat Distribution

Except the Lower Ashuelot River, watersheds in this group include substantial portions of the Connecticut River mainstem. The Ashuelot River watershed extends up through Keene, sharing landform, geology and elevation characteristics. The northernmost extent of this watershed group (approximately in Northumberland) occurs where the Connecticut River becomes less like the mainstem of a large river and more like the headwater tributary to a large river.

1.8 Extent and quality of data

The strongest parameter defining this watershed group is the enriched calcareous geology along the Connecticut River mainstem. The moderate elevation and the combination of landforms were similar to other moderate elevation watershed groups. The watersheds in the southwestern corner of New Hampshire were particularly difficult to assign to a specific watershed group, given their similarity with watersheds in other parts of New Hampshire. Despite these uncertainties, the Connecticut River mainstem unifies this collection of watersheds. The connected geography, the need to consider the Connecticut River mainstem as one system, and the similar human uses and threats all support the definition of this watershed group.

Element 2: Species/Habitat Condition

2.1 Scale

Due to the large land area covered by the major watershed groups (Figure 3), a fine scale classification (Figure 4) was used, when possible, to assess the relative condition of aquatic habitats across the state. The types and sources of information were extremely variable and covered many different scales, and so the following sections refer to both the major and fine scale systems. The actual scale at which the natural conditions and processes lead to differences in aquatic communities is uncertain.

The large river ecosystem of this watershed group is divided into two fine scale systems (Figure 4). Fine scale system 1 includes 5 watersheds of the Connecticut River in central western New Hampshire (from Northumberland to Lebanon). Fine scale system 2 includes 6 watersheds of the Connecticut River in southwestern New Hampshire (from Lebanon to the New Hampshire/Massachusetts border). All watersheds in the Connecticut River watersheds group have similar connectivity and large river ecosystem characteristics.

2.4 Relative Quality of Habitat Patches

Fine scale system 1 encompasses 1078 km^2 (266,308 acres) in New Hampshire. Headwater streams (watershed area <48.28 km^2) are the most dominant stream/river type in this system, comprising 75% of the total stream area. Large rivers (watershed area >2589.99 km^2) comprise 24% and small rivers (watershed area of 77.70-518.00 km^2) comprise 1%. The most dominant elevations are moderate (243.84-518.16 m) and low (6.10-243.84 m) elevations, at 68.2% and 23.2%, respectively.

The Connecticut River Rapids Macrosite is recognized for high concentrations of ecologically significant habitats and rare, threatened, and endangered species at both federal and global levels (Francis and Mulligan 1997). It extends from the confluence of the Connecticut and Ompompanoosuc Rivers (across from Hanover) to Claremont. A section of the macrosite falls within fine scale system 1. The greatest percentages of rare, threatened, and endangered species occur in the Hanover-Lebanon area. Dwarf wedgemussels occur within the macrosite. The area is used by migratory shorebirds, provides summer habitat for bald eagles, and supports Jesup's milk vetch (*Astragalus robbinsii* var. *jesupii)* in its floodplains (Francis and Mulligan 1997).

Fine scale system 2 encompasses 1097 km^2 (271,020 acres). Headwater streams are the most

dominant stream/river type in this system, comprising 86% of the total stream area. Large rivers, medium rivers (watershed area of 518.00-2,589.99 km^2), and small rivers comprise 7%, 4%, and 2%, respectively. Moderate and low elevations dominate the area, at 51.6% and 46.8% of the watershed.

Within fine scale system 2, the Connecticut River offers a mosaic of habitat types for aquatic species. Numerous rapids and riffles provide suitable coldwater fish habitat. The Connecticut River Rapids Macrosite continues from fine scale system 1 downstream to Claremont. Deeper and slower water further downstream provides habitat to warmwater fish species. Confluences of feeder tributaries and the Connecticut River mainstem are important aquatic habitats that provide thermal refuges (Francis and Mulligan 1997).

Areas around the Vernon Dam impoundment and Ashuelot River confluence in Hinsdale provide necessary nesting and wintering habitat for waterfowl, ospreys, and eagles (Francis and Mulligan 1997, Zankel 2004). The Ashuelot River watershed provides suitable habitat for great blue heron (*Ardea herodias*) colonies and rookeries, containing 7.5% of the statewide population. Common loons (*Gavia immer*), blue-gray gnatcatchers (*Polioptila caerulea*), and common nighthawks (*Chordeiles minor*) have been observed nesting and feeding along the Ashuelot River (NHDES 1993).

Throughout the lower and middle sections of the Connecticut River watershed group, lakes and ponds with surface areas less than 4.05 hectares (10 acres) are the most abundant (96% of the total number of lakes and ponds). There are relatively few larger lakes and ponds. For lakes and ponds greater than 4.05 hectares, there is an average density of 1.25 lakes/ponds per 100 km^2 of land. Moore Reservoir (3,490 acres) is the only lake greater than 405 hectares (1,000 acres). Fifty-three percent of lakes and ponds are at elevations of 6.10-243.84 m (20-800 ft) and 46% are at elevations of 243.84-518.16 m (800-1,700 ft).

2.2 Relative Health of Populations

Land Use

Bank erosion from water level fluctuations, boat wakes, and upstream bank stabilization projects have been identified as significant problems, especially in Haverhill. Bank erosion is projected to increase from rising trends in recreation and development (Francis and Mulligan 1997). A survey of 1,300 landowners along the Connecticut River indicates bank erosion as the primary landowner concern (NHDES 1999).

In fine scale system 1, most land within 0.40 km (0.25 mi) of the Connecticut River consists of sparsely settled farms and forests, with 8.4% of total land area classified as agricultural (Francis and Mulligan 1997). There is less fragmentation compared to downstream areas of the Connecticut River. Total land area consists of 79% unfragmented land and 2.9% developed land. The highest densities of development (residential, commercial, and industrial) occur in the Lebanon and Hanover areas (Francis and Mulligan 1997). The estimated population for 2005 is 25,869 people (15 people/km^2). The density of roads (expressed as km of road/ km^2 of total land area) maintained by the New Hampshire Department of Transportation (NHDOT) is 0.66 km/km^2 and the density of private/gravel roads is 0.42 km/km^2.

The northern areas of the Connecticut River in fine scale system 2 are predominately rural and undeveloped. Fine scale system 2 has the highest density of agricultural land in New Hampshire at 8.5% of total land area. Total land area consists of 74% unfragmented land and 4.3% developed land. The estimated population for 2005 is 37,696 people (20 people/km^2). The density of roads maintained by NHDOT is 0.79km/km^2 and the density of private/gravel roads is 0.66km/km^2.

Housing increases for census blocks adjacent to lakes and ponds in the Connecticut River watershed group were estimated using 1990 values and projected 2020 values (see Lake Type Classification for methods). Changes between rural (<0.063 housing units/ha), exurban (0.063 to 0.25 units/ha), and suburban (0.25 to 2.5 units/ha) housing densities could indicate increases in shoreline development, impervious surfaces, and non-point source pollution. Census blocks are expected to change from exurban to suburban around 38 lakes and from rural to exurban around 120 lakes.

Water Quality

Water quality in the Connecticut River watershed has gradually improved over the past few decades. Algal blooms, sedimentation, erosion, and bacterial, point,

and non-point source pollution still occur (Francis and Mulligan 1997). In 1986 and 1987, chromium and PCBs were found in fish tissue in the Connecticut River.

The Connecticut River Management Plan expressed the need for more long-term water quality monitoring data. A 1995 NHDES survey of Moore Reservoir indicates an improvement in water quality. The reservoir was classified as eutrophic by NHDES in 1979 and reclassified as oligotrophic in 1995 (NHDES 1995).

In 2004, levels of dissolved oxygen, pH, specific conductance, temperature, and bacteria were adequate to support aquatic habitats at 24 of 29 sampling stations in the middle and lower Connecticut River. In five sampling stations, there were low pH levels, invasive species (Eurasian milfoil (*Myriophyllum spicatum*)), or high concentrations of metals (aluminum and copper), which render these areas not fully supportive as aquatic habitat (Connecticut River Joint Commission 2004).

A wastewater treatment facility in Lebanon has a combined sewer outflow (CSO) that can be overwhelmed during heavy storms. Two treatment facilities in Vermont (St. Johnsbury and Springfield) have CSOs that may deposit untreated waste into tributaries of the Connecticut River mainstem during storms (Francis and Mulligan 1997).

Surface water quality monitoring of the Ashuelot River was conducted in 2003 as part of the NHDES Volunteer Rivers Assessment Program (VRAP). Dissolved oxygen and turbidity levels met state requirements for class B waters at all sample sites. Increased turbidity levels were observed near urban areas. The range of pH values (pH 5.47-7.36) was below state water quality standards for class B waters (pH 6.50-8.0). Natural environmental conditions (e.g., soils, geology, and wetland drainage) and acid deposition can lower pH values. In some locations, total phosphorus exceeded the NHDES total phosphorus level of concern (>0.05 mg/L). Phosphorus values increased near urban locations (NHDES 2003).

The number of National Pollution Discharge Elimination System (NPDES) permits regulated by NHDES per river kilometer is 0.029 permits/river km for fine scale system 1 and 0.014 permits/river km for fine scale system 2. The number of NPDES permits in fine scale system 1 is relatively high when compared to other systems in New Hampshire.

Invasive Species

There is a high potential for the spread of introduced invasive species in the Connecticut River watershed. The high recreation rate, suitable water chemistry, and close proximity to infected waterbodies (e.g., zebra mussels (*Dreissena polymorpha*) in Lake Champlain) could lead to exotic species infestations (Francis and Mulligan 1997). There are no documented occurrences of exotic aquatic plants in fine scale system 1 (Smagula 2004). In fine scale system 2, there have been 3 infestations of exotic aquatic plants. Eurasian milfoil was detected in the Connecticut River (Charlestown) in 1995. Variable milfoil (*Myriophyllum heterophyllum*) was found in Forest Lake (Winchester) in 1998 and the Ashuelot River (Winchester) in 2000 (Smagula 2004).

Several non-native fish populations have become naturalized in the Connecticut River. Increased water temperatures and enhanced habitat from large impoundments facilitate proliferation of these species. Several of these fish provide sport-fishing opportunities. Largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), walleye (*Stizostedion vitreum vitreum*), black crappie (*Pomoxis nigromaculatus*), northern pike (*Esox lucius*), rock bass (*Ambloplites rupestris*), and rainbow trout (*Oncorhynchus mykiss*) are examples of species that have naturalized populations (Francis and Mulligan 1997, Estuarine and Freshwater Working Group 2005).

To assess the likelihood of recreation or stocking contributing to invasive fish and aquatic plant introductions, the degree of remoteness of lakes and ponds was analyzed using GIS. The results indicate that 92% of lakes and ponds are within 500 m of a trail or road, 5% are enclosed by a protective buffer of 500-805 m without a mapped road or trail, and 3% are enclosed by a protective buffer of 805-1609 m without a mapped road or trail. No lakes or ponds have a buffer greater than 1609 m (1 mile).

Hydrology

There are approximately 111 active dams/impoundments in fine scale system 1 and 214 in fine scale system 2, which vary from large river impoundments for hydroelectricity production to small earthen dams that create wildlife ponds.

There are 0.034 impoundments/river km in fine

scale system 1 and 0.044 impoundments/river km in fine scale system 2. Fifty-three percent of the Connecticut River mainstem in New Hampshire and Vermont is impounded by 14 dams (Francis and Mulligan 1997). Targeted research on the ecological implications of flood control and hydroelectric dams along the Connecticut River mainstem and tributaries showed that altered flow rates affect the characteristics of river bottoms and adjacent floodplains. Impoundments resulted in habitat fragmentation and affected natural aquatic communities (NHDES 1999).

Moore Reservoir in Littleton is New Hampshire's largest undeveloped lake and New England's largest hydroelectric facility. New England Power Company owns the 49.6 km shoreline of this 1,412.35 ha reservoir (NHDES 1995, Francis and Mulligan 1997). Seasonal water level drawdowns of Moore Reservoir and Comerford Reservoir in Monroe vary from 9.14-12.19 m (30-40 ft) (Francis and Mulligan 1997). In both 1979 and 1995, NHDES noted the absence of rooted plants in Moore Reservoir due to water levels fluctuations (NHDES 1995).

2.3 Population Management Status

N/A

2.5 Habitat Patch Protection Status

Conserved land in fine scale system 1 comprises 17.8% of the total land area. Twenty-one percent of unfragmented land is protected through conservation. In fine scale system 2, 13% of the total land area and 16% percent of the unfragmented land is protected through conservation.

The Ashuelot and Connecticut Rivers are designated in the New Hampshire River Management and Protection Program (RMPP)(NHDES 2004). The RMPP regulates dam construction, instream water flow levels, channel modification, water quality, solid waste and hazardous waste storage/treatment facilities, and motorized boating traffic.

2.6 Habitat Management Status

It is difficult to assess the efforts to restore and manage habitats at such a broad level. A database of conservation groups may enhance cooperative efforts and eliminate repetitive or redundant projects.

There are conservation and management plans for the Ammonoosuc, Ashuelot, and Connecticut River watersheds. These plans identify ecologically significant areas and guide human use and management of these areas (Francis and Mulligan 1997, Ammonoosuc Conservation Trust 2004, Zankel 2004). Public outreach and education are identified as useful tools for conserving and restoring these watersheds. These plans provide highly detailed information at localized levels and should be used to help identify sensitive areas, local impacts, and management actions. The Connecticut River Management Plan (1997) is currently under revision.

Several agencies are actively involved in habitat restoration projects and identifying potential areas of habitat enhancement or improvement. Ongoing or recently completed projects include riparian buffer stabilization, stream bank erosion inventories, creating a task force for dam removal, landowner education, NHDES fish biomonitoring, and annual river clean ups. Ongoing habitat restoration focuses on Atlantic salmon, American shad, and blueback herring.

2.7 Sources of Information

A watershed classification based on geological, topographical, climactic, and connectivity attributes, developed by TNC, was used to define scale. Watershed management plans, GIS analyses, and anadromous fish restoration plans were used to identify significant habitats, relative condition, quality, and ongoing management and restoration efforts.

2.8 Extent and Quality of Data

Information on current habitat quality and restoration was highly concentrated on larger rivers. Smaller rivers in this watershed group were not well represented. Information from GIS analyses may not accurately represent all physical features.

2.9 Condition Assessment Research

Increased sampling of aquatic communities and water quality will provide more conclusive, long-term trend data. Additional monitoring would help identify the impacts of water flow alterations (e.g. erosion, changes in dissolved oxygen, and impoundments) on plants, fish, and other aquatic wildlife. Increased sampling of fish tissue throughout these watersheds may recognize

areas affected by contaminants. Habitat assessments, water quality monitoring, and aquatic community data are needed for the headwater streams and small tributaries of this watershed group. The pilot projects initiated by TNC in the Ashuelot River watershed should be expanded to other watersheds in this group to identify and protect additional areas of significant habitat.

Element 3: Species and Habitat Threat Assessment

Existing river management plans and GIS analyses indicate that non-point source pollution (especially sedimentation and stormwater runoff), altered hydrology, and invasive species are the primary threats to habitats in this watershed group.

Refer to the general threats section for Transportation Infrastructure, Development (Fragmentation, General), Non-Point Source Pollution (Runoff and Sedimentation), Acid Deposition, Introduced Species, Altered Hydrology, Recreation, Unsustainable Harvest (Forestry Operations and Management), and Agriculture.

Element 4: Conservation Actions

The Connecticut River Management Plan, The Ashuelot River Management Plan, and the Ammonoosuc Watershed Region Conservation Plan contain strategies for conservation in this area.

Refer to the general threats section for Transportation Infrastructure, Development (Fragmentation, General), Non-Point Source Pollution (Runoff and Sedimentation), Acid Deposition, Introduced Species, Altered Hydrology, Recreation, Unsustainable Harvest (Forestry Operations and Management), and Agriculture.

Element 5: References

5.1 Literature

Ammonoosuc Conservation Trust, Watersheds to Wildlife Inc., UNH Cooperative Extension. 2004. Ammonoosuc Watershed Region Conservation Plan-Draft. Ammonoosuc Conservation Trust. Sugar Hill, New Hampshire, USA.

Connect River Atlantic Salmon Commission. 1998. Strategic Plan for the Restoration of Atlantic Salmon to the Connecticut River. Available http://www.fws.gov/r5crc/documents/strplan.pdf (Accessed March 2005).

Connecticut River Joint Commission webpage. 2004. Connecticut River Water Quality Assessment. Available http://www.crjc.org/pdffiles/WQ2004Results%20table.pdf (Accessed March 2005).

Estuarine and Freshwater Working Group. 2005. State of New Hampshire Comprehensive Management Plan for the Prevention and Control of Aquatic Nuisance Species-Draft. Concord, New Hampshire, USA.

Francis, S., and A. Mulligan. 1997. Connecticut River Corridor Management Plan. Connecticut River Joint Commission. Charlestown, New Hampshire, USA.

New Hampshire Department of Environmental Services webpage 1991. The Connecticut River. Available http://www.des.state.nh.us/Rivers/connect.htm#Intro (Accessed March 2005).

New Hampshire Department of Environmental Services webpage 1993. The Ashuelot River. Available http://www.des.nh.gov/rivers/ashuelot.htm#desc-b-1-b (Accessed March 2005).

New Hampshire Department of Environmental Services. 1995. New Hampshire Lakes and Ponds Inventory. Volume 11. Concord, New Hampshire, USA.

New Hampshire Department of Environmental Services. 1999. New Hampshire Nonpoint Source Management Plan. Concord, New Hampshire, USA.

New Hampshire Department of Environmental Services. 2003. Ashuelot River Water Quality Report. Volunteer River Assessment Program. Concord, New Hampshire, USA.

New Hampshire Department of Environmental Services. 2004. Designated Rivers. Available http://www.des.state.nh.us/Rivers/desigriv.htm (Accessed March 2005).

New Hampshire Fish and Game Department. Freshwater Fishing Guide. 2004. Available http://www.wildlife.state.nh.us/Fishing/Fishing_PDFs/FW_Fishing_Guide.pdf (Accessed April 2005).

Smagula, A. 2004. Report of the New Hampshire Exotic Aquatic Species Program. New Hampshire Department of Environmental Services. Concord,

New Hampshire, USA.

United States Fish and Wildlife Service webpage. Land Protection Plan. Available http://www.fws.gov/r5soc/landprot.htm#38 (Accessed March 2005).

Zankel, M. 2004. A Land Conservation Plan for the Ashuelot River Watershed. The Nature Conservancy. Concord, New Hampshire, USA.

HABITAT PROFILE

Dunes

Associated Species: Piping Plover (Charadrius melodus), semi-palmated plover (Charadrius semipalmatus), Semipalmated Sandpiper (Calidris pusilla), Least Tern (Sterna antillarum), Horned Lark (Eremophila alpestris), "Ipswich" Savannah sparrow (P. s. princeps)
Global Rank: Not ranked
State Rank: Beach grass grassland (S1), Bayberry – beach plum maritime shrubland (S1)
Author: Allison M. Briggaman, New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

Coastal sand dunes are areas of sand and gravel that are deposited by wave and wind action within a marine beach system. Dunal formations include beach berms, frontal dunes, dune ridges, back dunes, and other sand and gravel areas. The coastal sand dune system is characterized primarily by American beach grass (Ammophila breviligulata) in the frontal dunes and by beach plum (Prunus maritime) in the back dunes (Maine Department of Environmental Protection (MDEP) 2004, Sperduto and Nichols 2004).

Coastal sand dunes are typically transverse dunes that form at right angles to prevailing winds (Lutgens and Tarbuck 2000). Waves bring sand to the shore where it is transported by onshore winds. Sand is considered any loose, granular material with grains 0.05 to 2.0 millimeters in diameter. Sand comes from igneous, metamorphic, and sedimentary rock.

Obstacles—such as driftwood, fencing, or vegetation—reduce wind speed and cause sand to accrete. As sand accumulates, plants adapted to the beach environment emerge, stabilizing the surface and promoting further dune formation (Broome 2004). Dune plants are subject to fluctuating environmental conditions that affect their growth, survival, and community structure. The most important factors include temperature, desiccation, low moisture retention, soil erosion, sand accretion, soil salinity, salt spray, changes in organic matter and pH (Maun 1994).

Other types of vegetation that occur in the shifting sands of the frontal dunes and dune ridges include seaside goldenrod (Solidago sempervirens), hair hudsonia (Hudsonia tomentosa var. tomentosa), poverty oat grass (Danthonia spicata), little bluestem (Schizachyrium scoparium), beach pea (Lathyrus japonicus), seabeach pinweed (Lechea martima), jointweed (Polygonella articulata), perennial umbrella-sedge (Cyperus lupulinus), sea-beach needlegrass (Aristida tuberculosa) and Gray's umbrella-sedge (Cyperus grayi) (Dunlop and Crow 1985, Dunlop et al. 1983).

Sandy soils are typically more stable in the back dunes, allowing other types of vegetation to grow, including climbing poison ivy (Toxicodendron radicans), Virginia rose (Rosa virginiana), small sundrops (Oenothera perennis), yarrow (Achillea millefolium) and large climbing false buckwheat (Polygonum scandens) (Dunlop and Crow 1985, Dunlop et al. 1983).

1.2 Justification

Many avian species depend on coastal sand dunes. The state endangered and federally threatened piping plover (*Charadrius melodus*), horned lark (*Eremophila alpestris*), and least tern (*Sterna antillarum*) use coastal sand dunes for breeding while the semi-palmated plover (*Charadrius semipalmatus*), semi-palmated sandpiper (*Calidris pusilla*), sanderling (*Calidris alba*), short-eared owl (*Asio flammeus*), horned lark and Ipswhich/Savannah sparrow (*P. s. princeps*) use

coastal sand dunes for migration. The sanderling, short-eared owl, horned lark, and Ipswhich/Savannah sparrow use coastal sand dunes for wintering (Hunt 2004).

Coastal sand dune systems include sand deposits within a marine beach system that have been artificially covered by structures, lawns, roads, and fill (MDEP 2004). Prior to World War II, more than 90% of the nation's coastal barrier real estate existed as natural areas, largely inaccessible to the public (United States Fish and Wildlife Service (USFWS) 1996). Today coastal sand dunes have been lost to construction of homes, roads, parking lots, jetties, seawalls, and other structures in New Hampshire and along the entire Atlantic coast.

In Maine, historic dune nesting habitat has been reduced over 70% due to development (USFWS 1996). Significant development has also occurred along the New Hampshire coast in recent decades. However, no data are available to quantify the severity of dune habitat loss in the state. Protection of coastal development against strong ocean storms is important because damage from storms can result in billions of dollars of damage. Because they are both natural and economical, coastal sand dune systems provide coastal development with the best protection against storms, wind, waves, erosion, and sea level rise (MDEP 2004).

1.3 Protection and Regulatory Status

Coastal sand dune systems are protected under the Federal Coastal Zone Management Act of 1972 as well as New Hampshire RSA 482-A pertaining to Fill and Dredge in Wetlands. The New Hampshire Department of Environmental Services (NHDES), Watershed Management Bureau, Coastal Program has regulatory authority regarding RSA 482-A and associated administrative rules pertaining to coastal sand dune systems.

Coastal sand dune systems that serve as breeding grounds for federal and state listed species are protected through the Federal Endangered Species Act (1973), and New Hampshire RSA 212-A:6 IV(a) Endangered Species Conservation Act (1979). Coastal sand dune systems that occur in the Hampton Harbor Wildlife Management Area, Hampton Beach State Park and Odiorne State Park are state owned lands open to the public for recreation and protected from development. Local town ordinances and New Hampshire State Parks rules help protect dune habitats by prohibiting such activities as the use of fireworks and campfires and restricting motorized vehicle use on dunes and beaches.

1.4 Population and Habitat Distribution

New Hampshire has 18.57 miles of coastline along the Atlantic Ocean (NHDES 2004), most of which is rocky shore. According to the Coastal Sand Dune Systems map that was created for this process, coastal sand dune systems comprise approximately 1.78 miles of the immediate coastline and occur primarily in Hampton and Seabrook.

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

Polygons representing any of the diagnostic natural communities, as defined by New Hampshire Natural Heritage Bureau (NHNHB), within the coastal sand dune system were selected for this habitat. These communities are beach grass grassland, bayberry–beach plum maritime shrubland, coastal interdunal marsh/swale, and maritime wooded dune. Communities with overlapping polygons were dissolved to form one polygon with the dominant community name. The result was a shape-file of four small polygons along the coast of New Hampshire.

These polygons were then reviewed by New Hampshire Fish and Game (NHFG) personnel and modified to include known and potential occurrence of coastal sand dune systems from survey efforts conducted along the coast. The result was 13 polygons comprised of 7 known coastal dunes locations and 6 potential dune locations.

1.7 Sources of Information

Sources regarding habitat and distribution include NHNHB Natural Communities of New Hampshire, NHFG Nongame and Endangered Wildlife Program, piping plover monitoring data, and personal knowledge

1.8 Extent and Quality of Data

Dune occurrence is well documented by NHFG surveys. The Nongame and Endangered Wildlife Program monitors breeding piping plovers along the seacoast and conducts a census of the entire coast annually. NHNHB has conducted extensive field surveys documenting the occurrence of American beach grass (Sperduto and Nichols 2004).

1.9 Distribution Research

The current distribution of coastal dunes is well documented. Further research should include determining the historic distribution and abundance of coastal sand dunes and the magnitude of habitat lost in recent history (50 years). In addition, areas of potential dune habitat restoration should be identified.

Element 2: Species/Habitat Condition

2.1 Scale

Polygons representing coastal sand dune systems were grouped by geographic location. Those polygons that comprised more than one jurisdiction were split by land ownership. Grouping in this manner resulted in 13 conservation-planning units.

2.2 Relative Health of Populations

The majority of coastal sand dune systems that remain occur along the Atlantic coast in the towns of Hampton and Seabrook (33.0 acres and 117.7 acres respectively). Two smaller areas occupy 9.1 acres in Hampton/Seabrook Harbor and 7.4 acres at Odiorne State Park in Rye.

2.3 Population Management Status

Not addressed for this habitat.

2.4 Relative Quality of Habitat Patches

Seabrook Town Beach hosts the most extensive coastal sand dune systems that remain in the state. Smaller remnants of dunes occur at various locations along the coast including state owned lands in Hampton/Seabrook harbor, at Hampton Beach State Park and Odiorne State Park. All coastal sand dune systems are under severe pressure from human recreation and development.

2.5 Habitat Patch Protection Status

See element 1.3 above.

2.6 Habitat Management Status

In areas where piping plovers are known to occur, habitat is managed to protect nesting areas during the breeding season. Management activities include fencing suitable habitat areas, restricting motorized vehicle use, and coordinating beach management activities such as beach raking and boardwalk maintenance. Habitat management for piping plovers is conducted by NHFG according to USFWS Atlantic Coast Piping Plover Population Revised Recovery Plan guidelines and in cooperation with town officials.

NHFG owns the Hampton Harbor Wildlife Management Area (WMA), which is comprised of 9.13 acres of dunes. No habitat management plan is in place for this WMA, and no active management has occurred at this site.

Dredging of Hampton/Seabrook harbor and the inlet typically takes place annually between November and March. Dredge spoil is dumped on the dunes in Hampton and Seabrook to stabilize dunes and replenish beaches. Mechanical maintenance of coastal sand dune systems is carried out by local towns and New Hampshire State Parks and includes, but is not limited to, bulldozing of dunes, planting vegetation, installation and maintenance of boardwalks and pathways, and mechanical cleaning of the beach.

The town of Seabrook established the Seabrook/Sun Valley Beach Management Committee, a volunteer committee, in 2001. The purpose of the committee is to establish a long-term management plan for the Seabrook town-maintained beach and Sun Valley beach, which falls under the town of Hampton's jurisdiction. This committee has worked with NHDES to obtain funding and has worked with an engineering consultant to develop a management plan for the town beach. The final version of the management plan was completed in June 2004 and includes primary objectives such as, "maintaining control of dune heights and protection of private properties abutting the beach" (Seabrook 2004).

2.7 Sources of Information

Information on management and regulations was obtained from the USFWS Atlantic Coast Piping Plover Population Revised Recovery Plan and from local communities. Geographic Information Systems data-layers were used to identify key habitat areas and determine quality of habitat patches.

2.8 Extent and Quality of Data

Dune occurrence is well documented by NHFG surveys. The Nongame and Endangered Wildlife Program monitors breeding piping plovers along the seacoast and conducts a census of the entire coast annually. The Marine Fisheries Division conducts MRFFS at over 40 recreational fishing sites along the seacoast annually. NHNHB has conducted extensive field surveys documenting the occurrence of American beach grassSperduto and Nichols 2004).

2.9 Condition Assessment Research

A coastal geological survey of the New Hampshire coast is important. The survey should determine the current health and condition of existing dunes, project likely changes to current dunes in future decades, and determine protocol for managing, protecting and improving the health of existing dunes.

Element 3: Species and Habitat Threat Assessment

3.1.1 Recreation (General Disturbance), 4.00, Critical

(A) Exposure Pathway
Sunbathing, swimming, jogging, dog walking, kite flying, volleyball, jet skiing, surfing and fishing are all popular recreational activities in or nearby dune habitats, and the effects of human presence on the dunes are long lasting. Unrestricted access has lead to many unofficial pathways, which have allowed trampling, loss of vegetation, and erosion on the dunes. Increased human presence also deters native species from nesting and/or feeding, can result in trampling of nests and chicks, and can lead to nest abandonment. Additionally, human refuse attracts predators

High recreational use is supported in turn by intensive management including installation and maintenance of boardwalks for human access, mechanical raking to clean beaches, removal of wrack and debris, and public safety operations such as patrol by local police on horseback and in vehicles.

(B) Evidence
During summer 2003, Hampton Beach State Park reported 122,890 visitors (J. Lyones, New Hampshire Department of Resource and Economic Development, personal communication). These numbers are in keeping with the fact that beach visits are the second most popular recreational activity, and visits are likely to rise as population increases (National Survey on Recreation and the Environment 1994, New Hampshire Office of State Planning 2003).

Recreational management activities affect the dune ecosystem by altering the natural processes of dune formation, increasing erosion, trampling and killing native plant and animal species, and altering species' natural behaviors.

The piping plover, which breeds among sandy dunes and beaches along the Atlantic coast, is a state endangered and federally threatened species. The decline of piping plovers beginning in the 1940s has been attributed primarily to habitat loss and disturbance by humans and their pets (USFWS 1996).

3.1.2 Development (Habitat Loss and Conversion)

(A) Exposure Pathway
The natural shifting of sand from wind and wave action can have negative impacts on property value and industry along the coast. Hampton/Seabrook harbor and the inlet are dredged annually for navigation. Dredge spoil is dumped on the dunes in both Hampton and Seabrook to stabilize dunes and replenish beaches.

Increased shoreline development raised property owner concern regarding beach and dune stabilization. Dune stabilization efforts include planting American beach grass, bulldozing, and snow fencing. Shoreline modification efforts include seawall and jetty construction. Stabilization and modification interrupt natural dune succession, disturb native natural communities, and limit reestablishment.

(B) Evidence
Man-made structures along the shoreline, or manipulation of natural inlets, disrupt the natural forces necessary for beach and dune creation and renewal and can result in habitat loss or degradation (Melvin et al. 1991). Artificial barriers block the natural flow of sand and sediment, preventing the formation and maintenance of dunes. In addition, beach ecosystems are threatened by the removal of wrack, which provides nutrients and beach stability (Gulf of Maine Council Habitat Restoration Subcommittee 2004). Dredging of inlets can affect spit formation adjacent to inlets, and jetties can cause widening of islands as well as growth of vegetation on inlet shores (USFWS 1996).

3.2 Sources of Information

Information regarding dune threats was compiled from expert review and consultation, literature review, fact sheets and the Internet.

3.3 Extent and Quality of Data

Recreational uses and their impacts on coastal sand dune systems as well as the effects of shoreline stabilization on coastlines are well documented.

3.4 Threat Assessment Research

Additional research is needed to determine the impact of shoreline stabilization efforts, including dredging, beach replenishment, jetties, seawalls, mechanical manipulation of dunes, and the establishment and removal of vegetation on New Hampshire coastal dunes.

Element 4: Conservation Actions

4.1.1 Create and maintain official, designated pathways for access to and from beaches

(A) Direct threats include: human disturbance, recreational management and shoreline/dune modification.

(B) Justification

- Directing foot traffic along designated pathways for access to and from beaches will reduce the number of paths over dunes and will reduce trampling and loss of vegetation.
- Official paths should be installed and maintained at all main beach access points as well as at designated areas along the length of the beach.
- Some official paths and boardwalks are in place and maintained. Spacing of these walkways should be evaluated to determine where additional paths and boardwalks are needed and will be most effective.
- Placement of new walkways should be a decision made by representatives from the local communities as well as by town, state, and federal officials.

(C) Conservation Performance Objective
The objective of creating and maintaining official designated walkways is to direct all human access to and from beaches along designated paths to reduce trampling and loss of vegetation on dunes and prevent erosion.

(D) Performance Monitoring
Monitoring should be performed daily during the summer months when recreational use of beaches is at its peak. Monitoring should include observing the number of people using official walkways, observing other locations where people are using the beach, recording the number of people using these other areas, and noting the distance from these areas to official designated access points.

(E) Ecological Response Objective
The goal of installing and maintaining designated official walkways is to reduce human foot traffic over dunes and to allow natural dune formation and growth as well as succession of dune vegetation. Successful protection of existing dunes will be indicated by the natural succession of distinct natural communities in the frontal dune and back dune areas.

(F) Response Monitoring
Response monitoring should include vegetation sampling and monitoring at predetermined areas throughout the dunes. Response monitoring should note the types and density of vegetation occurring. Over time, a reduction in the amount of open space and an increase in the amount of vegetation should be observed. In addition, long term response monitoring should show a change in vegetative structure,

especially in the back dunes where a variety of shrub species should become established.

(G) Implementation
A cooperative agreement should be established between NHFG, United States Fish and Wildlife Service (USFWS), the NHDES, and local town officials to determine the most appropriate locations, maintenance techniques, and monitoring protocol for official pathways.

(H) Feasibility
Local town public works departments and DRED have the expertise to install and maintain paths and boardwalks. NHFG and the NHDES have the expertise to carry out monitoring.

4.1.2 Improve enforcement of existing laws and regulations, Regulation and Policy.

(A) Direct threats include: human disturbance, recreational management, and shoreline/dune modification.

(B) Justification

- Improving enforcement of existing laws and regulations will help to reduce the number of unofficial paths leading from private residences over the dunes and thus reduce trampling and loss of vegetation and erosion. It will also help promote natural dune succession. Improving existing laws and regulations will help to ensure that dredgers follow permit requirements.
- Improving enforcement of existing laws and regulations will promote natural dune formation and growth as well as the establishment and succession of natural dune vegetative communities.
- Improving enforcement of existing laws and regulations should be targeted to all existing dune areas and any restored areas.
- Improving enforcement of existing laws and regulations is needed immediately and should be a continuous year-round effort. Enforcement efforts should be increased during the summer months when recreational use of beaches and dunes is most intense.
- Enforcement efforts can be adjusted depending on public response and the results of performance and response monitoring efforts.

(C) Conservation Performance Objective
The objective of improving enforcement of existing laws and regulations is to reduce the number of unofficial paths leading from private residences over the dunes, reduce trampling and loss of vegetation, reduce erosion, and promote natural dune growth and formation and vegetative succession. Improving existing laws and regulations will also help to ensure that dredgers follow permit requirements.

(D) Performance Monitoring
Performance monitoring will be entailed by the increased efforts of town, state and federal officials to identify strategies to improve enforcement of existing laws and regulations and to ensure dredgers follow permit requirements.

(E) Ecological Response Objective
The desired ecological response to improving enforcement of existing laws and regulations is natural dune growth and formation and the succession of dune vegetative communities.

(F) Response Monitoring
Response monitoring will be entailed by the cooperation of town officials and state agencies to identify and implement strategies for increased enforcement of existing laws and regulations.

(G) Implementation
NHFG and NHDES should work with towns to identify strategies for increasing enforcement of existing laws and regulations. Funding sources need to be identified to support additional law enforcement staff at both the town and state levels.

(H) Feasibility
Local towns and NHFG have the expertise to carry out enforcement of existing laws and regulations. However, both town and state law enforcement are constrained by limited staff and funding.

4.1.3 Create and implement a comprehensive education and outreach plan for residents, day visitors, community and town officials, Education and Outreach.

(A) Direct threats include human disturbance, recreational management, and shoreline/dune modification
(B) Justification

- Implementing a comprehensive education and outreach plan will help to raise awareness and garner support for protecting and maintaining New Hampshire's remaining dunes.
- Raising public awareness will help to protect dunes from human disturbance and thus allow for natural dune formation and growth as well as vegetative succession.
- Education and outreach should be targeted both at beach users and local decision makers as well as at local conservation commissions and public schools.
- An education and outreach plan should be created to raise awareness and garner local support for protecting and reducing further losses and degradation of dunes. Education and outreach efforts should increase during the summer months when recreational use is at its peak.
- Education and outreach efforts can be conducted in a variety of ways depending on the audience, the time of year, and can be adjusted based on feedback received from outreach efforts.

(C) Conservation Performance Objective
The objective of creating a comprehensive education and outreach plan is to increase community support and involvement in the protection and management of this unique habitat. Such a plan would raise awareness by providing information about dune ecosystems, as well as by emphasizing the benefits of healthy dunes to humans and their property.

(D) Performance Monitoring
The performance of education and outreach efforts will be determined by the number of people interested in participating in presentations and other outreach efforts.

(E) Ecological Response Objective
The desired ecological response to creating an education and outreach plan is natural dune formation and growth, which will natural vegetative succession of existing dunes and potential dune restoration areas.

(F) Response Monitoring
Response monitoring will be done by observing increased involvement in the protection and management of dune habitats as well as by observing a decrease in human uses that harm dune habitats.

(G) Implementation

- Create and install educational displays at all main beach entrances
- Give informative presentations to town officials, local conservation commissions, community groups involved in beach management, local police departments and state parks personnel
- Give mini-presentations to day visitors at beaches that include guided walks and information about dune ecosystems
- Create and distribute an informational mailing to all residents who live along beaches/dunes
- Create an educational program to be used in local schools and encourage student involvement in beach management

(H) Feasibility
NHFG has limited funding and staff. Funding sources should be identified, and additional staff should be acquired to develop an education and outreach plan for dune habitats and the piping plover.

4.1.4 Identify and carry out habitat restoration in most suitable areas, Restoration and Management, Habitat Protection.

(A) Direct threats affected include: shoreline/dune modification

(B) Justification:

- Dune restoration along the coast will help to stabilize the New Hampshire shoreline and protect property in a natural and cost effective manner
- Development pressure along the coast is severe and continues rapidly. Work should

begin immediately to identify potential dune restoration sites and to determine the appropriate interventions.

- Dune restoration efforts will take place at those sites determined by a feasibility study to be most suitable.

Conservation Performance Objective
The objective of dune habitat restoration is to restore areas of historical dune occurrence and to increase the amount of dune habitat in the state.

(D) Performance Monitoring
Performance will be measured by the success of restoration efforts in protecting and repairing dune ecosystems

(E) Ecological Response Objective
The desired ecological response to dune habitat restoration is an increase in the amount of healthy dune habitat in the state.

(F) Response Monitoring
Successful dune restoration will be indicated by an increase in the amount of dune habitat in the state.

(G) Implementation
A feasibility study needs to be conducted to determine historical occurrences of dune habitats, ascertain which areas are most suitable for habitat restoration and identify steps necessary to begin restoration.

(H) Feasibility
Funding for a feasibility study and restoration efforts should be pursued by NHFG, NHDES, DRED, and the Parks Division

4.1.5 Require dredge applicants to consult with NHFG Nongame and Endangered Wildlife Program, regarding disposal and placement of dredge material, Regulation and Policy.

(A) Direct threats include: recreational management and shoreline/dune modification.

(B) Justification

- Requiring dredge and fill applicants to consult with NHFG Nongame and Endangered Wildlife Program will help to ensure that existing dune habitat is not degraded and may potentially help to restore dune habitat in historical areas.
- Reviewing dredge and fill permits will help to determine where dredge material should be placed and will promote natural shoreline stabilization and reduce the risk of destroying dune habitat. Only dredge and fill permits pertaining to Hampton/Seabrook harbor and the immediate coast should be reviewed. Dredge and fill permits should be reviewed year round, as necessary. Dredge operations should continue to be conducted only between November and March.
- Reviewing dredge applications and advising on the placement of dredge material may help to maintain existing dune habitat and restore historical dunes.

(C) Conservation Performance Objective
Reviewing dredge applications will provide input on the disposal and placement of dredge material in an effort to promote natural shoreline stabilization, minimize degradation of existing dunes, and conduct habitat restoration.

(D) Performance Monitoring
Performance will be evident by the inclusion of NHFG Nongame and Endangered Wildlife Program in all dredge applications pertaining to Hampton/Seabrook harbor and the adjacent coast.

(E) Ecological Response Objective
The objective is to promote natural shoreline stabilization, minimize degradation of existing dunes and conduct habitat restoration.

(F) Response Monitoring
Success of dredge application review will be evident in the success of natural shoreline stabilization, natural dune formation and growth, and the successful restoration of dunes in identified areas.

(G) Implementation
NHFG, Nongame and Endangered Wildlife Program has the authority to review dredge applications and provide advisement on the disposal and placement of dredge material. The USFWS has the authority

to change wording in dredge applications to require applicants to consult with NHFG Nongame and Endangered Wildlife Program during planning.
(H) Feasibility
Given the authority of the NHFG and USFWS, it is highly feasible to revise the wording on dredge permit applications.

4.1.6 Coordinate recreational management activities on beaches and dunes, including boardwalk installation and maintenance, beach raking and motorized vehicle use, Habitat Protection.

(A) Direct threats include: recreational management and shoreline/dune modification.

(B) Justification (some justifications sound like recommendations)
Coordinating recreational management activities and managing motorized vehicle use will help to minimize degradation and erosion of dunes. Recreational management activities and motorized vehicle use should be coordinated in areas where dune habitat occurs. Recreational management activities and motorized vehicle use should be coordinated year round to protect dune habitats. Efforts should be increased during the summer months when use of beaches and dunes is at a peak. Coordination of recreational management can be flexible so that town, state and federal groups can work in successful partnerships.

(C) Conservation Performance Objective
The objective of coordinating recreational management activities on beaches and dunes, including boardwalk installation and maintenance, beach raking and motorized vehicle use is to protect dune habitats, promote dune formation, promote natural succession of dune vegetative communities.

(D) Performance Monitoring
Performance monitoring should include monitoring beach management activities and motorized vehicle use on dunes and beaches.

(E) Ecological Response Objective
The desired ecological response of coordinating recreational management activities on beaches and dunes is to promote natural dune growth, promote natural succession of dune vegetative communities, reduce erosion, and minimize harm to dunes from human activities.
(F) Response Monitoring
Successful coordination of recreational management activities on beaches and dunes including boardwalk installation/maintenance, beach raking and motorized vehicle use will be evident in the minimum use of motorized vehicles on beaches/dunes and the effectiveness recreational management activities with minimal impact to dunes.

(G) Implementation
Collaborative between members from the following groups should be established: NHFG, NHDES, DRED, local town officials, local police and emergency respondents and local conservation commissions. This coalition should meet regularly to discuss recreational management activities and motorized vehicle use on beaches and dunes and should work to effectively carry out efforts with minimum impact to dunes.

(H) Feasibility
NHFG Nongame and Endangered Wildlife Program has experience in coordinating recreational management activities and managing motorized vehicle use on beaches and dunes where the state endangered and federally threatened piping plover occurs. However, NHFG is limited in its ability to fund and staff these efforts year round. Funding is needed to support additional personnel who can adequately coordinate recreational management activities and motorized vehicle use on New Hampshire beaches and dunes.

4.2 Conservation Action Research

Significant habitat loss due to development has already occurred along the New Hampshire seacoast, and development pressure continues. All potential sites for dune habitat restoration should be studied for restoration feasibility.

Element 5: References

5.1 Literature

Broome, S.W. 2004. Restoration and Management

of Coastal Dune Vegetation. North Carolina State University. <http://www.soil.ncsu.edu/lockers/Broome_S/pdf/ram.pdf>. Accessed 29 October 2004.

Dunlop, D.A., G.E. Crow, and T.J. Bertrand. 1983. Coastal Endangered Plant Inventory: A Report on the Seabrook Dunes, Its Vegetation and Flora. Report prepared for the NH Office of State and Energy Planning by the Department of Botany and Plant Pathology and NH Agricultural Experiment Station, University of New Hampshire, Durham, NH.

Dunlop, D.A., and G.E. Crow. 1985. The vegetation and flora of the Seabrook Dunes with special reference to rare plants. *Rhodora* 87: 471-486.

Gulf of Maine Council Habitat Restoration Subcommittee. 2004. The Gulf of Maine Habitat Restoration Strategy. Gulf of Maine Council on the Marine Environment.

Hunt, P. 2004. A Regional Perspective on New Hampshire's Birds of Conservation Priority:

Objectives, Threats, Research Needs, and Conservation Strategies DRAFT. Audubon Society of New Hampshire.

Lutgens, F.K. and E. J. Tarbuck. 2000. Essentials of Geology. Prentice Hall, Inc. Upper Saddle River, New Jersey, USA.

Maine Department of Environmental Protection. 2004. Land & Water Quality, Special Topics, Coastal Sand Dune Systems page. <http://www.maine.gov/dep/blwq/topic/dunes/>. Accessed 29 October 2004.

Maun, M.A. 1994. Adaptations enhancing survival and establishment of seedlings on coastal dune systems. Vegetatio 111: 59-70.

Melvin, S.M., C.R. Griffin, and L.H. MacIvor. 1991. Recovery strategies for piping plovers in managed coastal landscapes. Coastal Management 19: 21-34.

Michigan State University. 2004. Geography of Michigan and the Great Lakes Region, Sand Dunes page. <http://www.geo.msu.edu/geo333/dunes.html>. Accessed 9 February 2005.

National Survey on Recreation and the Environment: 1994. The Interagency National Survey Consortium, Coordinated by the USDA Forest Service, Recreation, Wilderness, and Demographics Trends Research Group, Athens, GA and the Human Dimensions Research Laboratory, University of Tennessee, Knoxville, TN.

New Hampshire Department of Environmental Services (NHDES). 2004. Watershed Management Bureau, Coastal Management Program, New Hampshire Tidal Shoreline Mileages By Waterbody page. <http://www.des.state.nh.us/coastal/pdf/tidal_shoreline.pdf>. Accessed 11 January 2005.

New Hampshire Office of State Planning. 2003. Department of Resources and Economic Development. New Hampshire Outdoors, Statewide Comprehensive Outdoor Recreation Plan, 2003-2007. Concord, New Hampshire, USA.

Seabrook Town Report. 2004. <http://www.seabrooknh.org/Alerts_Postings/Town%20Report%202004.pdf>. Accessed 5 April 2005.

Sperduto, D.D. and W.F. Nichols. 2004. Natural Communities Of New Hampshire. New Hampshire Natural Heritage Bureau, Concord, New Hampshire. Pub. UNH Cooperative Extension, Durham, New Hampshire, USA.

United States Fish and Wildlife Service (USFWS). 1996. Piping Plover (*Chardrius melodus*), Atlantic Coast Population, Revised Recovery Plan. Hadley, Massachusetts, USA.

HABITAT PROFILE

Floodplain Forests

Associated Species: Jefferson Salamander, northern leopard frog, Wood Turtle, Red Shouldered Hawk, Cerulean Warbler, Eastern Red Bat, Silver Haired Bat

Federal Listing: Not listed
State Listing: Not listed
Global Rank: Not ranked
State Rank: Alder alluvial shrubland (S3), Alder – dogwood – arrowwood alluvial thicket (S4), Alluvial mixed shrub thicket (S4), Aquatic bed (S4S5), Balsam fir floodplain/silt plain (S2), Basswood – white ash – black maple floodplain forest (S1), Blue-joint – goldenrod – virgin's bower riverbank/floodplain (S3S4), Herbaceous riverbank/floodplain (S2S4), Herbaceous/wooded riverbank/floodplain (S4), Meadowsweet alluvial thicket (S3?), Oxbow buttonbush swamp (S3), Oxbow marsh (S3), Red maple floodplain forest (S2S3), Riverbank/floodplain fern glade (SU), Silver maple – false nettle – sensitive fern floodplain forest (S2), Sugar maple – ironwood – short husk floodplain forest (S1), Sugar maple – silver maple – white ash floodplain forest (S1S2), Swamp white oak floodplain forest (S1), Sycamore floodplain forest (S1)
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Element 1: Distribution and Habitat

1.1 Habitat Description

Floodplains occur in river valleys adjacent to river channels and are prone to periodic flooding. Floodplains are often comprised of forests, oxbows, meadows, and thickets. The habitats, vegetation, and hydrologic regime of floodplains are strongly influenced by watershed size, gradient, and channel morphometry. Most open or partially wooded floodplain communities occur on low floodplains. Sloughs, oxbows, vernal pools, and other depressions in the floodplain tend to be inundated for longer periods than low floodplains (Sperduto 2004). Floodplain soils range from well-drained coarse sand on levees to poorly drained silts and mucks in depressions, and tend to be moderately to strongly minerotrophic (Sperduto 2004).

Montane/near-boreal floodplains are found primarily along rivers in the White Mountains or northern New Hampshire, and have relatively high gradients and flashy flood regimes compared to other floodplain systems. Sugar maple and balsam fir are dominant trees, and riparian wetlands such as oxbows and sloughs are uncommon in these high-gradient floodplains.

M*ajor river silver maple floodplains* occur primarily along the Connecticut and Merrimack Rivers, and occasionally on lower reaches of major tributaries. These floodplains are often interspersed with oxbow marshes and shrub communities. The forested areas are characterized by a canopy of silver maple (*Acer saccharinum*) over a lush herbaceous layer, with a sparse shrub layer.

Temperate minor river floodplains are found along large streams and small rivers in central and southern New Hampshire. These ecosystems are usually comprised of a mosaic of red maple forests, oxbows, vernal pools, and shrub thickets. Minor river floodplains generally have reduced flood intensity and duration compared to large river floodplains. In addition to red maple, sycamore and swamp white oak floodplain forests occur less commonly (Sperduto and Nichols 2004).

1.2 Justification

Riparian forests support diverse natural communities, protect and enhance water quality (they filter and sequester pollution), and control erosion and sediment (NHOSP 1989, Welsch 1991, Dahl 2000). Tockner and Stanford (2002) estimate that in Europe and North America, up to 90% of flood plains are under cultivation and are functionally extinct.

Riparian forests support a variety of wildlife resources. They provide breeding habitat for a number of bird species, including the red-shouldered hawk (*Buteo lineatus*), veery (*Catharus fuscescens*), cerulean warbler (*Dendroica cerulea*), American redstart (*Setophaga ruticilla*), warbling vireo (*Vireo gilvus*), Baltimore oriole (*Icterus galbula*), and chestnut-sided warbler (*Dendroica pensylvanica*) (Foss et al. 2000a, Hunt 2005). They also provide habitat for migratory and upland breeding birds (Foss et al. 2000b). Mammals associated with rivers and streams, particularly beaver (*Castor canadensis*), mink (*Mustela vison*), and river otter (*Lutra canadensis*), rely on riparian forests. Floodplain wetlands, such as vernal pools and oxbow marshes, are important breeding areas for a number of amphibians, including Jefferson salamander (*Ambystoma jeffersonianum*) and northern leopard frog (*Rana pipiens*). These wetlands also provide habitat for reptiles, such as wood turtle (*Glyptemys insculpta*), Blanding's turtle (*Emydoidea blandingi*), and spotted turtle (*Clemmys guttata*).

1.3 Protection and Regulatory Status

- Any laws that deal with regulation of freshwater wetlands would apply in portions of the floodplain considered jurisdictional wetlands (RSA 482-A).
- FEMA administers the National Flood Insurance Program, which works with local jurisdictions to regulate development in floodplains, with the primary purpose of minimizing future flood damage (FEMA 2005).
- The Shoreland Protection Act (NHDES, RSA 483-B) requires that farmers follow BMPs as established by the New Hampshire Department of Agriculture. Most of these BMPs pertain to the storage and/or application of fertilizers and pesticides near waterways for maintaining water quality and do not address floodplain habitats. The Shoreland Protection Act also limits the amount of tree removal and other activities within 250 ft of rivers and requires a primary structure setback of at least 50 ft.

1.4 Population and Habitat Distribution

Floodplain forests are found along rivers throughout New Hampshire. The *montane/near-boreal floodplain system* is found primarily in the White Mountains and North Country, although there are some examples in the Sebago-Ossipee region and along the Pemigewasset River south of the White Mountains. M*ajor river silver maple floodplains* are found along the main stems of large rivers, such as the Merrimack, Connecticut, Pemigewasset, and Androscoggin Rivers, and the lower stretches of major tributaries. *Temperate minor river floodplains* occur on rivers and large streams throughout central and southern New Hampshire (Sperduto 2004).

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

The majority of floodplain forest element occurrences (NHNHB 2005) encompassed an elevation range of up to 21 feet up the bank away from the river. Thus, all areas within 21 feet of elevation change of a river were mapped, using the most recent state plane grid derived from the digital elevation model (Complex Systems Research Center 1999). Resulting polygons that extended into lakes, the ocean, or unreasonably far from the river were clipped to extend no more than 500m from a river, or 1000m from a river if they also were within 250m of a tributary stream. This resulted in a base floodplain layer. Areas within this floodplain layer that were dominated by forest cover (Complex Systems Research Center 2001) were selected. In addition, floodplain wetlands that were adjacent to a selected forest polygon were also selected. The resulting polygons were merged, creating the floodplain forest layer.

All polygons within 1 km of major rivers (USEPA 1998) were classed as *major river silver maple floodplain systems* (Sperduto 2004). Polygons that did not

fall into this system classification, and which occurred within the 4 northern ecoregion subsections (Connecticut Lakes, Mahoosic-Rangeley, Vermont Piedmont, and White Mountains), and which overlapped coniferous or mixed forest (from the New Hampshire Landcover Assessment 2001) were classed as *montane/near-boreal floodplain systems*. *Montane/near-boreal floodplain systems* often have both a deciduous and coniferous component (Sperduto 2004), so in addition, any non-coniferous floodplain polygons within 1 km of the same river segment as the coniferous floodplain polygons were also classed as *montane/near-boreal floodplain system*. All of the floodplain polygons not falling into one of these 2 systems were assigned to the third system, the *temperate minor river floodplain*. Mapped floodplain forest polygons (see element 1.6) were grouped into complexes of polygons within 500m of each other, and attributes characterizing habitat quality and quantity were assigned using available GIS data layers.

Data limitations: Errors in the elevation data could create some error in the base floodplain layer. In most cases, this creates an over prediction of habitat rather than an under prediction. Potential inaccuracy in landcover classification would also cause some errors in the data. Because of the limitations of the modeling process, some floodplain polygons have been assigned to systems incorrectly. As a result, a single floodplain complex may contain polygons from different systems. Despite some polygons being incorrectly attributed, the predicted area of floodplain forest systems can provide an informative picture of floodplain habitat in the state.

1.7 Sources of Information

NHNHB publications, State and Federal Agency web sites, NatureServe website, textbooks, and peer-reviewed literature.

1.8 Extent and Quality of Data

See section 1.6

1.9 Distribution Research

Surveys should verify predicted floodplain forests, particularly for rare communities within the temperate minor river floodplain system, such as basswood–white ash–black maple floodplain forest (S1), swamp white oak floodplain forest (S1), and Sycamore floodplain forest (S1). Rare wildlife should be incorporated into habitat-based inventories.

Element 2: Species/Habitat Condition

2.1 Scale

Mapped floodplain forest polygons were assessed within 10 digit watershed units (HUC-10).

2.2 Relative Health of Populations

The average area of floodplain forest in a watershed was 633 ha ± 565 SD and varied from 23 to 2792 ha. The *temperate minor river floodplain* system comprised approximately half of all mapped floodplain hectares in the state. The remaining floodplain polygons were divided roughly evenly between the *major river silver maple floodplain* and the *montane/near-boreal floodplain*. This imbalance is due in part to the number of small rivers in southern New Hampshire, and in part to the amount of *major river silver maple floodplain* that has been converted to agriculture. The greatest area for the *montane/near-boreal floodplain* was in the Upper Ammonoosuc River drainage, while the Middle Androscoggin River watershed had the largest amount of *major river silver maple floodplain*. Both of these watersheds are in northern New Hampshire. The largest area of *temperate minor river floodplain* was in the Lamprey River watershed, in the seacoast region.

2.3 Population Management Status

Otter, mink, other furbearers, and waterfowl, are managed by NHFG.

2.4 Relative Quality of Habitat Patches

A number of habitat quality attributes were computed through GIS for the mapped floodplain forest polygons, but because of the number of polygons and attributes, they will not be described here. Also, a number of exemplary floodplain forest natural communities have been identified across the state. Many floodplain forests near developed areas (e.g., much of the Merrimack River floodplain) have been invaded

by exotic plants (see element 3.3.3- Invasive Species) or are fragmented by roads or agriculture.

2.5 Habitat Patch Protection Status

Protected floodplain forest habitat (area, percent) was calculated for HUC 10 watersheds (n=72) using the conservation lands data layer (UNH Complex Systems, GRANIT). The mean protected floodplain forest within watersheds was 24 % ± 22 SD (0-92%). Eight watersheds had greater than 50% protection. However, these statistics can be misleading in some cases because of varying hectares of habitat within watersheds. For example, approximately 75% of the floodplain forest habitat in the Lower Pemigewasset River watershed was on protected land (in WMNF), totaling 350 ha. In comparison, only 18% of the habitat in the Lamprey River watershed was on protected land, but this totaled 496 ha. There were 7 watersheds in which none of the mapped habitat was on protected lands (e.g., Upper and Lower Millers River, Littleton Tributaries) or had relatively low amounts of habitat (185 ha, range: 34-655 ha).

There was some variation in the percentage of protected land among the 3 floodplain forest systems: 22% for *temperate minor river floodplain* habitat, 24% for *major river silver maple floodplain* and 34% for *montane/near-boreal floodplain* systems. The higher percentage of *montane/near-boreal floodplain* protected reflected its occurrences on WMNF land and the Second College Grant, owned and managed by Dartmouth College. Although the *temperate minor river floodplain* system had the lowest percentage of protected land of the 3 systems, it had the greatest area of protection.

2.6 Habitat Management Status

In New Hampshire and throughout the country, USACE is working with TNC to develop strategies for managing dams and waterways (USACE 2005). The New Hampshire chapter of TNC is currently working with USACE on management of dams and river flows in the Ashuelot River watershed and may expand this work to other managed river systems.

2.7 Sources of Information

Condition of floodplain habitats was based entirely on available GIS analyses. GIS data layers were attained from various sources (see Metadata for details).

2.8 Extent and Quality of Data

Condition of floodplain habitats was based largely on available GIS analyses (see section 1.6). A portion of predicted floodplain forests has been designated as exemplary natural communities by the NHNHB.

2.9 Condition Assessment Research:

Conduct GIS analyses to categorize quality of floodplain forest complexes (e.g., high, moderate, low). Attributes have been assigned to floodplain forest complexes but these variables need to be weighted. A subset of high quality sites should be field verified. Floodplain forest sampling should include an assessment of habitat availability for at-risk wildlife. This work can be conducted by NHFG with assistance from other wetland and wildlife experts. Ranked floodplain forest complexes should be incorporated into NHDES wetland permit review and mitigation prioritization and selection.

Element 3: Species and Habitat Threat Assessment

3.1.1 Development (Fragmentation, Habitat Loss and Conversion)

(A) Exposure Pathway
Floodplain habitats are restricted to relatively narrow bands that occur discontinuously along rivers, and are naturally fragmented by changes in topography or underlying geology along a river's course. However, fragmentation by human activities can be a serious threat to wildlife that use these floodplains. Agricultural fields, roads, and residential and commercial development all contribute to the fragmentation of floodplain forests, with agriculture having the greatest impact.

(B) Evidence
The effects of habitat fragmentation on many types of wildlife are well documented. Open upland habitats

(agricultural and old fields) present a significant barrier to amphibian dispersal (Gibbs 1998, Rothermel and Semlitsch 2002). Literature regarding the effects of fragmentation on forest birds is even more extensive (Blake and Carr 1987, Darveau et al. 1995, Hobson and Bayne 2000).

3.1.2 Altered Hydrology, Altered Natural Disturbance

(A) Exposure Pathway
Floodplain forests are periodically flooded, and this regular disturbance creates and maintains these communities (Bornette and Amoros 1996). There are over 5000 dams in New Hampshire, and a large percentage of New Hampshire's floodplain forests occur along stretches of river that have had their flow and flood regimes modified by dams.

(B) Evidence
Dams significantly alter natural flood regimes. Higher floodplain terraces that may have naturally flooded every 20-100 years may never receive flooding after a dam is built to regulate flow (Nislow and Magilligan 2000). Water storage dams often have different effects on floodplains than "run-of-river" dams that allow for normal river flow outside periods of high water. Water storage dams often permanently alter the species composition and structural diversity of downstream floodplains, whereas such effects are much less severe below run-of-river dams (Nilsson et al. 1997). On a heavily dammed river, Kingsford and Thomas (2004) found dramatic declines in all bird groups that used floodplain wetlands. Both storage dams (NHNHB 1998, NHNHB 1999, NHNHB 2000) and run-of-river dams (NHNHB 1996, NHNHB 1997) have been built in New Hampshire. The changes in vegetation resulting from these impoundments can also impact the wildlife that use these habitats.

3.1.3 Introduced Species

(A) Exposure Pathway
Invasive plant species are a serious threat to natural systems (Stein et al. 2000). Invasive alien plants threaten natural communities by out-competing native plants for light, nutrients and space, altering the physical structure of the vegetation, and altering nutrient cycles. Many native plants support host-specific invertebrates, which could be impacted by competition from invasives. Floodplain habitats are particularly vulnerable to invasive plants because the frequent disturbances from flooding give aliens opportunities to establish, and because these species tend to thrive in the nutrient rich soils characteristic of floodplains.

(B) Evidence
In New Hampshire, there are several exotic plants that are particularly problematic in floodplain habitats, including Oriental bittersweet (*Celastrus orbiculatus*), Japanese knotweed (*Polygonum cuspidatum*) and black swallow-wort (*Vincetoxicum nigrum*) (ISI 2005). Although research into specific effects of invasive plants on wildlife has been limited, at least one study has shown that Japanese knotweed can have measurable negative impacts on amphibians (Maerz and Blossey 2002).

3.2 Sources of Information

Literature reviews, state and federal agency websites, fact sheets, and reports were used to assess the exposure pathway and evidence of threats to floodplain forest systems in New Hampshire. GIS data layers were gathered from GRANIT, NHDES, USGS, and NHDOT to assess threats.

Initially, a list of threats was identified by NHFG and sent out for review. A group of wetland and wildlife experts met on 27 January 2005 to rank threats to marsh and shrub systems (participants included Kim Babbitt, Kim Tuttle, Pam Hunt, Carol Foss, Chris Martin, Laura Deming, Heather Hermann, Benjamin Nugent, and Matthew Carpenter), and at this meeting threats to floodplain habitats were ranked and further modified based on expert review and new information.

3.3 Extent and Quality of Data

Some threats to floodplain forest habitats and the associated flora and fauna are well understood (e.g., habitat destruction/fragmentation). Other threats (e.g., invasive plants, alteration of river flows) need further study.

3.4 Threat Assessment Research

- Collect vegetation data along impounded rivers to gauge effects of river flow modification.
- Collect invasive plant data to identify current threat areas and species, and target sites for invasive management, in conjunction with the efforts of the Invasive Plant Atlas of New England (IPANE) project (IPANE 2005).

Element 4: Conservation Actions

Many of the habitat protection strategies described in watershed profiles will benefit floodplain forests. These include managing river impoundments to simulate natural water flows, removing non-functioning dams, strengthening the Shoreland Protection Act (RSA 483-B), and protecting the highest quality sites.

4.1.1 Identification of potential floodplain forest restoration sites, and development of a floodplain forest restoration plan, Restoration and Management

(A) Threats
Development (Fragmentation, Habitat Loss and Conversion, Non-Point Source Pollution (Chemical Contaminants, Runoff and Sedimentation)

(B) Justification

- A successful restoration plan will identify sites that will connect patches of fragmented floodplain forest, preclude the conversion of floodplain agricultural fields to residential or commercial development, and reduce the effects of agricultural runoff by replacing agricultural fields and enhancing riparian buffers to remaining fields.
- Successful restoration will create or restore quantifiable areas of habitat and will enhance connectivity between extant habitat patches.
- Monitoring of the restoration sites will allow managers to assess successional processes at restoration sites and modify management strategies as necessary.

(C) Conservation Performance Objective

The objective of identifying floodplain forest restoration sites and developing a restoration plan is to restore floodplain forest habitat in areas currently used for agriculture. The plan will set goals for the number of restoration sites and the number of restored hectares within the first 5 years of the project. Success will be measured by determining whether these goals were met, and subsequently, by monitoring of the sites to ensure that the restoration sites are developing toward floodplain forest composition and structure, as defined by New Hampshire natural community and natural community system descriptions.

(D) Performance Monitoring

The restoration plan should select sites based upon their ability to connect existing blocks of floodplain forest habitat. Sites will also need to be in areas in which a natural flood regime still exists (i.e., the stretch of river is not influenced by impoundments). Site selection should ensure that sites are distributed among affected watersheds throughout the state.

(E) Ecological Response Objective

The desired ecological response to floodplain forest restoration is to increase and enhance New Hampshire's floodplain forest habitat. Successful habitat restoration would result in the creation of floodplain forest communities and systems as described by the NHNHB. These restored habitats would also support the range of affected wildlife species, where appropriate, as listed in the plan.

(F) Response Monitoring

Once work begins on given sites, monitoring will require annual visits to ensure that floodplain forest vegetation is developing and that invasive species are not threatening to inhibit floodplain habitat development. These monitoring visits will provide the necessary information to determine if succession is proceeding as desired, or if additional management (invasive control, further planting) is needed.

(G) Implementation

Prior to the development of the plan, maps will be created showing existing floodplain forest habitat and agricultural areas within floodplains, to enable the selection of potential restoration sites. The restoration plan, including prioritized sites, will be written in consultation with experts in riparian ecology and ecological restoration, and completed within 1 year. Once the plan is written and sites are identified, the first projects should begin within 3 years.

(H) Feasibility

A restoration project of this sort is large-scale and resource intensive and will require the participation of outside experts and organizations as well as willing landowners. Projects will have to occur on public land, or access will need to be gained on private land, either through cooperation with the landowner, landowner incentive programs, or direct acquisition. Funding for this project will probably need to be procured through federal grant programs.

4.1.2 Develop and implement invasive plant species management plan for floodplain forests, Restoration and Management

(A) Threats
Invasive plants

(B) Justification

- An invasive species management plan will identify high-quality floodplain forest habitat that is threatened by invasive plant species and will develop strategies to control them. Evaluations of habitat quality will include the presence of at-risk wildlife species.
- Controlling invasive plant species will allow for the restoration and enhancement of native vegetation, which will benefit an array of wildlife.
- Management will be targeted to specific sites, because invasive plant control can be time and labor intensive.
- Because the spread of invasive plants is a relatively slow process, management activities can extend over a period of many years.
- Monitoring sites for decreases in the abundance of invasive plants and a subsequent increase in the cover of native vegetation will allow for refinement of management techniques.

(C) Conservation Performance Objective

The objective of developing and implementing an invasive plant species management plan is to alleviate the impact of invasive plant species on floodplain forests, using standardized methods developed by other organizations (IPANE). Success will be indicated by the creation and implementation of the plan within 2 years.

(D) Performance Monitoring

In the first season, invasive species surveys should be conducted on at least 25 floodplain forest sites. Following site evaluation, an invasive species control plan will be developed for selected sites, with an associated site monitoring plan.

(E) Ecological Response Objective

The desired ecological response is a reduction in the abundance of invasive plant species in floodplain forests. Successful invasive control will be indicated by a measurable reduction in the cover of invasives, and a resultant increase in the cover of native vegetation.

(F) Response Monitoring

Management sites will be sampled for cover of invasive plant species and cover of native plant species using standard fixed vegetation plot techniques. The effects of control methods on both native and exotic species will be monitored by regular re-sampling of these fixed plots. The analysis of these plot data will provide an assessment of the efficacy of the control treatments and will direct any alterations of the management plan.

(G) Implementation

Floodplain forest sites will be selected from the habitat map for invasive sampling. Once data have been gathered at the sites, an invasive control plan will be

developed in collaboration with experts in invasive species management. At the sites, fixed vegetation plots will be established to measure the effects of the control techniques. Vegetation data will be collected before and after treatment, with return visits in subsequent years to monitor the site and conduct additional control measures.

(H) Feasibility

The implementation of an invasive species control plan would be very labor intensive and would likely require help from volunteer organizations. Herbicides and mechanical devised could be very expensive. An effective control project is a long-term endeavor which will require an equivalent commitment of resources.

4.2.1 Conservation Action Research

- The development of the restoration plan will require considerable research into the best current methods in ecological restoration. The restoration projects themselves will require extensive monitoring to evaluate their success in restoring floodplain forest habitat.
- Thorough inventories of invasive species in floodplain habitats will need to be conducted prior to developing a management plan. Development of a series of permanent plots will be necessary to monitor changes following management activities.

Element 5: References

5.1 Literature

Blake, J.G., and J.R. Karr. 1987. Breeding birds of isolated woodlots: Area and habitat relationships. Ecology 68: 1724-1734.

Bornette, G., and C. Amoros. 1996. Disturbance regimes and vegetation dynamics: role of floods in riverine wetlands. Journal of Vegetation Science 7: 615-622.

Complex Systems Research Center. 2001. Digital elevation model. http://www.granit.sr.unh.edu/data/datacat/pages/dem.pdf. Accessed 22 February 2005.

Complex Systems Research Center. 2001. New Hampshire Land Cover Assessment 2001. http://www.granit.sr.unh.edu/data/datacat/pages/nhlc01.pdf Accessed 9 July 2003.

Dahl, T.E. 2000. Status and trends of wetlands in the conterminous United States 1986 to 1997 U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. 82 pp.

Darveau, M., P. Beauchesne, L. Belanger, J. Hout, and P.LaRue. 1995. Riparian forest strips as habitat for breeding birds in the boreal forest. Journal of Wildlife Management 59: 67-78.

Federal Emergency Management Agency (FEMA). 2005. National Flood Insurance Program. Website: http://www.fema.gov/fima/nfip.shtm.

Foss, C.R., P.D. Hunt, and D.B. Wells. 2000a. New Hampshire Floodplain Forest Project: Effects of patch size on breeding bird community composition and nesting success in floodplain forest fragments in the Merrimack River watershed. Report to New Hampshire Department of Environmental Services.

Foss, C.R., P.D. Hunt, and D.B. Wells. 2000b. New Hampshire Floodplain Forest Project: Landbird use of selected floodplain forests in the Merrimack River watershed during spring migration. Report to New Hampshire Department of Environmental Services.

Gibbs, J.P. 1998. Distribution of woodland amphibians along a forest fragmentation gradient. Landscape Ecology 13:263-268.

Hobson, K.A., and E. Bayne. 2000. Effects of forest fragmentation by agriculture on avian communities in the southern boreal mixedwoods of western Canada. Wilson Bulletin 112(3):373-387.

Hunt, P. 2005. A regional perspective on New Hampshire's Birds of Conservation Priority: objectives, threats, research needs, and conservation strategies. Audubon Society of New Hampshire, Concord, New Hampshire, USA.

Invasive Plant Atlas of New England. 2005. http://invasives.eeb.uconn.edu/ipane/.

Invasive Species Initiative. 2005. http://tncweeds.ucdavis.edu/index.html.

Kingsford, R.T. and R.F. Thomas. 2004. Destruction of wetlands and waterbird populations by dams and irrigation on the Murrumbidgee River in arid Australia. Environmental Management 34(3):383-396.

Maerz, J.C. and B. Blossey. 2002. The Impact of

Japanese Knotweed Invasions on the Pre-Migratory Foraging of Green Frogs. Unpublished study. Available at: http://www.invasiveplants.net/japim.htm.

New Hampshire Department of Environmental Services. 2004. Dam removal and river restoration program. Website: http://www.des.state.nh.us/Dam/DamRemoval/.

NH Natural Heritage Bureau. 2005. Database of rare species and exemplary natural community occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

New Hampshire Natural Heritage Inventory. 1998. A natural features survey of the Surry Mountain Lake Project. Department of Resources and Economic Development. Concord, New Hampshire, USA.

New Hampshire Natural Heritage Inventory. 1999. A natural features survey of the Hopkinton-Everett Lakes Project. Department of Resources and Economic Development. Concord, NH.

New Hampshire Natural Heritage Inventory. 2000. A natural features survey of the Edward MacDowell Lake Project. Department of Resources and Economic Development. Concord, NH.

New Hampshire Natural Heritage Program. 1996. A natural features survey of the Franklin Falls Dam property. Department of Resources and Economic Development. Concord, New Hampshire, USA.

New Hampshire Natural Heritage Program. 1997. A natural features survey of the Blackwater Dam property. Department of Resources and Economic Development. Concord, New Hampshire, USA.

Nilsson, C., R. Jamsson, U. Zinko. 1997. Long-term responses of river-margin vegetation to water-level regulation. Science 276:798-800.

Nislow, K.H., and F.J. Magilligan. 2000. Hydrologic alteration in a changing landscape: effects of impoundment in the upper Connecticut River basin, USA.

Poff, N.L., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegaard, B.D. Richter, R.E. Sparks, and J.C. Stromberg. 1997. The Natural Flow Regime: A paradigm for river conservation and restoration. BioScience 47(11):769-784.

Rothermel, B.B., and R.D. Semlitsch. 2002. An experimental investigation of landscape resistance of forest versus old-field habitats to emigrating juvenile amphibians. Conservation Biology 16(5): 1324-1332.

Sperduto, D.D. 2004. Wetland Ecological Systems of New Hampshire. NH Natural Heritage Bureau, Concord, New Hampshire, USA.

Sperduto, D.D., and W.F. Nichols. 2004. Natural Communities of New Hampshire. NH Natural Heritage Bureau, Concord, NH. Pub. UNH Cooperative Extension, Durham, New Hampshire, USA.

Stein, B.A., L.S. Kutner and J.S. Adams, eds. 2000. Precious Heritage: The status of biodiversity in the United States. Oxford University Press. New York, NY.

United States Army Corps of Engineers. 2005. River project brings together Corps, The Nature Conservancy.

Available at: http://hq.environmental.usace.army.mil/Corps_Environment/story10.htm.

United States Environmental Protection Agency. 1998. US EPA Reach File 3. http://www.fgdl.org/metadata/fgdc_html/eparr3.fgdc.htm Accessed 2000.

HABITAT PROFILE

Grasslands

Associated Species: Northern Harrier (Circus cyaneus), Upland Sandpiper (Bartramia longicauda), Purple Marten (Progne subis), Eastern Meadowlark (Sturnella magna), Horned Lark (Eremophila alpestris), Grasshopper Sparrow (Ammodramus savannarum), Vesper Sparrow (Pooecetes gramineus, northern leopard frog (Rana pipiens), and Wood Turtle (Glyptemys insculpta).

Federal Listing: Not listed
State Listing: Not listed
Global Rank: Not ranked
State Rank: Not ranked
Authors: James D. Oehler, Ellen Snyder, and Alina J. Pyzikiewic, New Hampshire Fish and Game, Consulting Wildlife Biologist

Element 1: Distribution and Habitat

1.1 Habitat Description

Extensive grasslands are defined as areas greater than 10 ha that are dominated by grasses, forbs, and sedges with little shrub or tree cover (generally les than 10%) (Vickery and Dunwiddie 1997, DeGraaf and Yamasaki 2001). Grasslands include hayfields and pastures, fallow fields, cropland (cornfields and other row crops), airports, military installations, landfills, forb, and sedge-dominated meadows, heathlands, and similar non-alpine areas (Vickery and Dunwiddie 1997, Mitchell et al. 2000). Native plant species typical of northeastern grassland include goldenrod (*Solidago* spp.), aster (*Aster* spp.), big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), and meadowsweet (*Spirea alba*) (Mehrhoff 1997). Rare plant species found in New England grassland include wild lupine (*Lupinus perennis*), butterfly weed (*Asclepias tuberosa*), and northern blazing star (*Liatris scariosa* var. *novae-angliae*) (Mehrhoff 1997).

1.2 Justification

Native grasslands were once the most widely distributed vegetative cover in North America (Knopf 1995). A decline in this habitat type in the Northeast has led to a precipitous decline in grassland bird populations, which are disappearing faster than any other group of birds in this region (Sauer et al. 2003). Seven grassland birds are listed as endangered or threatened in at least 1 state in the region (Mitchell et al. 2000). In New Hampshire, grasslands serve as primary breeding and nesting grounds for several avian species of conservation concern including the state endangered northern harrier (*Circus cyaneus*), state endangered upland sandpiper (*Bartramia longicauda*), state threatened grasshopper sparrow (*Ammodramus savannarum*), eastern meadowlark (*Sturnella magna*), horned lark (*Eremophila alpestris*), and vesper sparrow (*Pooecetes gramineus*).
Large (>10 ha) grasslands are important because many grassland birds require large areas. For instance, eastern meadowlarks require at least 6 ha, grasshopper sparrows at least 12 ha, savannah sparrows 8 to 16 ha, and upland sandpipers 40 to 80 ha (Jones and Vickery 1997).

Other species of conservation concern that would benefit from the conservation of grasslands include black racer, smooth green snake, northern leopard frog, wood turtle, and others. Grassland invertebrates include a host of grasshoppers, butterflies, moths, and spiders (Vickery and Dunwiddie 1997).

1.3 Protection and Regulatory Status

Grasslands have no special regulatory status. Grasslands that are habitat for endangered or threatened species are protected under RSA 212 if modifying the habitat would result in those species' inability to use the habitat.

A number of programs exist that protect critical grasslands and farmland from development. LCHIP provides fee simple or conservation easement grants to communities, land trusts, and others to help protect priority lands. Since 1979, the State Department of Agriculture has administered an Agricultural Land Preservation Program, which was created under RSA 432:18-31a for the sole purpose of protecting prime farmland through conservation easements. In addition, the program works with land trusts, conservation organizations, and municipalities to protect important farm resources. The state, through the Current Use Advisory Board within the Department of Revenue Administration, administers the Current Use Taxation program, which was created via RSA 79-A to encourage, among other things, the protection of agriculture and wildlife resources. The program reduces state property taxes by 20 percent for lands of at least 4 ha that are open year-round to public recreational use.

At the federal level, the NRCS administers the Farmland Protection Program through the USDA. The Farmland Protection Program provides funds to help purchase development rights to keep farmland in agriculture. The program provides up to 50 percent of the fair market easement value (NRCS 2005a).

At the local level, many municipalities have passed open space bonds to help protect natural resources of local and statewide importance. Since 2000, municipalities have invested over $125 million in land protection (SPNHF 2005). It is unknown how many hectares of grassland or farmland have been protected through these investments.

1.4 Population and Habitat Distribution

Grasslands in New Hampshire are largely restricted to hay fields, cropland, airports, capped landfills, and military installations. According to the grassland habitat mapping completed by NHFG, there are 94,578 ha of grassland complexes at least 10 ha in size. Most of these grasslands occur in Grafton county (18,937 ha: 20%) followed by Merrimack and Coos counties [12,139 (13%) and 11,635 (12%) ha, respectively]. Cheshire, Hillsborough, Rockingham, Strafford, and Sullivan counties contain 7,300 to 9,600 ha of extensive grassland each, whereas Carroll and Belknap counties contain the least amount of grassland at approximately 4,700 ha each.

1.5 Town Distribution Map

At least one grassland complex larger than 10 ha occurs in nearly every town in New Hampshire. The exceptions are 20 towns and territories in Coos County, 3 towns in Carroll County, 4 towns in Grafton County, and 2 towns in each of Cheshire, Hillsborough, and Rockingham Counties (figure 1).

1.6 Habitat Map

The New Hampshire Landcover Assessment (Complex Systems Research Center 2002) was used to map extensive grassland larger than 10 ha. Much habitat for rare grassland birds is classified as disturbed or cleared. Where such areas abutted active agricultural plots, the two were joined. In this way, areas greater than 10 ha were isolated and converted to a separate shape file.

Polygons were then overlaid atop 1998 Digital Orthophotos and the entire state was scanned at a scale of 1:50,000 to identify areas erroneously mapped as grassland. Invalid polygons were deleted from the data layer, and if only a portion of the polygon was misclassified, the polygon boundary was edited. Polygons that were misclassified were often shrub swamps, wet meadow, developed areas, or timber harvest areas reverting to forest. Only those polygons that were significantly misclassified were edited.

1.7 Sources of Information

Sources of information for this element included technical reports, Breeding Bird Survey data, and peer reviewed journal articles. The New Hampshire Landcover Assessment (CSRC 2002) was used to map grassland habitat. 1998 digital orthophotos were used to check the accuracy of the grassland habitat data layer.

1.8 Extent and Quality of Data

Data for mapping grasslands were obtained from the New Hampshire Landcover Assessment (CSRC 2002). The assessment was obtained from interpretation of satellite imagery (pixel size = 30 m) using standard digital image processing techniques. Because the satellites used cannot capture items on the ground less than 30 m in size, many hedgerows and tree lines that

typically separate fields were not delineated. Thus, this data layer really depicts grassland complexes and not individual grassland patches. The coarse scale of the satellite imagery caused some imprecision in the delineation of boundaries, which may be offset when laid over an aerial photograph.

Because the entire state was scanned to identify misclassification errors, errors of commission (classifying an area as grassland when it is really some other land cover type) should be relatively few. Even so, it is possible that some errors were missed during the scanning. Similarly, it is possible that some true grassland areas were omitted.

1.9 Distribution Research

Research is needed to clarify the complex relationships between land use, natural disturbance, and biogeography of rare wildlife. Historically, many Native American and European land uses imitated natural disturbance regimes capable of maintaining grasslands. These land uses included firewood and timber harvesting, controlled burning, and clearing for year-round or seasonal settlements and agriculture. Some of the natural disturbances these land uses may imitate include fire, extreme weather, herbivory, extensive colonial nesting (passenger pigeons), and sand plain terracing resulting from alluvial denudation and deposition.

Native grasslands and heathlands are recognized as fine-scale, fire-driven structural features of pitch pine and scrub oak woodlands (NHNHB). However, more inclusive land use and biogeographic data suggest a broader historic extent of native grasslands and heathlands. Other research should determine causes of grassland wildlife declines, explore the relationship between invertebrates and grassland, and improve techniques for grassland mapping.

Element 2: Species/Habitat Condition

2.1 Scale

Counties will be used as the conservation-planning units for this habitat. The majority of grassland habitats in New Hampshire are related to agricultural activity. Most technical and financial assistance is provided to farmers on a county-basis by the Farm Services Agency, Natural Resources Conservation Service, University of New Hampshire Cooperative Extension, Conservation Districts, and others.

2.2 Relative Health of Populations:

Although the amount of grassland habitat in New Hampshire has been declining over numerous decades, it is difficult to determine the extent of grasslands in New Hampshire prior to European settlement. The creation and maintenance of grasslands prior to European settlement are ascribed to beavers and Native American use of fire.

Numerous reports, largely based on historic accounts, suggest that Native Americans in coastal regions and river valleys used fire to create and maintain agricultural fields and to improve hunting grounds and travel corridors (Day 1953, Harris 1972, Cronon 1983, Whitney 1994). The resulting mosaic included habitat, including grassland, in different states of succession. However, archaeological data are equivocal, and the effect that Native American fires had on vegetation composition and distribution in the region is unclear.

Beavers likely contributed to the creation of open areas (Askins 1997). After a beaver dam is abandoned, the previously dammed area succeeds to a meadow dominated by sedges, grasses, and forbs. Though no empirical data exist to elucidate the extent of beaver activity in New Hampshire or the region, it is known that beaver activity may influence 20 to 40% of the total length of second- to fifth-order streams (Naiman et al. 1988). Additionally, a study in the Adirondack Mountains found that beaver dams created patches of disturbance that covered, on average, 6.7 to 12 ha (Remillard et al. 1987). Given their habitat requirements, it is plausible that many grassland endemic species could have used beaver meadows during presettlement times (e.g., grasshopper sparrow, savannah sparrow).

An analysis of wet flats in New Hampshire (the flat floodplain area adjacent to streams and rivers that would be affected by beavers) shows that nearly 30% (267 out of 961) of the wet flats 7 to12 ha in size are affected by agriculture and likely no longer serve as grassland habitat because of current management practices (e.g., repeated mowing during the breeding season or planting to crops). Another 17% (165 out of 961) are effected by development (CSRC 2001, TNC 2003).

Native sand plain grasslands may have been more common in New Hampshire prior to European settlement, especially in coastal lowlands and along the Merrimack and Connecticut Rivers in southern New Hampshire. However, only small remnants occur within historic and current pitch pine areas (see the Pine Barren habitat profile).

Despite local losses of specific grassland types (e.g., sand plain grassland) the amount of grassland in New Hampshire increased dramatically after European settlement. Much land was cleared for farmland in the eighteenth and nineteenth centuries, and grasslands abounded at that time (Askins 1997). In 1850 there were over 910,000 ha of improved farmland (hayfields and cropland) in New Hampshire (Silver 1957). However, when agricultural practices were abandoned and fields reverted to woodland or became developed during the twentieth century, grasslands and the species associated with them began their slow decline. Currently, there are approximately 101,175 ha of farmland in New Hampshire, and most of it is intensively managed so as not to be suitable for wildlife (Jones and Vickery 1997, USDA 2004).

2.3 Population Management Status

N/A

2.4 Relative Quality of Habitat Patches

Most of New Hampshire's grasslands are cultivated fields and are thus ill suited to most wildlife. Farm fields are either in a row crop (e.g., corn) or are used for hay or pasture. Hayed fields are typically mowed more than once during the breeding bird season, which likely destroys bird nests (Bollinger et al. 1990). Mowing more than once a season also harms grassland reptiles like black racers, smooth green snakes, and eastern garter snakes (Mitchell 2003). Roads and development fragment fields into patches that may not be big enough to sustain grassland-nesting birds. It also introduces more predators (e.g., cats, raccoons, foxes, crows, blue jays, etc.).

In a study of land use change in Rockingham and Strafford Counties, the University of New Hampshire CSRC documented a roughly 50% decline in active agricultural land from 1962 to 1998. Of the increase in developed land in Strafford County from 15,155 acres (1962) to 33,616 acres (1998), 3,487 acres were converted from active agriculture. In Rockingham County, of the increase in developed land from 36,519 acres (1962) to 98,417 acres (1998), 11,685 acres were converted from active agriculture (Fay Rubin, Complex Systems Research Center, unpublished report). In northern Coos County, where northern harriers breed in large grasslands, the amount of hayfield declined from 54% to 44% from 1982 to 1993 (Serrentino 1988).

2.5 Habitat Patch Protection Status

Only 8% of the grasslands larger than 10 ha are conserved in New Hampshire. The percentage of conserved grasslands by county ranges from 4 to 11% with the most area conserved in Merrimack and Strafford counties (11% each) and the least in Belknap county (4%).

2.6 Habitat Management Status

Financial & Technical Assistance Programs:
Several programs provide financial and technical assistance to farmers for managing and preserving agriculture fields for wildlife. These include the USDA's Conservation Reserve Program (CRP), Environmental Quality Incentive Program (EQIP), and Wildlife Habitat Incentives Program (WHIP), as well as the USFWS's Partners for Fish & Wildlife Program (Partners Program), and the NHFG Small Grants Program. University of New Hampshire Cooperative Extension Wildlife Specialists also provide technical assistance to farmers and other landowners on wildlife habitat management issues.

The Conservation Reserve Program provides financial incentives to landowners in the form of annual rent payments to encourage them to take highly erodible cropland out of production (FSA 2005). Financial assistance may also be provided to help establish a suitable cover crop or to restore habitats that were lost during agriculture conversion (e.g., floodplain forest).

The Conservation Research Program is not much used in New Hampshire. On average, only 85.5 ha were enrolled under this program between 2001 and 2003 (FSA 2002, FSA 2003a, FSA 2004). A major reason for this is that the rental rates paid to farmers are based on soil productivity and local dry land cash rates, and priority is given to projects with low costs (FSA 2003b). Since, on a nationwide scale, soil pro-

ductivity is relatively low and the local cash rates are high in New Hampshire and the northeast in general, CRP projects in this region are not often chosen for funding (figure 2). The Conservation Research Program would perhaps become a more viable option for farmers in this state if CRP acreage enrollment goals were established by region (e.g., Midwest, Northeast, etc.) (Oehler 2003).

The Environmental Quality Incentives Program offers financial and technical assistance to help agricultural producers install or implement structural and management practices on eligible agricultural land (NRCS 2005b). An EQIP Technical Committee in each state sets eligible habitat improvement practices, of which there are nearly 70 in New Hampshire. These include such things as nutrient management, installation of manure storage facilities, and restoration of declining habitats. Eligible EQIP practices that would benefit grasslands include brush management, pasture and hay planting, prescribed grazing, restoration and management of declining habitats (New Hampshire NRCS 2005a). Statistics are currently unavailable to determine how many ha have been treated with each of these practices. In 2005, New Hampshire received nearly $8 million for EQIP.

The Wildlife Habitat Incentives Program encourages the creation of quality wildlife habitat on private land through technical and financial assistance (NRCS 2005c). Like EQIP, a WHIP Technical Committee in each state sets eligible habitat improvement practices. Like many states in the northeast, New Hampshire's list of eligible practices includes such things as brush management, prescribed burning, grass planting, and other practices applicable to grasslands (New Hampshire NRCS 2005b). Statistics are currently unavailable to determine how many ha have been treated with each of these practices. In 2005, New Hampshire received over $1,000,000 for WHIP.

Since 1990, the USFWS's Partners for Fish & Wildlife Program in New Hampshire has provided technical and financial assistance to landowners, state agencies, many organizations and individuals to restore fish and wildlife habitat such as coastal wetlands, riparian habitats, and grasslands (USFWS 2001). Since its inception, the Partners Program has restored over 40.5 ha of upland habitat (USFWS 2001).

New Hampshire Fish and Game administers the Small Grants Program that was established to fund all or part of the cost of small-scale habitat restoration and enhancement projects on privately owned lands. Up to $50,000 per year is committed to the Small Grants Program. The funds are obtained via a $2.50 habitat fee required of all who purchase a New Hampshire hunting license. Twelve habitat management practices are eligible for funding, of which three are relevant to grasslands. These include mowing to maintain grasslands and shrublands, establishment and maintenance of cool season grasses and clovers, and establishment and maintenance of warm season grasses (NHFG undated). Since 2000, 400 ha have been mowed, 31 ha have been planted to cool season grasses or maintained via soil amendments, and 3.5 ha have been planted to warm-season grasses or maintained via soil amendments (NHFG unpublished data).

Management on State Lands

The NHFG owns in fee-simple or under conservation easement just over 334 ha of fields (NHFG unpublished data). One-hundred-and-seventy-three ha are maintained in active agriculture (either hay or cropland), and the remainder is maintained via brush hog mower with mowing occurring every 1 to 3 years after the bird nesting season.

Few of the NHFG fields are greater than 10 ha. The Osborne Wildlife Management Area (WMA) in Belknap County is an easement owned property with a complex of fields totaling 64 ha. The property owner actively farms these fields. The Lime Pond conservation easement in Coos County has an 11 ha field that is currently not maintained. The Fort Hill WMA in Coos County has the largest complex of fields on NHFG property, totaling 153 ha. Forty-two ha are owned under a conservation easement and are actively farmed by the property owner, a dairy farmer. An additional 74 ha of fields are owned in fee simple status by the department and leased to the same dairy farmer. Thirty-seven ha are owned in fee simple status, but the previous landowner retained the agriculture rights.

The Department of Resources and Economic Development (DRED) owns in fee-simple or under conservation easement approximately 543 ha of fields and other early-successional openings (DRED unpublished data). Forty ha are maintained in active

agriculture (either hay or cropland). One-hundred-and-thirty-seven ha are maintained via mowing by State Parks or NHFG. The remainder is not maintained on a regular basis.

Like NHFG, DRED owns or manages few fields greater than 10 ha. Specifically, 9 properties may provide opportunities for grassland. These, along with the NHFG owned or managed fields, should be evaluated for their potential to provide grassland habitat.

Management on Other Lands

All others grassland complexes greater than 10 ha occur on private land and, to a much lesser extent, on land of private land trusts, municipalities, and other conservation organizations/agencies. It is not known to what extent grasslands on other conservation lands are maintained. Grasslands on private lands are typically owned by farmers and are therefore maintained as cropland or pastureland.

2.7 Sources of Information

Sources of information for element 2 include journal articles, websites, GIS data, and white papers.

2.8 Extent and Quality of Data

It is difficult to ascertain how suitable the mapped grassland complexes are for grassland-related wildlife species. The minimum mapping unit for the New Hampshire Landcover Assessment was 30 square meters (CRSC 2001). This resolution is often too coarse to pick up hedgerows and tree lines that may separate fields and render them useless to area-dependent grassland birds. Higher resolution satellite imagery would be needed to adequately map and evaluate grassland complexes in an efficient manner. The alternative would be field ground truthing of mapped complexes to determine their suitability, but that would be extremely time consuming. Concentrating on larger complexes, especially those on state land, would be more manageable. Although Farm Bill and other financial assistance programs are used in New Hampshire and elsewhere in the country, little has been done to evaluate wildlife species' response to the management.

2.9 Condition Assessment Research

- Assess the availability of higher resolution satellite imagery to use to better map grassland complexes and their condition
- Assess the number of farmers currently more than once per season from the highest priority grasslands. Such an assessment could be used as an indicator of grassland health and could be monitored to track grassland health through time.
- Assess in more detail the rate of loss of open space to development and the attendant effects on grasslands
- Assess effectiveness of Farm Bill programs by implementing monitoring programs on lands where Farm Bill monies have been applied

Element 5: References

5.1 Literature

Askins, R.A. 1997. History of grasslands in the northeastern United States: implications for bird conservation. Pages 119-136 *in* Grasslands of northeastern North America: ecology and conservation of native and agricultural landscapes, P. D. Vickery and P. W. Dunwiddie, editors. Massachusetts Audubon Society, Lincoln, Massachusetts, USA.

Askins, R., and D. Thompson. 2003. Assessment of the importance of grasslands in the central Connecticut River Valley for conservation of grassland birds.

Bollinger, E.K., P.B. Bollinger, and T.A. Gavin. 1990. Effects of hay-cropping on eastern populations of the bobolink. Wildlife Society Bulletin 18:142-150.

Complex Systems Research Center. 2002. Landcover assessment - 2001. University of New Hampshire, Durham. http://www.granit.sr.unh.edu/data/datacat/pages/nhlc01.pdf. Accessed 8 February 2002.

Cronan, W. 1983. Changes in the land: Indians, colonists, and ecology of New England. Hill and Wang, New York, New York, USA.

Day, G. 1953. The Indian as ecological factor in the northeastern forests. Ecology 34:329-346.

DeGraaf, R.M., and M. Yamasaki. 2001. New Eng-

land wildlife: habitat, natural history, and distribution. University Press of New England, Hanover, New Hampshire, USA.

Denny, R.N. 1974. The impact of uncontrolled dogs on wildlife and livestock. Transactions of the North American Wildlife and Natural Resources Conference 39: 257-291.

Farm Service Agency. 2005. Conservation Reserve Program. U.S. Department of Agriculture. http://www.fsa.usda.gov/dafp/cepd/crp.htm.

Farm Service Agency. 2004. Conservation Reserve Program fiscal year summary: FY 2003. U.S. Department of Agriculture. 14pp.

Farm Service Agency. 2003a. Conservation Reserve Program fiscal year summary: FY 2002. U.S. Department of Agriculture. 14pp.

Farm Service Agency. 2003b. Conservation Reserve Program: fact sheet. U.S. Department of Agriculture. http://www.fsa.usda.gov/pas/publications/facts/html/crp03.htm.

Farm Service Agency. 2002. Conservation Reserve Program fiscal year summary: FY 2001. U.S. Department of Agriculture. 14pp.

Hoopes, E.M. 1993. Relationships between human recreation and piping plover foraging ecology and chick survival. Thesis, University of Massachusetts, Amherst, Massachusetts, USA.

Jones, A., and P.D. Vickery. 1997. Conserving grassland birds: managing agricultural lands including hayfields, cropfields, and pastures for grassland birds. Grassland Conservation Program, Center for Biological Conservation, Massachusetts Audubon Society, Lincoln, Massachusetts, USA.

Jones, A., and P.D. Vickery. 1997. Distribution and population status of grassland birds in Massachusetts. Pp. 187-199 *in* Grasslands of northeastern North America: Ecology and conservation of native and agricultural landscapes, P.D. Vickery and P. W. Dunwiddie, editors. Massachusetts Audubon Society, Lincoln, Massachusetts, USA.

Knopf, R.L. 1995. Declining grassland birds. Pages 296-298 *in* Our living resources: a report to the nation on the distribution, abundance and health of U.S. plants, animals, and ecosystems, E.T. LaRoe, G.S. Farris, C.E. Puckett, P.D. Doran, and M.J. Mac, editors. U. S. Department of the Interior, National Biological Service, Washington, D.C., USA.

Mehrhoff, L.L. 1997. Thoughts on the biogeography of grassland plants in New England. Pages 15-23 *in* Grasslands of northeastern North America: ecology and conservation of native and agricultural landscapes, P.D. Vickery and P.W. Dunwiddie, editors. Massachusetts Audubon Society, Lincoln, Massachusetts, USA.

Mitchell, J.C. 2003. DRAFT Habitat management guidelines for amphibians and reptiles of the northeastern United States. Partners in Amphibian and Reptile Conservation. 57pp.

Mitchell, L.R., C.R. Smith, and R.A. Malecki. 2000. Ecology of grassland breeding birds in the northeastern United States: a literature review with recommendations for management. U.S. Geological Survey, Biological Resources Division, New York Cooperative Fish and Wildlife Research Unit, Department of Natural Resources, Cornell University, Ithaca, New York, USA.

Naiman, R.J., J.M. Melillo, and J.E. Hobbie. 1988. Ecosystem alteration of boreal forest streams by beaver (*Castor canadensis*). Ecology 67:1254-1269.

New Hampshire Office of the Natural Resources Conservation Service. 2005a. New Hampshire EQIP approved practice list. U.S. Department of Agriculture. http://www.nh.nrcs.usda.gov/programs/program_documents/EQIP/2004_EQIP_Practice_List.pdf

New Hampshire Office of the Natural Resources Conservation Service. 2005b. New Hampshire WHIP approved practice list. U.S. Department of Agriculture. http://www.nh.nrcs.usda.gov/programs/WHIP 2005 Practice List 1-28.pdf.

Natural Resources Conservation Service. 2005a. Farmland Protection Program. U.S. Department of Agriculture. http://www.nrcs.usda.gov/programs/eqip/.

Natural Resources Conservation Service. 2005b. Environmental Quality Incentives Program. U.S. Department of Agriculture. http://www.info.usda.gov/nrcs/fpcp/fpp.htm.

Natural Resources Conservation Service. 2005b. Wildlife Habitat Incentives Program. U.S. Department of Agriculture. http://www.nrcs.usda.gov/programs/whip/.

New Hampshire Fish & Game Department. Undated. Private lands habitat conservation – Small Grants Program: program overview. New Hampshire Fish & Game Department. 11pp.

Norment, C. 2002. On grassland bird conservation

in the northeast. The Auk 119: 27-279.

Serrentino, P. 1998. A survey and habitat evaluation of northern harriers (*Circus cyaneus*) in northwest Coos County, New Hampshire. Report to Silvio O. Conte National Fish and Wildlife Refuge (U.S. Fish and Wildlife Service).

Simes, C.A. 1999. Domestic dogs in wildlife habitats. *In* Effects of recreation on Rocky Mountain wildlife: a review for Montana, G. Joslin and H. Youmans, coordinators, Committee on Effects of Recreation on Wildlife, Montana Chapter of The Wildlife Society.

Society for the Protection of New Hampshire Forests. 2005. Press release: town meeting voters approve $23 million for conservation. Concord, New Hampshire, USA.

Oehler, J.D. 2003. State efforts to promote early-successional habitats on public and private lands in the northeastern United States. Forest Ecology and Management 185:169-177.

Parshall, T., and D.R. Foster. 2002. Fire on the New England landscape: regional and temporal variation, cultural and environmental controls. Journal of Biogeography 29:1305-1317.

Patterson, W.A. III, and K.E. Sassaman. 1988. Indian fires in the prehistory of New England. Pages 107-135 *in* Holocene human ecology in northeastern North America, G.P. Nichols, editor. Plenum Publishing Corporation, New York, New York, USA.

Remillard, M.M., G.K. Gruendling, and D.J. Bogucki. 1987. Disturbance by beaver (*Castor canadensis* Kuhl) and increased landscape heterogeneity. Pages 103-122 *in* Landscape heterogeneity and disturbance, M.G. Turner, editor. Springer Verlag, New York, New York, USA.

Sauer, J.R., J.E. Hines, and J. Fallon. 2004. *The North American breeding bird survey, results and analysis 1966 - 2003. Version 2004.1. United States Geological Service Patuxent Wildlife Research Center, Laurel, Maryland, USA.*

Silver, H. 1957. New Hampshire game and furbearers. New Hampshire Fish & Game Department, Concord, New Hampshire, USA.

Swain, P.C., and J.B. Kearsely. 2001. Classification of the natural communities of Massachusetts. Natural Heritage & Endangered Species Program Massachusetts Division of Fisheries and Wildlife, Westborough, Massachusetts, USA.

The Nature Conservancy. 2003. Ecological landunit data layer. Conservation Science Support Program, Eastern Resource Office of The Nature Conservancy, Boston, Massachusetts, USA.

United States Department of Agriculture. 2004. 2002 census of agriculture. National Agricultural Statistics Service, U.S. Department of Agriculture, Washington, D.C. http://www.nass.usda.gov/census/.

United States Fish and Wildlife Service. 2001. Partners for Fish and Wildlife Program: New Hampshire. http://northeast.fws.gov/partners/Documents/State Summaries/NH-needs.pdf

Vickery, P.D., J.R. Herkert, F.L, Knopf, J. Ruth, and C.E. Keller. 2005. Grassland birds: an overview of threats and recommended management strategies. *In* Strategies for bird conservation: The Partners in Flight planning process, R. Bonney, D.N. Pashley, R.J. Cooper, and L. Niles, editors. Cornell Lab of Ornithology. http://birds.cornell.edu/pifcapemay

Vickery, P.D., and P.W. Dunwiddie, editors. 1997. Grasslands of northeastern North America: ecology and conservation of native and agricultural landscapes. Massachusetts Audubon Society, Lincoln, Massachusetts, USA.

Whitney, G. 1994. From coastal wilderness to fruited plain: a history of environmental change in temperate North America from 1500 to present. Cambridge University Press, Cambridge, Massachusetts.

Yalden, P.E., and D. Yalden. 1990. Recreational disturbance of breeding golden plovers *Pluvialis apricarius*. Biological conservation 51: 243-262.

Element 6: List of Figures

Figure 1. Distribution of extensive grasslands in New Hampshire.

HABITAT PROFILE

Hemlock Hardwood Pine Forest

Associated Species: Timber rattlesnake, Northern Goshawk, Veery, Cerulaean Warbler, Eastern Pipistrelle, Eastern red bat, Northern myotis, Silver haired bat, black bear, bobcat

Global Rank: Not ranked
State Rank: Not ranked
Author: Carol R. Foss, Audubon Society of New Hampshire

Element 1: Distribution and Habitat

1.1 Habitat Description

Hemlock hardwood pine forests are a transitional forest regions or "tension zones" in New Hampshire. In latitude and elevation, they occur between hardwood conifer forests to the north (mostly above 1,400 ft) and oak pine (Appalachian or central hardwood) forests to the north (mostly below 900 ft). This transitional forest lacks most boreal species and central hardwood species that characterize these other forests, but has many Alleghanian species such as *Pinus strobus* (white pine) and *Tsuga canadensis* (hemlock). Many of the other species of this system are common throughout eastern United States. Hemlock hardwood pine forests are found throughout the state from the White Mountains south below about 1,500 feet. Dry-mesic to mesic glacial till soils are most abundant, but this system also occupies river terraces, sand plains, and stabilized talus areas covered by a forest canopy. It includes dry, sandy soils with red oak and white pine that have not been burned enough to support pitch pine sand plains system. These areas are likely to succeed to hemlock and/or beech over the long term without the return of fire.

The main matrix forest community that defines this system is hemlock beech oak pine forest. Hemlock and beech are the primary late-successional trees in this community, with maximum ages of about 500 and 300 years, respectively. *Quercus rubra* (red oak) and *Pinus strobus* (white pine) are also typically abundant, in contrast to their absence or low abundance in northern hardwood conifer forest systems. Most of the old-field white pine stands in central New Hampshire are successional examples of this system. *Acer saccharum* (sugar maple) and *Betula alleghaniensis* (yellow birch) are occasional but of less importance than in northern hardwood conifer forests. They are most frequent in mesic areas such as concavities and along drainages where *Fraxinus americana* (white ash) is frequent, or locally abundant in patches of semi-rich sugar maple forests. *Picea rubens* (red spruce) and *Abies balsamea* (balsam fir) are generally sparse or absent, but are occasional on the lower slopes of some mountains south of the White Mountains (i.e., Ossipee Mountains, Mt. Monadnock). Central hardwood/ Appalachian species are essentially absent, including hickories (*Carya* spp.), oaks (*Quercus* spp.) other than red oak, dogwoods, and southern herbs (see oak – pine forest description). These more southern species appear in occasional outposts in the south, where oak pine forests dominate.

Numerous herbs are ubiquitous in both the northern hardwood conifer and hemlock hardwood pine forest regions, including *Trientalis borealis* (starflower), *Aralia nudicaulis* (wild sarsaparilla), and *Maianthemum canadense* (Canada mayflower). Plants more prominent in hemlock hardwood pine forests than in northern hardwood conifer forests include *Hamamelis virginiana* (witch hazel), *Betula lenta* (black birch), *Prunus serotina* (black cherry), *Ostrya virginiana* (ironwood), *Viburnum acerifolium* (maple-leaved viburnum), *Gaultheria procumbens* (wintergreen), and *Gaylussacia baccata* (black huckleberry).

Variation in soils or landscape position within this system explains much of the variation in community composition. Hemlock forests often occur in ravines

or extremely rocky sites; beech forests occur on coarse washed till soils; semi-rich mesic sugar maple forests occur in colluvial landscape positions or are associated with bedrock or till with greater base-cation contributions to the soil; hemlock beech northern hardwood forest occurs in more mesic settings or at higher elevations near the transition to northern hardwood conifer forests; dry red oak – white pine forests occur on sandy or rocky soils that may perpetuate oak and pine dominance locally with repeated disturbance.

1.2 Justification

Hemlock hardwood pine forest is the most widely distributed forest type in New Hampshire, covering nearly 50% of the state's land area. Available data indicate that approximately 15% of the state's potential hemlock hardwood pine forest is on permanently protected lands. This forest type supports 140 vertebrate species in the state, including 15 amphibians, 13 reptiles, 73 birds, and 39 mammals. Threatened and endangered wildlife species occurring in this forest type include osprey, Cooper's hawk, timber rattlesnake, and eastern hognose snake. Intense development in New Hampshire has reduced the area of this forest type influenced by natural disturbance regimes, resulting in a preponderance of the forest currently in older age classes. A full range of age classes well distributed on the landscape is important to support the diversity of wildlife species that depend on this forest type.

1.3 Protection and Regulatory Status

Approximately 15% of New Hampshire's hemlock hardwood pine forest occurs on conservation lands. Forestry on state lands is covered by RSAs 216, 217, and 218. RSA 227 stipulates requirements for residual basal area in riparian areas. The manuals "Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire" (Cullen 1996) and "Good Forestry in the Granite State" (FSSWT 1996) provide recommended management practices for sustainable forestry in New Hampshire.

1.4 Distribution

Hemlock hardwood pine forest is widely distributed in New Hampshire with every county except Coos supporting between 5% and 20% of the total area of this forest type. Counties supporting less than 10% of this type include Merrimack, Carroll, Cheshire, Grafton, and Hillsborough.

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

To develop a map of hemlock hardwood pine forest in New Hampshire a model was developed for each ecoregion subsection of the state based on the 2001 NH Land Cover Assessment, elevation, landform, and soils. The model was developed by experts from The Nature Conservancy (TNC) and the New Hampshire Natural Heritage Bureau (NHNHB).

First, relevant forested 2001 New Hampshire Land Cover Assessment grid values were combined with elevation ranges from sea level to 2,000 feet (CSRC 2001, USGS 2003). Ecological Land Units, created by The Nature Conservancy's Conservation Science Support, were then added to capture additional areas likely to have geo-physical conditions favorable to hemlock hardwood pine, or remove areas likely to have geo-physical conditions unfavorable to hemlock hardwood pine (TNC 2003). Specifically, north-facing side slopes and north-facing coves were removed from some land cover/elevation classes, and some land cover/elevation classes were restricted to only north-facing side slopes and north-facing coves. South-facing side slopes and south-facing coves were removed from some land cover/elevation classes, and some land cover/elevation classes were restricted to only south-facing side slopes and south-facing coves.

To further refine the model, soil types associated with hemlock-hardwood-pine were identified by Natural Resource Conservation Service scientists and selected from digitized county soil data, where available (e.g., Merrimack county soils have not been digitized) (NRCS 2002, Homer 2005). The soils were selected, and then clipped to only include forested areas based on the New Hampshire Landcover Assessment, and added to the existing model information. The same was done for Appalachian oak-pine, and then Appalachian oak-pine was used to erase areas from hemlock-hardwood-pine where there was overlap, so that Appalachian oak-pine takes precedence over hemlock-hardwood-pine. NHFG then applied a filter

to determine the majority forest type between neighboring polygons in the TNC model, and smoothed the boundaries to generalize the transition between matrix forest types. This process is expected to somewhat over-predict locations of Appalachian oak-pine, but to better capture broad patterns of Appalachian oak-pine.

Model results were reviewed by experts from TNC, NHFG, and NHNHB, who agreed that the broad patterns depicted by the model align with reasonable expectations. No ground truthing was conducted.

1.7 Sources of Information

The hemlock hardwood pine map was developed based on expert input from scientists from the NHNHB and the New Hampshire Chapter of The Nature Conservancy. The results were reviewed by additional scientists from the NHFG and the Audubon Society of New Hampshire. A variety of GIS data was used to generate the map including elevation data from the United States Geological Survey, landform data from The Nature Conservancy's eastern regional office, land cover data from the New Hampshire Landcover Assessment, and soils as outlined by Natural Resource Conservation Service scientists.

1.8 Extent and Quality of Data

The hemlock-hardwood-pine habitat map depicts broad landscape patterns but has limited fine-scale accuracy. Additional refinements will likely be necessary based on ground truthing of the existing map. The Natural Resource Conservation Service provided a table of soil series that were believed to be strongly correlated with hemlock-hardwood-pine and other forest types (Homer 2005). Soil series were provided by ecoregional subsection and elevation ranges. There was considerable overlap between series outlined for hemlock-hardwood-pine and some of the other forest types, especially Appalachian oak pine. However, the transition between Appalachian oak pine and hemlock hardwood pine was especially difficult to delineate. As such, the soil series that were thought to be most strongly correlated with hemlock hardwood pine but did not overlap with Appalachian oak pine were used in the mapping of hemlock hardwood pine. Additional review and refinement of the soils information is necessary for future iterations.

1.9 Distribution Research

Additional fieldwork is needed to evaluate correlations between soil series and forest type as outlined in Homer (2005). County soil surveys outline soils suitable for forestry from an economic perspective. However, little has been done to evaluate soils from an ecological perspective (e.g., if left unmanaged, an area with a particular soil would eventually succeed to hemlock-hardwood-pine forest).

Fieldwork is also needed to ground truth the hemlock-hardwood-pine map.

Element 2: Species/Habitat Condition

2.1 Scale

County

2.2 Relative Health of Populations

An approximately 3% decrease in forest area occurred between 1992 and 1993 and 2001 in the 9-county area where nearly 100% of New Hampshire's potential Hemlock-Hardwood-Pine forest occurs. An additional approximately 3% decrease is projected to occur between 2001 and 2025 (calculated from data in SPNHF 2005).

2.4 Relative Quality of Habitat Patches

Analysis pending

2.5 Habitat Patch Protection Status

Approximately 15% of the potential hemlock hardwood pine forest area in the 9-county area where nearly 100% of this forest type occurs is in conservation ownership (calculated from TNC data).

2.6 Habitat Management Status

Approximately 10% of the 9-county area where nearly 100% of potential hemlock hardwood pine forest occurs is in certified Tree Farms (calculated from data in Thorne and Sundquist 2001).

2.7 Sources of Information

See 1.7

2.8 Extent and Quality of Data

See 1.8 regarding extent and quality of data associated with the TNC matrix forest map. Tree farm data from Thorne and Sundquist 2001 is based on a New Hampshire Tree Farm program database issued in August 2000. Data regarding changes in forest area from SPNHF 2005 include information from the New Hampshire Land Cover Assessment, 2001 and results of predictive modeling.

2.9 Condition Assessment Research

- Research is needed to determine the extent of this forest type that occurs in large unfragmented blocks
- Research is needed to determine the age class distribution of this forest type on the landscape

Element 3: Habitat Threat Assessment

3.1.1 Development (Habitat Loss and Conversion)

(A) Exposure Pathway
Development reduces matrix forest habitat by converting natural forest to landscaped lawns and impermeable surfaces (e.g., buildings, roads). Development also contributes to forest fragmentation by directly reducing habitat, increasing traffic on existing roads, and requiring construction of new transportation infrastructure.

(B) Direct Evidence
A study of 10 New Hampshire communities found that their populations increased by an average of 70.9% (range 9.7 to 189.7%) between 1974 and 1992, while developed land increased by an average of 137.2%. In the community with 9.7% population growth, developed land increased by 15.9% (New Hampshire Office of State Planning (NHOSP) 2000). See also tables 2.2 and 3.1.

3.1.2 Development (Land Use Planning)

(A) Exposure Pathway
In New Hampshire, land use decisions are made at the municipal scale by volunteer planning boards with little or no training in natural resource issues. In cities and some of the larger towns, professional planning staff evaluate proposed developments and provide input to the planning board, but this is the exception rather than the rule. Most professional planners lack training in ecology or natural resources. Decisions are typically based on engineering and aesthetic considerations, with no recognition of direct or cumulative impacts on the underlying ecological functions of the affected lands or on impacts to wildlife habitat.

(B) Direct Evidence
A Growth Management Advisory Committee convened by the NH Office of State Planning in 1999 concluded that:

- Impacts of growth and development are cumulative over decades
- Development in New Hampshire has occurred incrementally, resulting in fragmentation and loss of important and environmentally sensitive areas, including forest lands and wildlife habitat
- Communities seldom evaluate the potential impacts of their zoning ordinance or land use regulations (NHOSP 2000)

3.1.3 Introduced Species (Forest pathogens)

(A) Exposure Pathway
The hemlock wooly adelgid (*Adelges tsugae*), a small, sap-sucking insect native to Japan and China, became established in the Pacific Northwest in 1924 (na.fs.fed.us/fhp/hwa,). This insect became established in Virginia in the early 1950s and has since been spreading in the northeastern United States. As of 2004, infestations occurred throughout southern New England and in New Hampshire's Rockingham County. The adelgid is predicted to spread north and west throughout the southern half of New Hampshire by 2025 (Souto et al. 1996). This species can be spread through the transportation of infected nursery stock as well as by wind, birds, and mammals. Eastern hemlock (*Tsuga canadensis*) has demonstrated little or no resistance to adelgid damage and mortality (McClure et al. 2001).

(B) Direct Evidence
The hemlock wooly adelgid sucks sap from young hemlock twigs, resulting in needle drop, twig dieback, growth reduction, and tree mortality over the course of several years (USDA Forest Service1994). Infestations were detected in Portsmouth in 2000, Peterborough in 2001, Bedford and Epsom in 2002, Jaffrey in 2003, and Nashua and Hollis in 2004 (UNH Cooperative Extension 2004).

3.2 Sources of Information

Threat information was derived from a work session with forestry professionals and stakeholders, available data, published literature, and personal experience.

3.3 Extent and Quality of Data

Threats to hemlock-hardwood-pine forests resulting from the Hemlock Wooly Adelgid and resulting directly or indirectly from land conversion and development are well documented.

3.4 Threat Assessment Research

The major threats are adequately documented. Research should be directed to condition assessment and conservation actions.

Element 4: Conservation Actions

4.1.1 Incorporate Habitat Conservation into Local Land Use Planning
See Strategies: Local Regulation and Policy

4.1.2 Advise Conservation Commissions and Open Space Committees
See Strategies: Local Regulation and Policy, Education and Outreach

4.1.3 Promote Role of the Regional Planning Commissions in Landscape-Scale Conservation
See Strategies: Local Regulation and Policy

4.1.4 Protect unfragmented blocks and other key wildlife habitats
See Strategies: Land Protection

4.1.5 Develop a comprehensive land protection support program
See Strategies: Land Protection

4.1.6 Advocate adoption of sustainable forestry
See Strategies: Education and Outreach

4.1.7 Establish IRAT for Invasive Species
See Strategies: Interagency Regulation and Policy

4.1.8 Homeowner/landowner education series
See Strategies: Education and Outreach

4.1.9. Foster supply of native plants
See Strategies: Education and Outreach

4.2 Conservation Action Research

Research is needed to provide a sound scientific basis for new tools to help municipalities maintain large forest blocks and significant wildlife habitat in the face of development. Such research could include:

- Road noise effects on forest bird distribution and breeding status
- Behavior and land use of mesocarnivores in relation to development and road densities
- Bear use of mast stands relative to proximity of development
- Effects of residential lot sizes on habitat suitability and landscape permeability for selected wildlife species

Element 5. References

5.1 Literature

Complex Systems Research Center. 2001. New Hampshire land cover assessment – 2001. 30m raster data. Available from GRANIT, University of New Hampshire.

Homer, J. 2005. Soil types corresponding to the NH Natural Heritage Bureau forest systems classification. U.S. Department of Agriculture, Natural Resource Conservation Service, Lancaster, NH, U.S.A., Unpublished Report to New Hampshire Fish and Game Department.

Keys, J.E. and C.A. Carpenter. 1995. Ecological units of the eastern United States: first approxi-

mation. U.S. Department of Agriculture, Forest Service.

McClure, M.S., S.M. Salom, and K.S. Shields. 2001. USDA Forest Service Forest Health Technology Enterprise Team, FHTET-2001-03. Morgantown, WV

Natural Resources Conservation Service. Date varies, in progress with last revision in 2002. Soil Units of Rockingham, Sullivan, Cheshire, and Strafford Counties. Automated by and available from GRANIT, University of New Hampshire.

The Nature Conservancy, Conservation Science Support. 2003. Ecological Land Units. 30m raster data. Available from TNC, Eastern Resource Office, Boston, MA.

Sperduto, D, and M. Zankel. 2005. Distribution of matrix forest systems in New Hampshire by subsection, elevation, slope, and aspect. NH Department of Resources and Economic Development, Division of Forests and Lands, Natural Heritage Bureau, and The Nature Conservancy, Concord, NH, U.S.A. Unpublished Report to New Hampshire Fish and Game Department.

United States Geological Survey. Date varies, complete by 2003. National Elevation Dataset. 30m raster data. Projected by Complex Systems Research Center in January 2005, available from GRANIT, University of New Hampshire.

5.2 Data sources

USDA Forest Service. Northeastern Area: Hemlock Wooly Adelgid. http://na.fs.fed.us/fhp/hwa/.

Souto, D., T. Luther, and B. Chianese. 1996. Past and current status of HWA in eastern and Carolina hemlock stands. Pp. 9-15 in S.M. Salom, T.C. Tignor, and R.C. Reardon, eds. Proceedings of the First Hemlock Wooly Adelgid Review, USDA Forest Service, Morgantown, WV. http://na.fs.fed.us/fhp/hwa/maps/hwaprojectspreadmap.htm.

USDA Forest Service.2003. Hemlock Wooly Adelgid Pest Alert. USDA Forest Service Northeastern Area NA-PR-03-94. http://na.fs.fed.us/fhp/palerts/hemlock/hemlock.htm.

UNH Cooperative Extension. 2004. Hemlock Wooly Adelgid Invades State. http://ceinfo.unh.edu/News/new72204.htm

HABITAT PROFILE

High Elevation Spruce-Fir Forest

Associated Species: Spruce Grouse, Bay-Breasted Warbler, Bicknell's Thrush, American Marten, Canadian Lynx, Northern Bog Lemming

Global Rank: NA
State Rank: High-elevation spruce-fir, S4; High-elevation balsam fir, S3S4; Montane black spruce-red spruce, S1; Northern hardwood-spruce-fir, S4
Authors: Jillian R Kelly, New Hampshire Fish and Game; Carol R. Foss, Audubon Society of New Hampshire

Element 1: Distribution and Habitat

1.1 Habitat Description

Harsh climatic extremes and highly erosive soils play a significant role in determining the structure and species composition of high elevation spruce fir forests found in New Hampshire. Increased rainfall (more than 6 in per 1000 ft in elevation), snow cover (increase in weeks of snow cover per year), relative humidity (resulting in prolonged cloud cover) and wind movement (up to 25% more at 3,800 ft), coupled with decreased mean air temperature (decrease in number of frost free days) and shallow, nutrient poor soils result in stands predominated by coniferous tree species. The coniferous stands found at high elevations experience drastically slowed and limited growth due to the truncated growing season and harsh climatic extremes (Vogelmann et al. 1969) and have been separated into 4 primary natural communities: high elevation spruce fir (S4), high elevation balsam fir (S3S4), montane black spruce-red spruce (S1), and northern hardwood-spruce fir (S4) (Sperduto and Nichols 2004).

High elevation spruce-fir forests can be found between 2,500 and 3,500 ft. in elevation on upper mountain slopes and ridge tops (Sperduto and Nichols 2004). According to Sperduto and Nichols (2004), forest composition has been influenced by disturbance history, soils, and elevation. High elevation soils are generally very nutrient-poor, with a deep, slowly decomposing humus layer and therefore can impact species composition and growth (Sperduto and Nichols 2004). Characteristic vegetation includes red spruce (*Picea rubens*), balsam fir (A*bies balsamea*) and heartleaf, paper and yellow birches (*Betula spp.;* Sperduto and Nichols 2004).

High elevation balsam fir forests are found within the spruce-fir zone (3,500 to 4,500 ft) and can be considered the transition zone to black spruce (*Picea mariana*)/balsam fir krummholz or heath/krummholz which was categorized with the alpine zone for this process (Sperduto and Nichols 2004, J. Oehler personal comm.). Fir waves are often found within this zone and are characterized as linear patches of blow down or standing dead trees, oriented perpendicular to the prevailing wind, and arranged in a progression of waves of different age regeneration (Sperduto and Nichols 2004). Characteristic vegetation includes balsam fir (dominant;), birch, and red spruce (occasional; Sperduto and Nichols 2004).

Montane black spruce-red spruce forests are uncommon to rare in New Hampshire and are found at mid to high-elevation valley bottoms (2,500 to 3,000 ft.) in the White Mountains (Sperduto and Nichols 2004). Characteristic vegetation includes black spruce, and red spruce, mixing in with balsam fir (Sperduto and Nichols 2004).

Northern hardwood-spruce-fir forests are a transitional forest type found at intermediate elevations (2,100 to 2,800 ft). This forest type generally has lower productivity, increased moisture availability, and a higher percent cover of herbaceous species compared to lower elevation forests (Sperduto and Nichols 2004).

Habitats that may be embedded in high elevation spruce-fir forests include alpine communities, rocky ridges, cliffs, talus slope, and high elevation wetlands. See associated profiles.

1.2 Justification

High elevation spruce-fir forest has a very limited distribution in New Hampshire, covering approximately 4% of the state's land area. This forest type supports 66 vertebrate species in the state, including 2 amphibians, 2 reptiles, 38 birds, and 24 mammals. Threatened and endangered wildlife using this forest type include Canadian lynx and American marten. Blackpoll warblers and Bicknell's thrush breed exclusively in high elevation spruce-fir habitats. Other species that use high elevation habitat and may be less common at lower elevations include spruce grouse, boreal chickadee, white-winged crossbill, and three-toed woodpecker. Common species that use the spruce-fir cover at high elevations include moose, deer, bear, fisher, and common raven. Moose tend to winter at higher elevations where they browse on fir and mountain ash, and yellow birch. Black bears will use these stands for escape, denning, or even resting cover. High elevation ridgelines also serve as important migratory routes for songbirds, raptors, and bats.

High elevation spruce-fir provides some of the last areas relatively free of human disturbance. Furthermore, due to conservation efforts and poor accessibility, the high elevation areas represent some of the last large, remote, contiguous blocks of spruce-fir habitat. Silviculture practices resulting from budworm harvests and the historic high value of spruce-fir and/or mill demands that have been placed on spruce-fir have dramatically affected spruce-fir distribution at lower elevations, thus making high elevation habitat that much more important (Staats 1996).

Lastly, soil cover at these higher elevations is much more fragile (i.e., soil compaction can dramatically reduce the ability of the soil absorb extra moisture) than that found at lower elevations. Soils above 2,700 ft are usually very acidic, resulting in reduced nutrient availability to plants. Increased rainfall, snowfall, and moisture absorption capabilities of high elevation soils (due to the higher organic components) also make them a prime area for water filtration and water supply.

1.3 Protection and Regulatory Status

Approximately 87% of New Hampshire's High Elevation Spruce-Fir forest occurs on conservation lands. Current protection for high elevation spruce-fir includes a no-cut zone above 2,700 ft on state lands and Forest Service property and private conservation lands (Bunnell Tract and The Nature Conservancy), zoning ordinances (PD6 zones) in unincorporated towns, the cooperative High Elevation MOU for large landowners developed by NHFG and DRED, a conservation easement (held by DRED), and finally an MOU between the WMNF and NHFG pertaining to the management of wildlife habitats.

1.4 Habitat Distribution

High elevation spruce-fir habitat occurs in the White Mountain, Mahoosuc-Rangeley, and Connecticut Lake ecological subsections. High elevation spruce-fir can also occurs locally at higher elevations of the Vermont Uplands subsection in central/south-central New Hampshire. The majority of this forest type is found within the White Mountain subsection.

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

High elevation spruce-fir habitat was mapped using the Vermont Institute of Natural Science (VINS) elevation threshold that was dominated by spruce-fir, developed as part of a model to predict Bicknell's thrush presence/absence in and around New Hampshire. The threshold descends with an increase in latitude and reflects climatic effects on forest composition and structure. The New Hampshire Land Cover Assessment dataset was also used in this mapping process to identify spruce-fir cover above the elevation threshold in New Hampshire (CSRC 2001). The result was then combined with Hale's (in press) Bicknell's thrush probability surface. Hale developed the model for the White Mountain National Forest using image-derived data layers of dominant vegetation height and distance to nearest fir sapling cover type, a digital elevation model, and point count data to parameterize a multivariate logistic habitat model. Areas identified by Hale's probability surface and fir

sapling land cover, were included even if they fell below the VINS elevation threshold.

1.7 Sources of Information

High elevation spruce-fir habitat was identified using models developed by Hale (in press), Vermont Institute of Natural Science (VINS: Lambert et al. in press) combined with the New Hampshire Land cover analysis (CSRC 2001) and New Hampshire Natural Heritage Natural Communities of New Hampshire publication (Sperduto and Nichols 2004). Literature review and meetings with field experts also were used in the process.

1.8 Extent and Quality of Data

Information on high elevation spruce-fir distribution was derived primarily from the NHNHB description of Natural Communities in New Hampshire, and a literature search.

1.9 Distribution Research

Distribution research should concentrate on the historical distribution and abundance of high elevation spruce-fir, the area of high elevation spruce-fir forest that has experienced harvesting within the past 20 years, the long-term impacts of harvesting on forest structure and species composition, the overall effectiveness of the High Elevation MOU, and the effects of acid deposition and global warming on the distribution and abundance of high elevation spruce-fir.

Element 2: Species/Habitat Condition

2.1 Scale

Conservation-planning units for the high elevation spruce-fir habitat were based on watershed, land ownership, and proximity of multiple patches of high elevation habitat to one another (figure 2). Patches of habitat smaller than 5 acres were excluded from this analysis. Some analysis was also performed at the county scale.

2.2 Relative Health of Habitat

Historically, extensive alteration and harvesting occurred throughout the distribution of high elevation spruce-fir. Current habitat under federal or state ownership is protected from further harvesting, while parcels that remain under private ownership exhibit extensive impacts from recent harvesting.
An approximately 3% decrease in forest area occurred between 1992 and 1993 and 2001 in the two-county area where approximately 95% of New Hampshire's potential High Elevation Spruce-Fir forest occurs. An additional approximately 1% decrease is projected to occur between 2001 and 2025 (Calculated from data in SPNHF 2005).

2.3 Population Management Status

N/A

2.4 Relative Quality of Habitat Patches

Habitat units mapped at the scale defined for this process that would provide key ecological attributes include all the large patches, virtually all the medium patches and most of the small patches. Habitat patches that may not provide key ecological attributes include smaller (less than 50 acres) patches, which are isolated from larger patches.

The largest habitat patches can be found in the WMNF. Smaller patches include ridgelines moving north toward the Canadian border (figure 2). Trends or viability of key habitat for conservation actions include conservation of critical Bicknell's thrush habitat in WMNF, and recent conservation initiative to conserve the northern most high elevation spruce-fir crucial to more northern boreal species that will aid in linkages between high and low elevation spruce-fir forests.

2.5 Habitat Patch Protection Status

All of the large patches are currently in conservation ownership (WMNF). Ownership of medium-sized patches is distributed between the state, WMNF, and large private landowners. Of the 13 medium patches, five are preserved, two are conserved, and six are regulated under the High Elevation MOU. Of the six regulated patches, four also have zoning as PD6 zones part of an unincorporated town. Of the five small patches, one is preserved, two are unknown, and two are regulated under the High Elevation MOU and zoning for unincorporated towns.

Habitat management and restoration of high elevation spruce-fir has been highly effective. 92.1% of the high elevation habitat in New Hampshire is currently conservation land, or under guidance of a conservation easement. Virtually all of the remaining 7.8% falls under unincorporated town restrictions as PD6 zones, and/or have agreed to the State's high elevation MOU. The remaining (less than 1%) is unprotected by the high elevation MOU, conservation, easement, or unincorporated town zoning.

2.6 Habitat Management Status

Habitat management and restoration policy in the WMNF and virtually all state and conservation land is to allow natural succession to regenerate as much of the historical spruce-fir area as possible. Timber harvesting is still proposed under private land ownerships, with little to no effort to maximize spruce-fir regeneration after harvesting.

2.7 Sources of Information

Guide to the natural communities of New Hampshire (2004), Master Plan for the Unincorporated Places in Coos County (1989), Zoning Ordinances for Coos County unincorporated places (1991), New Hampshire High Elevation MOU (1996) were used as sources regarding habitat and distribution of high elevation habitat.

2.8 Extent and Quality of Data

See 1.8 regarding extent and quality of data associated with the TNC matrix forest map. Data regarding changes in forest area from SPNHF 2005 includes information from the New Hampshire Land Cover Assessment, 2001 and results of predictive modeling.

2.9 Condition Assessment Research

- Research is needed to determine the age class distribution of this forest type on the landscape.
- Research is needed to determine the proportions and distributions of live and dead/dying stands of this forest type.

Element 3: Habitat Threat Assessment

3.1.1 Acid Deposition

(A) Exposure Pathway
Combustion in vehicle engines, power plants, and other industrial processes generates nitrogen oxides and sulfur oxides, which enter the atmosphere and are transformed into acids. These chemicals can travel for hundreds of miles in the upper atmosphere before returning to earth as acid precipitation or dry deposition. In New Hampshire, vehicles generate 51% of nitrogen oxide emissions, while power plants generate 90% of sulfur oxide emissions and 39% of nitrogen emissions (NHDES 1989). However, much of the acidic deposition in the state comes from heavily industrialized areas in the mid-western and southwestern United States (New Hampshire Comparative Risk Project 1997). Acid deposition resulting from the emission of sulphur dioxide and nitrogen oxides leaches calcium from forest soils, thus making trees, especially high elevation spruce-fir, susceptible to stress. Sulphur and nitrogen oxides occur naturally, but more than 90% of the sulphur and 95% of the nitrogen in eastern North America originate from human sources, including emissions from the use of coal to produce electricity, base metal smelting, and fuel combustion in vehicles (www.atl.ec.gc.ca/msc/as/acidfaq.html).

(B) Direct Evidence
Northern New Hampshire, where most of the State's high elevation spruce-fir forest is located lies within an area of particularly low pH precipitation and high nitrate and excess sulfate deposition (Freedman 1995). Long-term data from the Hubbard Brook Experimental Forest document a long history of severe acid deposition (Likens et al. 1984).

Evidence of the severity, urgency, and underlying mechanisms of the threats associated with acid deposition in high elevation spruce/fir includes: Brynne Lazarus et al. (2004), Fermandez et al. (2003), Johnson et al (1986), Craig and Friedland (1991), Dehayes et al. (1999).

According to Lazarus et al. (2004), acid deposition is a significant factor contributing to the loss of spruce due to winter injury. Winter injury has been linked to the overall widespread decline of red spruce, particularly in the northeast (1960-1980). Johnson et

al. (1986) found that acidic compounds and heavy metals are approximately 3 to 8 times higher in high elevation coniferous forests than in adjacent low elevation hardwood forests. High deposition rates are likely the result of interception of compounds from cloud water.

3.1.2 Energy and Communication Infrastructure

(A) Exposure Pathway
Federal legislation and tax incentives have resulted in a rapid increase in wind energy development proposals. Currently, regulating state agencies and local governments have little information on the long-term local impacts and cost effectiveness of wind farms. Therefore, the ability to respond to proposals and mitigate impacts is limited. The direct threat is to the unique and fragile habitats of wind farm sites, as well as to the wildlife species associated with high elevation spruce-fir habitats. The development of wind farms results in a direct loss of habitat through road and facility construction and maintenance. Species such as spruce grouse, bay-breasted warbler, marten, Canada lynx, and Bicknell's thrush experience a direct loss of habitat as well as habitat fragmentation.

(B) Direct Evidence: Evidence that can be used to evaluate the severity, urgency, and underlying mechanisms of the threats associated with wind farm development on high elevation spruce-fir includes: USFWS (2003), Watefield (2003), PIF, VINS, Windpower Monthly (2003), Wind Power Development in Vermont and Bicknell's Thrush: A Primer

3.2 Sources of Information

Threat information was derived from a work session with forestry professionals and stakeholders, available data, published literature, and personal experience.

3.3 Extent and Quality of Data

Documentation on the impacts of wind farm development is limited to short-term studies. Evidence of timber harvesting impacts is based primarily on local expertise, as well as some research. Evidence on climate change and acid deposition is extensive and is concentrated primarily on extreme conditions, such as those found at higher elevations.

3.4 Threat Assessment Research

Information on presence, abundance, and population trends of species characteristic of high elevation spruce-fir should be of priority to collect. Impacts of climate change, forestry operations, acid deposition, and succession will be important as threats shift in impact and severity.

Element 4: Conservation Actions

4.1.1 Advise Integrated Interagency Wind Energy Risk Assessment Team, Regulation, and Policy

(A) Wind Farm Development

(B) Justification

- Examining potential long and short-term implications of wind farm development and maintenance will aid in making decisions and recommendations dealing with wind farm proposals at local, state, regional and a national level
- A measurable ecological response will be the amount of habitat that can be maintained or saved due to the complete documentation on wind farm impacts
- The spatial scale of the action is appropriate for the scale of the threat (regional)
- The timeframe for the action is immediate
- The action can be adapted based on new information

(C) Conservation Performance Objective
There is a need to understand the potential long and short-term implications of wind farm development, specifically on high elevation spruce-fir and the associated wildlife species in the Northeast.

(D) Performance Monitoring
Examining implications on other wind farm projects and identifying projects that have been approved should aid in performance monitoring.

(E) Ecological Response Objective
The ecological response objective is no net loss or impact on high elevation spruce-fir.

(F) Response Monitoring
To monitor the response the overall amount of high elevation spruce-fir should be tracked, especially as new data become available. Examining potential impacts of projects on habitat and associated species within the Northeast will also be important if wind towers are built in a specific area.

(G) Implementation
Implementation should occur through the NHFG, USFWS, and research through UNH.

(H) Feasibility: 1.25

4.1.2 Review of Master Plan for the Unincorporated Places in Coos County, Regulation and Policy

(A) Direct threats affected: Energy and Communication Infrastructure, Unsustainable Harvest (Forestry Operations and Management), Recreation, and Development

(B) Justification:

- Revision of the Master Plan for Unincorporated Towns, specifically dealing with development associated with wind farms, communication towers, ski areas and residential will lessen the relevant threats at specific locations.
- The beneficial ecological response will be no net loss or fragmentation of high elevation spruce-fir outside of protected areas.
- The spatial scale of the action is appropriate because of the 7.9% of the high elevation spruce-fir outside of conservation, only 0.3% is outside of the unincorporated towns.
- The timeframe is appropriate because the unincorporated towns planning board is currently dealing with proposals listed as threats.
- The conservation action can be adapted based on new information collected pertaining to the threats.

(C) Conservation Performance Objective
The conservation performance objective is to have more permanent regulation for high elevation spruce-fir habitat, specifically to deal with wind farm and communication tower proposals. Coordinate with the county commissioners in reviewing the unincorporated places master plan and zoning ordinances. For example, examine the guidelines of timber harvesting at high elevations as they relate to development proposals.

(D) Performance Monitoring
Performance monitoring can be done by examining the extent of fluctuation in high elevation spruce-fir area in the unincorporated towns. Actual changes to unincorporated town zoning can also provide an indication of performance.

(E) Ecological Response Objective
The desired ecological response is a decrease or stabilization in the loss of high elevation spruce-fir. Wildlife habitat in current and potential high elevation spruce-fir will be enhanced by minimizing the number of proposals that are approved without sufficient knowledge.

(F) Response Monitoring
Response monitoring can be done by mapping and monitoring habitat as new data become available (e.g., GIS data).

(G) Implementation
Implementation can be done through NHFG as data become available.

(H) Feasibility: 3.28

4.1.3 Protection and easements on remaining high elevation spruce-fir habitat, Habitat Protection

(A) Direct threats affected: Energy and Communication Infrastructure, Unsustainable Harvest (Forestry Operations and Management), Recreation, Development

(B) Justification

- The conservation action will address the threats by assessing protection based on the percentage of land with specific protection or

conservation status.

- The protection, conservation, and easements can concentrate on the most ecologically significant habitats, or on those in need of the most protection based on threats.
- The time frame is appropriate for the immediate threat to portions of the high elevation spruce-fir habitat.

(C) Conservation Performance Objective
To increase the amount of habitat protected or managed.

(D) Performance Monitoring
Assess the amount of high elevation spruce-fir (with GIS) with no conservation easements and or regulation to minimize loss and impacts.

(E) Ecological Response Objective
The stabilization or gain of high elevation spruce-fir habitat and associated species

(F) Response Monitoring
Response monitoring can be done by mapping habitat and monitoring associated high elevation wildlife species.

(G) Implementation
Implementation can be done through continued use of the High Elevation MOU, and through evaluation and expansion of unincorporated town zoning.

(H) Feasibility: 1.75

4.1.4 Education and outreach on causes, effects, and potential reduction of acid deposition

(A) Direct threats affected: Climate Change, Acid Deposition

(B) Justification

- The spatial scale of the threat is global, yet can be addressed statewide.
- The threats are current, and should be addressed as soon as possible.
- The conservation action can be adapted to new information.

(C) Conservation Performance Objective
The conservation performance objective is to decrease the loss of spruce-fir due to climate change and acid deposition.

(D) Performance Monitoring
Identifying the amount and quality of high elevation spruce-fir habitat can be the performance-monitoring objective.

(E) Ecological Response Objective
The ecological response objective is to increase or stabilize the amount of high elevation spruce-fir.

(F) Response Monitoring
Response monitoring can be done by identifying long-term changes in high elevation spruce-fir. Remapping the habitat when new data is available can do this.

(G) Implementation
NHFG can do the mapping using GIS. Education should occur at the state or national level.

(H) Feasibility: 1.25

Element 5: References

5.1 Literature

Craig, B. W. and A. J. Friedland. 1991. Spatial Patterns in Forest Composition and Standing Dead Red Spruce in Montane Forests of the Adirondacks and Northern Appalachians. Environmental Monitoring and Assessment 18:129-143.

Complex Systems Research Center, University of New Hampshire. 2001. NH GRANIT database. Complex Systems Research Center, Durham NH.

DeHayes, D. H, P. G. Schaberg, G. J. Hawley, and G. R. Strimbeck. 1999. Acid Rain Impacts on Calcium Nutrition and Forest Health. BioScience 49(10): 789-800.

Environment Canada. 2005. Atmospheric Science Division Acid Rain FAQ sheet. (www.stl.ec.gc.ca/msc/as/acidfaq.html)

Fernandez I.J., L. E. Rustad, S. A. Norton, J. S. Kahl, and B. J. Cosby. 2003. Experimental Acidification Causes Soil Base-Cation Depletion at the Bear Brook Watershed in Maine. Soil Science Society American Journal 67:1909-1919.

Intergovernmental Panel on Climate Change. 2002. Climate Change and Biodiversity. IPCC Technical Paper V. (http://www.ipcc.ch/pub/techrep.htm)

Iverson , L. R., A. M. Prasad, B. J. Hale, and E. K. Sutherland. 1999. An atlas of current and potential future distributions of common trees of the eastern United States. General Technical Report NE-265. Northeastern Research Station, USDA Forest Service.

Johnson, A. H., A. J. Friedland, J. G. Dushoff. 1986. Recent and Historic Red Spruce Mortality: Evidence of Climatic Influence. Water, Air and Soil Pollution 30:319-330.

Kerlinger, P. 2000. Avian mortality at communication towers: a review of recent literature, research, and methodology. Report prepared for: USFWS, Office of Migratory Bird Management.

Lazarus, B. E. P. G. Schaberg, D. H. DeHayes, G. J. Hawley. 2004. Severe red spruce winter injury in 2003 creates unusual ecological even in the northeastern United States. Canadian Journal of Forest Research. 34:1784-1788.

Matthews, S. N., R. J. O'Connor, L. R. Iverson, A. M Prasad. ?. Atlas of Climate change Effects in 150 Bird Species of the Eastern United States. GTR NE-318.

Partners in Flight, Northeast Working Group (PIF). 2003. Communication Towers and Migrating Birds.

Sperduto, D.D. and W. F. Nichols. 2004. Natural Communities of New Hampshire. NH Natural Heritage Bureau, Concord, NH. Pub. UNH Cooperative Extension, Durham NH.

Staats W. 1996. High Elevation MOU, Description of High Elevation Areas. Unpubl. Report, New Hampshire Fish and Game, Lancaster.

USFWS. 2003. Interim Guidelines to Avoid and Minimize Wildlife Impacts From Wind Turbines. USFWS memo.

Vermont Institute of Natural Science (VINS). 2003. Wind Power Development in Vermont and Bicknell's Thrush: A Primer.

Lamber, J.D., K.P. McFarland, C.C. Rimmer, and S.D. Faccio. 2001. Mountain Birdwatch 2000: final report to the U.S. Fish and Wildlife Service. Unpubl. Report, Vermont Institute of Natural Science, Woodstock.

Vogelmann H., J. W. Marvin, M. McCormack. 1969. Ecology of the Higher Elevations in the Green Mountains of Vermont. Unpubl. Report to the Governor's Commission on Environmental Control, Burlington.

Wakefield, S. 2003. Important Considerations when Siting Wind Farms in Vermont. TNC.

Windpower Monthly (http://www.wpm.co.nx/oct03/cont.htm)

5.2 Data Sources

W. Staats. 2005. Personal Communication. New Hampshire Fish and Game Department

HABITAT PROFILE

Coastal Transitional Watersheds

Associated Species: American Eel (Anguilla rostrata), Atlantic Salmon (Salmo salar), Bridle Shiner (Notropis bifrenatus), Burbot (Lota lota), Brook Trout (Salvelinus fontinalis), Lake Trout (Salvelinus namaycush), Lake Whitefish (Coregonus clupeaformis), Rainbow Smelt (Osmerus mordax), Round Whitefish (Prosopium cylindraceum), Slimy Sculpin (Cottus cognatus), Sunapee trout (Salvelinus aureolus), Tessellated Darter (Etheostoma olmstedi).

Federal Listing: Not listed
State Listing: Not listed
Global Rank: Not ranked
State Rank: Not ranked
Author: New Hampshire Fish and Game and The Nature Conservancy

Element 1: Distribution and Habitat

1.1 Habitat Description

Coastal transitional watersheds encompass watersheds with low elevation and some areas of moderate elevation between 800-1,700 ft. These watersheds include major tributaries to the Merrimack River and those watersheds dominated by large lakes and their tributaries in New Hampshire's Lakes Region. Acidic bedrock and sandy outwash plains are dominant. Several watersheds extending into Maine have a much higher percentage of calcareous bedrock, but these enriched sections do not influence the New Hampshire headwaters. The larger rivers in this watershed group are low gradient and meandering. There are greater percentages of moderate and high gradient tributaries in this watershed group than in the low tidal and low non-tidal groups, although low and very low gradient tributaries still dominate and very high gradient tributaries are nonexistent.

Habitats in this group are dominated by riffle-pool systems. There are some habitats with step-pool systems in high gradient areas and some with dune-ripple systems in areas of very low gradient, high sinuosity, and deep sands. Fish communities are dominated by warmwater species, although some coldwater communities may be found in areas with high groundwater input and/or higher elevation. The large lakes found in this watershed group provide unique habitats for a variety of lake-associated plant and animal species.

Low-Moderate Fine Scale Systems 10 and 14

Due to its proximity to the lower Merrimack River mainstem, fine scale system 10 is very similar to fine scale systems 11 and 12, although system 10 has substantial areas of moderate elevation, steeper landforms, and higher gradient tributaries. Fine scale systems 10 and 14 have nearly identical elevation profiles. Both are acidic in geology, but system 14 is more acidic-granitic and is dominated by very large lakes and/or streams feeding into these large lakes.

1.2 Justification

The most compelling and unique habitats in this watershed group are the large lakes in the Lakes Region and the sandy, meandering, and large tributaries to the Merrimack River in south-central New Hampshire. The Lakes Region is unique due to its large, deep, warmwater and coldwater fisheries and the watersheds that support them. The large Merrimack River tributaries include rivers that are larger, flatter, lower in elevation, and likely warmer than the large tributaries to the north. For example, these watersheds average over 348 km^2 (86,000 acres) compared to 188 km^2 (46,500 acres) for the Pemigewasset tributary watersheds just to the north. These large

Merrimack River tributaries are crucial for supporting numerous native and diadromous fishes.

1.4 Habitat Distribution

Low-moderate major watersheds occur in 14 watersheds in New Hampshire's larger tributary streams and rivers of the Merrimack River basin. They include watersheds that range from as far south as the Souhegan River watershed, to watersheds encompassing the drainages of the Lakes Region and the Ossipee River. Other major rivers in this habitat group include the main stems of the Piscataquog and Lower Contoocook Rivers to the west, and the Suncook, Soucook, Winnipesaukee Rivers to the east. Watersheds in this habitat group also surround Lakes Winnipesaukee, Winnisquam, Squam, Wentworth, and Ossipee. The easternmost watersheds are primarily in Maine, with the New Hampshire portions encompassing the acidic sandy outwash plains of the Ossipee and Little Ossipee headwaters.

This watershed group sits entirely within the Merrimack-Saco-Charles River Ecological Drainage Unit (EDU). This group primarily overlaps with the Southern New England Coastal Hills and Plains and the New Hampshire-Vermont Upland subsections of TNC's Lower New England-Northern Piedmont Ecoregion.

1.8 Extent and quality of data

Like all other major and fine scale habitat groups, elevation is the primary parameter defining low-moderate watersheds. Gentle side slopes and hill slopes are associated with the low to moderate elevations. Similar to other major watershed groups across New Hampshire, this watershed group has acidic bedrock. The rivers in these watersheds are acidic, moderately sloped rivers dominated by the sandy and cobble substrates characteristic of the Merrimack River drainage. While some watersheds and rivers in the moderate elevation-south major watershed group (fine scale system 9) share characteristics with this group, cold headwater streams at higher elevations are more dominant.

Element 2: Species/Habitat Condition

2.1 Scale

Due to the large land area covered by the major watershed groups (Figure 3), a fine scale classification (Figure 4) was used, when possible, to assess the relative condition of aquatic habitats across the state. The types and sources of information were extremely variable and covered many different scales, and so the following sections refer to both the major and fine scale systems. The actual scale at which the natural conditions and processes lead to differences in aquatic communities is unknown.

Low-moderate major watersheds (Figure 3) include major tributaries to the Merrimack River and watersheds dominated by large lakes in New Hampshire's Lakes Region. They are divided into two conservation planning units. Fine scale system 10 contains 6 watersheds of the major tributaries to the Merrimack River. Fine scale system 14 includes 8 watersheds that contain large lakes and their adjacent tributaries (Figure 4).

2.2 Relative Quality of Habitat Patches

Fine scale system 10 encompasses 3,017 km^2 (745,406 acres). Headwater streams (watershed area <48.28 km^2) dominate, comprising 85% of the total river/stream area. Small rivers (watershed area of 77.7-518.0 km^2) and medium rivers (watershed area of 518-2590 km^2) comprise 8% and 7% of the total river/stream area, respectively.

Fine scale system 14 encompasses 1,686 km^2 (416,611 acres). Headwater streams dominate, comprising 73% of the total river/stream area. Small rivers and medium rivers comprise 20% and 7% of the total river/stream area, respectively.

The Contoocook and North Branch Rivers provide several significant habitats and resources. The rivers and adjacent areas provide habitat for 117 bird species, including the pied-billed grebe (*Podilymbus podiceps*), bald eagle (*Haliaeetus leucocephalus*), common loon (*Gavia immer*), osprey (*Pandion haliaetus*), northern harrier (*Circus cyaneus*), common nighthawk (*Chordeiles minor*), eastern bluebird (*Sialia sialis*), purple martin (*Progne subis*), and great blue heron (*Ardea herodias*). There are 48 mammals and several endangered plant species present. The Contoocook

River provides both warm and coldwater fish habitat with its variety of surface waters, including rapids, impoundments, and slow waters. The Contoocook River is also an important area for the recovery of anadromous fish in the Merrimack River watershed. The Contoocook and North Branch Rivers have 25 and 5 impoundments, respectively, that are used for hydroelectricity, water storage, and flood control. The 7 major water withdrawals from the Contoocook River are used for town water supplies, sewage treatment, and industrial operations and account for more than 75,708L (20,000 gal) of water per day. There are 26 permits to discharge water from hydroelectric, wastewater treatment, and industrial facilities in the Contoocook River (NHDES 1991).

The three branches of the Piscataquog River (middle, north, and south) have excellent water quality and provide adequate habitat for several species of concern. Despite increased trends in development throughout the watershed, the river maintains pristine characteristics. A total of 4,407 ha (10,890 ac) of land along the river are protected. The watershed supports several bird species, including pied-billed grebe, peregrine falcon (*Falco peregrinus*), common loon, osprey, northern harrier, Cooper's hawk (*Accipiter cooperii*), and common nighthawk. There are amphibians and reptiles such as eastern hognose snake (*Heterodon platirhinos*), Blanding's turtle (*Emys blandingii*), eastern box turtle (*Terrapene carolina*), wood turtle (*Clemmys insculpta*), and spotted turtle (*Clemmys guttata*), and an exceptional abundance of the brook floater mussel (*Alasmidonta varicosa*). The diverse riffle-pool habitats of this 95.7% free-flowing system support both warm and coldwater fish species. The Piscataquog River is one of the most important Atlantic salmon nursery tributaries to the Merrimack River in southern New Hampshire. The watershed supports an exceptionally rare orchid and the small whorled pogonia (*Isotria medeoloides*). Impoundments along the Piscataquog River are used for hydroelectricity production and water storage. There are no permits for water discharge and only one permitted water withdrawal site for irrigation (NHDES 1993).

The Souhegan River in south-central New Hampshire also faces increased pressure from development. While local populations have continued to grow, there are still large areas of undeveloped land along the river. Land use is typically rural, with forests broken up by scattered residential housing. The river flows through more developed village centers. Several towns have produced plans for land use and other regulatory controls. In many towns, there are conservation areas for floodplains, wetlands, and aquifers. The Souhegan River provides a travel corridor for wildlife through areas with high population densities. The eastern hognose snake, blue spotted salamander (*Ambystoma laterale*), Blanding's turtle, spotted turtle, marbled salamander (*Ambystoma opacum*), great blue heron, Long's bitter cress (*Cardamine longii*), wild lupine (*Lupinus perennis*), bird's foot violet (*Viola pedata*), Siberian chives (*Allium schoenoprasum* var. *sibiricum*), skydrop aster (*Symphyotrichum patens* var. *patens*), goat's rue (*Tephrosia virginiana*), stiff tick-trefoil (*Desmodium obtusum*), and giant rhododendron (*Rhododendron maximum*) are examples of the 28 threatened or endangered species observed within the river corridor (NHDES 2000, Souhegan Watershed Association (SWA) 2003).

There is habitat for both warm and coldwater fish species. The Souhegan River is a productive Atlantic salmon nursery with adequate water temperatures, dissolved oxygen levels, food sources, and downstream fish passages on all impoundments, although there are no upstream fish passages. The Souhegan River is largely free flowing. Hydroelectric facilities operate by run-of-the-river methods. There are 9 registered water withdrawals for agricultural, industrial, irrigation, and municipal water supplies. There are 5 permitted discharge sites from municipal and industrial wastewater treatment facilities. Nonpoint source pollution is the greatest threat to water quality of the Souhegan River. Runoff from fertilizers, pesticides, herbicides, stormwater, and faulty septic systems can lead to excessive nutrients in the river system (SWA 2003).

Lakes and ponds throughout the watersheds of the Lakes Region and outer Merrimack River in New Hampshire were examined using GIS analysis. Lakes and ponds with surface areas less than 4.05 ha (10 ac) comprise 90% of the total number of lakes and ponds. There is a high concentration of large lakes in this area. Seven lakes are greater than 405 ha (1,000 ac) (Merrymeeting Lake (499 ha), Ossipee Lake (1,628 ha), Paugus Bay (497 ha), Squam Lake (2,748 ha), Wentworth Lake (1,253 ha), Winnipesaukee Lake (17,982 ha), and Winnisquam Lake (1,705 ha). There is an average density of 5.79 lakes/ponds greater than 4.05 ha per 100 km^2 in this unit. Most lakes

and ponds (81%) are at elevations of 6.10-243.84 m (20-800 ft), and 19% are at elevations of 243.84-518.16 m (800-1,700 ft).

2.3 Population Management Status

N/A

2.4 Relative Health of Populations

Land Use

Compared to other areas of New Hampshire, road density is high in this watershed group. Within fine scale system 10, the density of roads maintained by NHDOT is 1.15 km/km^2 (km of road/km^2 of land area) and the density of private/gravel roads is 0.82 km/km^2. Of the total land area of fine scale system 10, unfragmented land comprises 69%, developed land 5.8%, and agricultural land 6.9%. When compared to other systems in the state, both the percentage of agricultural land and the estimated population for 2005 (199,214 people or 65.5 people/km^2) are relatively high.

The high rate of population increase in the Lakes Region of New Hampshire has been well documented (Lakes Region Planning Commission (LRPC) 2004, SPNHF 2005). Since the completion of Interstate 93 in the 1960s, the population in the Lakes Region has doubled (LRPC 2004). In fine scale system 14, the estimated population for 2005 is 47,124 people (25.0 people/km^2). As a result of this population boom, there have been several negative impacts to the natural landscape, such as increased densities of fragmented land, roads, industrial activity, and residential development (LRPC 2004). The construction of impervious surfaces (e.g., roads, parking lots, and structures) can lead to increased stormwater runoff that carries non-point source pollutants. Within fine scale system 14, the density of roads maintained by NHDOT is 0.88 km/km^2 and the density of private/gravel roads is 0.92 km/km^2, which is the highest density of private/gravel roads in this area of New Hampshire. Of the total land area of fine scale system 14, 67% is unfragmented, 5.8% is developed, and 2.5% is agricultural land.

Estimated increases in census blocks adjacent to lakes and ponds were analyzed using 1990 and projected 2020 values (see Lake Type Classification for methods). The changes in housing density in rural (<0.063 housing units/ha), exurban (0.063-0.25 housing units/ha), and suburban (0.25-2.5 housing units/ha) areas could indicate increases in shoreline development, impervious surfaces, and nonpoint source pollution. Population estimates for 2005 census blocks predict that housing densities adjacent to lakes will change from suburban to urban at one lake/pond, exurban to suburban at 233 lakes and ponds, and rural to exurban around 198 lakes and ponds.

Water Quality

The LRPC (2004) identified the primary threats to lakes and rivers of the Lakes Region. Several pathways contribute to non-point source pollution. Pollutants in stormwater runoff can be amplified by increased impervious surfaces, malfunctioning septic systems, erosion and sedimentation, and improper drainage systems. The lack of surface water quality data is also a concern (LRPC 2004).

The New Hampshire Lakes Lay Monitoring Program (LLMP) conducts water quality surveys in Lake Winnipesaukee and Squam Lake. Overall, surveys indicate excellent to pristine-like water quality with high transparency, suitable dissolved oxygen, low nutrients (phosphorus), and low algal plant levels (chlorophyll *a*). Some areas within both lakes have slight algal blooms with the intensity varying from year to year (Lake Winnipesauke Watershed Association (LWWA) 2002, Squam Lakes Association (SLA) 2004). Mercury from airborne pollution is identified as a chronic problem to all lakes in the Lakes Region (LRPC 2004).

The surface water quality of 12 tributaries to Lake Winnipesaukee was studied in 2004 as part of the New Hampshire Department of Environmental Services (NHDES) Volunteer Rivers Assessment Program (VRAP). The only tributary that failed to meet state water quality standards for dissolved oxygen and turbidity was Hawkins Brook in Meredith. Five of eight dissolved oxygen measurements and one turbidity measurement from Hawkins Brook failed to meet state standards for class B waters. The range of pH values (pH 6.13-7.40) fell below state water quality standards for class B waters (pH 6.50-8.0) and 32% of pH samples were below state water quality standards. Acid precipitation and natural environmental conditions (e.g. soils, geology, wetland drainage) can lower pH values (NHDES 2004).

Surface water quality of the Piscataquog River was studied in 2002, 2003, and 2004 as part of the

NHDES VRAP (NHDES 2002, NHDES 2003, NHDES 2004). Turbidity levels consistently met state requirements for class B waters. Most samples (97%) met state standards for class B waters (6.50-8.0 mg/L). The range of pH values (pH 5.38-7.15) from 2002-2004 was below state water quality standards for class B waters (pH 6.50-8.0). Acidic precipitation and natural environmental conditions (e.g. soils, geology, wetland drainage) can lower pH values.

Surface water quality of the Soucook River was studied in 1999 and 2003 as part of the NHDES VRAP (NHDES 1999, NHDES 2003). Turbidity levels exceeded state minimum standards for class B waters. Three percent of dissolved oxygen samples were below state water quality standards in 1999 (range 3.12-11.16 mg/L) and samples exceeded state water quality standards in 2003. In 1999, 33% of water pH samples (pH 5.43-7.31) and in 2003 27% of water pH samples (pH 5.57-7.57) were below state water quality standards.

The number of point source pollutant sites regulated through NHDES is relatively low in these areas. The number of National Pollutant Discharge Elimination System (NPDES) permits for fine scale system 10 and fine scale system 14 are 0.012 and 0.006 NPDES permits/river km, respectively.

Invasive Species

The two fine scale systems within this area have the highest occurrences of exotic aquatic plants in New Hampshire. Variable milfoil (*Myriophyllum heterophyllum*) has been documented in at least 28 water bodies in fine scale system 10 and fine scale system 14. Examples of water bodies with documented infestations of variable milfoil include Crescent Lake (1980), Gorham Pond (2000), Hopkinton Lake (2000), Jones Pond (2003), Little Suncook River (2000), Northwood Lake (1990), Ossipee Lake (1995), Silver Lake (1995), Squam River (2000), Squam Lakes (2000), Waukewan Lake (1980), Winnipesaukee Lake (1970), Winnipesuakee River (2000), and Winnisquam Lake (1995) (Smagula 2004).

To assess the likelihood that recreation or stocking contribute to invasive fish and aquatic plants, the degree of remoteness of lakes and ponds was analyzed through GIS. The results indicate that 2,956 lakes and ponds (95.8%) are within 500 m of a trail or road, 103 lakes and ponds (3.3%) are enclosed by a protective buffer of 500-805 m without a mapped road or trail, and 26 lakes and ponds (0.8%) are enclosed by a protective buffer of 805-1609 m without a mapped road or trail. Only one pond has a buffer greater than 1609 m (1 mile).

The LRPC (2004) identified invasive plants that are carried on boats or sold commercially as the primary threat to lakes and rivers of the Lakes Region. The rivers and lakes in this system are increasing in popularity for recreation. There were 100,935 boats registered in New Hampshire in 2003 (LWWA 2004), many of which will be used in the lakes region, and the number of hours spent by anglers in bass tournaments increased from 8,304 to 23,084 hrs in just four years from 1996-2000 (LWWA 2004). The increase in recreation could lead to an increased risk of invasive species infestations. The LWWA estimates that 10% of the 2100 boats inspected by lake hosts in 2003 were carrying plants (LWWA 2004). The Lake Host program has prevented the spread of fanwort in 2003 and stopped variable milfoil from entering or leaving Lake Winnipesuakee in 2004 (New Hampshire Lakes Association (NHLA) 2004).

Several non-native fish populations have become naturalized within the watersheds of the Lakes Region and Merrimack River. Increased water temperatures and altered habitats from large impoundments facilitate proliferation of these species. Several of these fish provide sport-fishing opportunities. Illegal stocking by fishermen is a major source of non-native fish introductions. Largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), rock bass (*Ambloplites rupestris*), bluegill (*Lepomis macrochirus*), black crappie (*Pomoxis nigromaculatus*), landlocked Atlantic salmon (*Salmo salar*), brown trout (*Salmo trutta*), and rainbow trout (*Oncorhynchus mykiss*) are examples of species that have naturalized populations in New Hampshire (New Hampshire Fish and Game Department (NHFGD) 2004, Estuarine and Freshwater Working Group 2005). Landlocked Atlantic salmon, brown trout, and rainbow trout are annually stocked by NHFGD.

Hydrology

There are approximately 579 active dams/impoundments in fine scale system 10 and 157 in fine scale system 14. The number of impoundments in fine scale system 10 and fine scale system 14 is 0.077/river km and 0.039/river km, respectively. Fine

scale system 10 has a very high concentration of impoundments per river kilometer when compared to other areas of New Hampshire.

Culverts at stream crossings likely create additional habitat fragmentation. Because road density is relatively high in this area, there may be an increased number of road and stream intersections. Each crossing is a potential cause of fragmentation and a point of entry for stormwater runoff containing petrochemicals and road sands and salts.

An excessive amount of drinking water withdrawals is identified as a concern for lakes and rivers of the Lakes Region (LRPC 2004). Water withdrawals can lower water levels and reduce instream habitat. Aquatic species that are limited to thermal refuges in the summer may be further impacted from water withdrawals, which are often greatest during this time.

2.5 Habitat Patch Protection Status

Within fine scale system 10, conserved land comprises 13.3% of total land area and unfragmented land comprises 16%. Within fine scale system 14, conserved land comprises 14.7% of total land area and unfragmented land comprises 19%.

The Contoocook, Pemigewasset, Piscataquog, and Souhegan Rivers are each designated in the New Hampshire Rivers Management and Protection Program (RMPP) (NHDES 2004). The RMPP regulates dam construction, instream water flow levels, channel modification, water quality, solid and hazardous waste storage/treatment facilities, and motorized boat traffic.

2.6 Habitat Management Status

It is difficult to assess the efforts to restore and manage habitats at such a broad level. A database of conservation groups may enhance cooperative efforts and eliminate redundancy and repetition. There are conservation and management plans for the upper Merrimack, Piscataquog, and Souhegan Rivers. These plans identify ecologically significant areas and guide human use and management of these areas. Public outreach and education are identified as useful tools for conserving and restoring these watersheds. Because these plans provide highly detailed information at local levels, they should be used to help identify sensitive areas, local impacts, and management actions.

The NHLA is a statewide organization committed to the preservation and protection of lakes and ponds in New Hampshire. Through collaboration with lake associations, state agencies, and educators, the NHLA is enhancing shoreline and watershed protection, water quality, boating safety, lake environment education, and fish and wildlife preservation (NHLA 2001).

Several agencies are actively involved in habitat restoration projects and identifying potential areas of habitat enhancement or improvement. Ongoing or recently completed projects include the mapping of ecologically significant areas, reviews of environmental impacts and dam relicensing, riparian buffer and stream bank stabilization, developing conservation easements, invasive plant and water quality monitoring, creating a task force for dam removal, NHDES fish biomonitoring, landowner education, and annual river clean ups. Restoration efforts include the restoration of Atlantic salmon and brook trout populations and warmwater fish passage.

The NHDES Weed Watcher program trains volunteers to collect plant data and detect infestations of invasive plant species in the early stages when eradication may still be possible (NHDES 2002). In 2005, 110 lakes throughout New Hampshire have Weed Watcher programs (Amy Smagula, NHDES, personal communication).

There are two pilot projects being conducted by NHDES on the Souhegan and Lamprey Rivers to determine the instream flows needed to retain the ecological integrity of the river and supply water for various users. The studies will be used to inform future studies on other designated rivers in the state.

2.8 Extent and Quality of Data

The information on current habitat quality and restoration efforts gathered from literature reviews was highly concentrated on larger rivers of this habitat group. The smaller rivers within this habitat group were not well represented. Information obtained from GIS analyses may not accurately represent all physical features.

2.9 Condition Assessment Research

Increasing sampling of aquatic communities and water quality will provide more conclusive long-term trend data. Additional monitoring is needed to identify impacts of water flow alterations (e.g. erosion, changes in dissolved oxygen, and impacts on plants, fish and other aquatic wildlife). Increased sampling of fish tissue throughout these watersheds may identify areas affected by contaminants. Habitat assessments, water quality monitoring, and aquatic community data are needed for the headwater streams and small tributaries of these systems. The pilot projects initiated by The Nature Conservancy in the Ashuelot River watershed should be expanded to other watersheds in this habitat group to identify and protect additional areas of significance.

Element 3: Species and Habitat Threat Assessment

Existing river management plans, local watershed associations, and GIS analyses indicate that non-point source pollution (especially sedimentation and runoff from stormwater and agriculture), invasive species, recreation, habitat fragmentation, and development/sprawl are the primary threats to this area.
Refer to the general threats section for: Transportation Infrastructure, Development (Fragmentation and indirect effects), Non-Point Source Pollution (Runoff and Sedimentation), Acid Deposition, Introduced Species, Altered Hydrology, Recreation, Unsustainable Harvest (Forestry Operations and Management), and Agriculture.

Element 4: Conservation Actions

Conservation actions in this watershed group should focus on controlling the negative effects of development and reducing the impacts of recreational activities, especially the intentional or accidental spread of invasive species. Setting long-term goals for removing inactive dams and improving road/stream crossings will help restore the connectivity of these watersheds.

There are several strategies for conservation action in the RMPP management plans for the Merrimack, Piscataquoag, and Souhegan Rivers. Plans developed by the LRPC, SLA, and LWWA offer strategies to control growth and protect shoreline.

Refer to the general strategies for: Transportation Infrastructure, Development (indirect effects), Fragmentation, Pollutants (Acid Deposition), Invasive Species, Altered Hydrology, Sedimentation, Recreation, Forestry, Pollutants (Stormwater runoff), and Agriculture.

Element 5: References

Estuarine and Freshwater Working Group. 2005. State of New Hampshire Comprehensive Management Plan for the Prevention and Control of Aquatic Nuisance Species-Draft. Concord, New Hampshire, USA.

Lakes Region Planning Commission. 2004. Lakes Region Natural Resource Report. Available http://www.lakesrpc.org/. (Accessed May 2005).

Lake Winnipesaukee Watershed Association. 2002. UNH LLMP. Available http://www.winnipesaukee.org/unh-llmp.htm. (Accessed May 2005).

Lake Winnipesauke Watershed Association (LWWA). 2004. State of the Lake 2004. Meredith, New Hampshire, USA.

New Hampshire Department of Environmental Services. 1990. The Pemigewasset River. Available http://www.des.state.nh.us/Rivers/pemig.htm (Accessed March 2005).

New Hampshire Department of Environmental Services. 1991. The Contoocook River. Available http://www.des.state.nh.us/Rivers/contooc.htm (Accessed April 2005).

New Hampshire Department of Environmental Services. 1993. The Piscataquog River. Available http://www.des.state.nh.us/Rivers/piscat.htm (Accessed April 2005).

New Hampshire Department of Environmental Services. 1999. Soucook River Water Quality Report. Volunteer River Assessment Program. Concord, New Hampshire, USA.

New Hampshire Department of Environmental Services. 2000. The Souhegan River. Available http://www.des.state.nh.us/Rivers/souhegan_report.htm (Accessed April 2005).

New Hampshire Department of Environmental Services. 2002. Exotic Species Program. Available http://www.des.state.nh.us/wmb/exoticspecies/survey.htm. (Accessed May 2005).

New Hampshire Department of Environmental

Services. 2002. Piscataquog River Water Quality Report. Volunteer River Assessment Program. Concord, New Hampshire, USA.

New Hampshire Department of Environmental Services. 2003. Piscataquog River Water Quality Report. Volunteer River Assessment Program. Concord, New Hampshire, USA.

New Hampshire Department of Environmental Services. 2004. Designated Rivers. Available http://www.des.state.nh.us/Rivers/desigriv.htm (Accessed March 2005).

New Hampshire Department of Environmental Services. 2003. Soucook River Water Quality Report. Volunteer River Assessment Program. Concord, New Hampshire, USA.

New Hampshire Department of Environmental Services. 2004. Piscataquog River Water Quality Report. Volunteer River Assessment Program. Concord, New Hampshire, USA.

New Hampshire Department of Environmental Services. 2004. Lake Winnipesaukee Tributaries Water Quality Report. Volunteer River Assessment Program. Concord, New Hampshire, USA.

New Hampshire Fish and Game Department. Freshwater Fishing Guide. 2004. Available http://www.wildlife.state.nh.us/Fishing/Fishing_PDFs/FW_Fishing_Guide.pdf (Accessed April 2005).

New Hampshire Lakes Association. 2001. History, Purpose, and Organization. Available http://www.nhlakes.org/history_purpose.htm. (Accessed April 2005).

New Hampshire Lakes Association. 2004. Lake Host Program. Available http://www.nhlakes.org/docs/04-LH-Program-Summary-Stats.pdf. (Accessed April 2005).

Scott, David, J. McLaughlin, V. Parmele, F. Latawiec-Dupee, S. Becker and J. Rollins. (1991) Squam Lakes Watershed Plan. Office of State Planning, Concord, NH.

Smagula A. 2004. Report of the New Hampshire Exotic Aquatic Species Program. New Hampshire Department of Environmental Services. Concord, New Hampshire, USA.

Society for the Protection of New Hampshire Forests (SPNHF). 2005. New Hampshire's Changing Landscape. Population Growth and Land Use Changes. What They Mean for the Granite State. Concord, New Hampshire, USA.

Souhegan Watershed Association. 2003. Souhegan Water Quality. Available http://www.souhegan.org/quality.html. (Accessed May 2005).

Souhegan Watershed Association. 2003. Souhegan Watershed Facts. Available http://www.souhegan.org/watershed.html. (Accessed May 2005).

Squam Lakes Association. 2004. Squam Lakes Water Quality. Available http://www.squamlakes.org/sla/ecological.htm. (Accessed May 2005).

Walsh, T. and A. Tillberg. 2005. Lake Winnipesauke tributaries water quality report 2004. State of New Hampshire Volunteer River Assessment Program. New Hampshire Department of Environmental Services, Concord, New Hampshire.

HABITAT PROFILE

Non-Tidal Coastal Watersheds

Associated Species: Alewife (Alosa pseudoharengus), American Brook Lamprey (Lampetra appendix), American Shad (Alosa sapidissima), Atlantic Sturgeon (Acipenser oxyrhynchus), Banded Sunfish (Enneacanthus obesus), Blueback Herring (Alosa aestivalis), Bridle Shiner (Notropis bifrenatus), Burbot (Lota lota), Brook Trout (Salvelinus fontinalis), Rainbow Smelt (Osmerus mordax), Redfin Pickerel (Esox americanus americanus), Sea Lamprey (Petromyzon marinus), Shortnose Sturgeon (Acipenser brevirostrum), Slimy Sculpin (Cottus cognatus), Swamp Darter (Etheostoma fusiforme), Tessellated Darter (Etheostoma olmstedi)

Federal Listing: Not listed
State Listing: Not listed
Global Rank: Not ranked
State Rank: Not ranked
Author: New Hampshire Fish and Game and The Nature Conservancy

Element 1: Distribution and Habitat

1.1 Habitat Description

Non-tidal coastal watersheds contain river systems that are similar to low tidal watersheds except they are above the tidal extent and many are connected to the deep and large Merrimack River mainstem. Low non-tidal watersheds contain extensive, deep, and coarse sediment deposits, although this watershed group contains a large swath of moderately calcareous metasedimentary bedrock and less fine marine clay than low tidal watersheds. Despite having less fine marine clay, low non-tidal watersheds may still have more buffering capacity than other parts of the state due to the influence of the moderately calcareous metasedimentary bedrock.

Low non-tidal watersheds have a relatively high percentage of low to mid-elevation landforms with gentle sloping hills and abundant wet and flat landforms. The lower Merrimack River mainstem, south of the Winnipesaukee River confluence in Franklin, dominates much of this watershed group, which has more miles and a greater percentage of large river habitats than any system other than the Connecticut River watershed.

Low to moderate gradient streams dominate the tributaries of this system. They are generally composed of riffle-pool habitats with occasional dune-ripple habitats in areas of deep and extensive coarse sediment. There is no strictly tidal marsh community of plants and animals as in low tidal systems. Depending on fish stocking, habitat quality, and the ability of fish to move upstream past barriers in the Merrimack River, diadromous fish (such as American shad (*Alosa sapidissima*), alewife (*Alosa pseudoharengus*), American eel (*Anguilla rostrata*), Atlantic salmon (*Salmo salar*), or blueback herring (*Alosa aestivalis*)) may spawn or rear their young in these low non-tidal rivers. Some fish that are more characteristic of large and deep lakes may occur in these watersheds as the Merrimack River deepens and slows throughout sections of the mainstem.

Low non-tidal watersheds primarily include the larger watersheds directly adjacent to the Merrimack River mainstem, although the smaller brooks draining into the mainstem provide unique habitats. The mouths of small streams along large river mainstems may provide refuges and breeding habitats for both local and wide-ranging fish species. However, most of these smaller streams are dammed at our near their confluence with the Merrimack River, which prevents natural connectivity to upstream habitats.

Low Non-Tidal Fine Scale Systems: 11, 12
Fine scale systems 11 and 12 are fairly similar. Both

watershed types are nearly entirely low elevation, composed of more gentle landforms, have a high degree of coarse sediment, and are highly influenced by the large Merrimack River mainstem and lower slow-flowing sections of large tributaries. There are a few key differences between these systems, the primary being that the southern fine scale system 11 overlaps with a large swath of moderately calcareous bedrock (Berwick Formation), which may provide significant buffering capacity to those streams. This bedrock is characterized by multiple metasedimentary and metavolcanic geologic units with up to 15% calcareous rock, some of the "richest" in the state. Fine scale system 12 watersheds are more directly adjacent to the Merrimack River mainstem, whereas fine scale system 11 also includes watersheds of larger tributary rivers flowing south across the Massachusetts border.

1.2 Justification

The large mainstem of the Merrimack River and associated small and medium tributaries are critical habitats for diadromous and other wide-ranging migratory fish. There are few large river habitats in the state (or in the region) that support this suite of species and ecological processes, and so all large rivers are a high priority for conservation. Large river habitats require representation across wide geographies.

1.4 Habitat Distribution

Low non-tidal watersheds occur in nine watersheds in New Hampshire's south-central Merrimack Valley region, including small tributaries to the Merrimack River south of the town of Franklin. These watersheds extend north from the Massachusetts state line to the confluence with the Winnipesaukee River. The rivers in this system are not tidally influenced.

Low non-tidal watersheds sit entirely within the Merrimack-Saco-Charles River Ecological Drainage Unit (EDU) and the Southern New England Coastal Hills and Plains subsections of TNC's Lower New England-Northern Piedmont Ecoregion. The southernmost watersheds cross into Massachusetts, including small tributaries to the Merrimack River such as the Nashua River, Beaver Brook, Salmon Brook, Nesenkeag Brook, Chase Brook, and portions of the Squannacook River watershed in Massachusetts.

1.8 Extent and quality of data

While low non-tidal watersheds are distinct from other major watershed groups, the fine scale systems embedded within this group are less clear. The major landscape parameter defining the difference is the abundant calcareous bedrock in the southern watersheds. It is unclear whether this difference has a significant effect on the composition of aquatic species. This difference may have a stronger influence on current and long-term water chemistry and water quality, such as the ability to buffer the effects of acid deposition.

Both fine scale systems are important from a statewide perspective. The enriched bedrock of fine scale system 11 may provide unique and long-term buffering capacity, and fine scale system 12 has unique small stream connectivity with the Merrimack River mainstem. Additional research and data would help further determine the relative importance of these fine scale systems compared to other watersheds in the state. For example, the Connecticut River and low tidal watersheds also have enriched bedrock, and the Connecticut River systems also have small tributary connections with a large river mainstem. A regional analysis comparing these habitats with those in Massachusetts might help focus conservation actions depending on adequate fish passage for diadromous species and whether watersheds with enriched geologic features have a detectable influence on assemblages of aquatic species.

Element 2: Species/Habitat Condition

2.1 Scale

Due to the large land area covered by the major watershed groups (Figure 3), a fine scale classification (Figure 4) was used, when possible, to assess the relative condition of aquatic habitats across the state. The types and sources of information were extremely variable and covered many different scales, and so the following sections refer to both the major and fine scale systems. The actual scale at which the natural conditions and processes lead to differences in aquatic communities is unknown.

The low non-tidal watershed group can be divided into two smaller units, the upper Merrimack inner basin (fine scale system 12) and the lower Merrimack drainages (fine scale system 11) (Figure 4).

2.2 Relative Quality

The upper Merrimack inner basin (fine scale system 12) encompasses 899.9 km^2. It consists of 81% small headwater streams (watershed area <48.28 km^2), 8% small rivers (watershed area of 77.70-518.00 km^2) that drain into the large mainstem of the Merrimack River, and 11% large rivers (watershed area >2590 km^2). This system lacks the full range of river sizes typical of most other watershed groups. The lower Merrimack group (fine scale system 11) encompasses 1,422 km^2 and contains a greater variety of river sizes, with 8% small rivers, 4% medium-sized rivers (watershed area of 518.00-2590 km^2), and 4% large rivers.

There are 429 lakes and ponds with a surface area greater than 1 acre in the low non-tidal watershed group. Of these water bodies, 137 are greater than 4.05 ha (10 ac). The group has a relatively high density of lakes greater than 4.05 ha (5.4/100 km^2), behind the low-moderate and moderate south watershed groups (Figure 3).

Deep, coarse sediment left by retreating glaciers creates a number of unique communities, including pine barrens, floodplain forests, and inland sand dunes along the banks of the upper Merrimack River (fine scale system 12). The river corridor is used by bald eagles (*Haliaeetus leucocephalus*) during winter and as a migration route for songbirds in the spring and fall. The Merrimack River is important habitat for freshwater mussels, including the state endangered brook floater (*Alasmidonta varicosa*). The river also provides important spawning habitat for anadromous fish such as alewives, American shad, blueback herring, Atlantic salmon, and sea lamprey (*Petromyzon marinus*) (USFWS 2000).

In addition to the mainstem of the Merrimack River, fine scale system 11 contains a number of low gradient, meandering streams and small rivers that join the Merrimack River in Massachusetts. The vegetated shorelines of the lakes, rivers, and ponds in these watersheds provide important habitat for many uncommon or rare native fish such as the banded sunfish (*Enneacanthus obesus*), redfin pickerel (*Esox americanus americanus*), and bridle shiner (*Notropis bifrenatus*). These three fish species commonly use the abundant wetlands in this system, which often grade into pond or stream habitats. The connections between open water, wetland, and upland habitats is critical to the many species of fish, amphibians, waterfowl, and turtles that use multiple habitat types throughout their life cycles. Beyond the urban areas of Manchester and Nashua, much of the headwaters of the lower tributaries to the Merrimack River, such as the Squanacook and Nissitissit Rivers, remain forested.

2.3 Population Management Status

N/A

2.4 Relative Health

Land Use

The lower Merrimack River and its surrounding watersheds (fine scale system 11) are in the fastest growing part of New Hampshire (SPNHF 2005). The population grew by an average of 12,498 people per year between 1990 and 2000. Road density is the highest in the state at 2.77 km of road/km^2 of land area. The upper Merrimack River corridor (fine scale system 12) is close behind with the second highest road density (2.39 km/km^2). The population is increasing the fastest along Interstate 93, which parallels the mainstem of the Merrimack River (SPNHF 2005). A proposed expansion of this highway will put increasing development pressure on these systems. The well-drained, sandy soils of these watersheds are highly suitable for development. Developed land currently makes up 17.5% of fine scale system 11 and 15% of fine scale system 12. These proportions of developed land are twice that of the next closest system (the low tidal fine scale system 13 at 8%). Lake shorelines are a high priority for developers. Census blocks around 76 of the 470 lakes greater than 4.05 ha in low non-tidal watersheds are predicted to increase in density class by the year 2020 (TNC 2005).

The amount of agricultural land is also relatively high in fine scale systems 11 and 12 (5.9% and 6.6%, respectively). Chemicals, excess nutrients, and sediments that run off agricultural fields can degrade adjacent water bodies. Forested buffers around headwater streams can reduce the impacts of runoff from developed and agricultural land. The amount of forested land within 250 ft (76.2 m) of headwater streams in fine scale systems 11 and 12 is the lowest in the state at 63.06% and 63.64%, respectively. Further loss of forested buffers adjacent to headwaters will be detrimental to aquatic habitats throughout low non-tidal watersheds.

Water Quality

The Merrimack River was once listed as one of America's ten dirtiest rivers (NHDES 2000). The Clean Water Act has led to great improvements in water quality by regulating industrial sources of pollution. The upper Merrimack River has excellent water quality for a large river, although water quality monitoring does reveal some issues. While the river passes NHDES class B water quality standards during dry weather, the river exceeds standard levels of fecal coliform after heavy rains (Landry and Tremblay 2000). Volunteer sampling of invertebrates at sites along the river reveals a decline in the number of species from upstream to downstream (Landry and Tremblay 2000). The decrease in water quality after heavy rains and the decline in species richness downstream are signs of non-point source pollution. Although non-point source pollution is the major contributor of pollutants to the Merrimack River watershed, wastewater treatment facilities are also a significant source of phosphorous, nitrogen, and *E. coli* (USACE 2004). Although none of New Hampshire's waters meet water quality standards for mercury, the lower Merrimack and coastal watersheds of southeastern New Hampshire have been specifically identified as "mercury hotspots" (Evers 2005).

The mainstem of the lower Merrimack River has relatively poor water quality. Manchester and Nashua are the major sources of pollution through combined sewer outflows (CSOs), which occur when wastewater treatment facilities are bypassed during heavy rainfall. The cities are currently working with NHDES to reduce pollution from CSOs. There is less information about the watersheds of the tributaries that join the Merrimack River in Massachusetts. While the New Hampshire portions of these watersheds lack the point sources of the urban areas downstream, rapid development will likely have an increasing impact on water quality (Dunn 2002).

Hydrology

New Hampshire's aquatic ecosystems are fragmented by a history of small-scale industrialization, which resulted in a high density of small dams throughout the southern watersheds (NHDES 1999). There are 367 active dams in the lower Merrimack River watershed. The number of dams for every 10 km of river in fine scale systems 11 and 12 is 2.49 and 1.92, respectively. The proportion of free-flowing river reaches in fine scale systems 12 and 11 are the second and third lowest in the state, behind the lower Connecticut River. Only the Amoskeag Dam in Manchester has a fishway for upstream fish passage, which provides access to just 8 km (5 mi) of river upstream. The fishway is designed to allow anadromous fish to pass upstream during spring spawning runs. Design elements that regulate flow and a short operating season limit the effectiveness of the fishway for most freshwater fish species.

Culverts and stream crossings add to the aquatic habitat fragmentation caused by dams (Warren and Pardew 1999). With the highest road density in the state, these watersheds are extremely fragmented. The relatively high density of roads, parking lots, roofs, and driveways contribute to stormwater runoff from impervious surfaces. Not only does this runoff inject sediment and contaminants into water bodies, but it also alters local hydrological patterns (NHDES 1999), which can lead to significant alterations in stream geomorphology and aquatic habitats.

The Amoskeag Dam in Manchester, Garvin Falls Dam in Bow, and the Hooksett Dam in Hooksett are the 3 major hydroelectric dams on the Merrimack River. The operation of these facilities creates large impoundments, causes unnatural water level fluctuations above the dams, and alters flows below the dams. The three dams are currently undergoing relicensing, which presents an opportunity to improve fish passage at the Amoskeag fishway and install fish passage at the other two dams.

An estimated 1.2 billion L (320 million gallons) of water are withdrawn from the Merrimack River watershed per day for municipal drinking water, irrigation, and industrial uses (MRWC 2001). The NHDES has identified the lower Merrimack River as potentially impacted by water withdrawals. A local resident reported that the operation of the Methuen Falls hydropower project on the Spickett River repeatedly drained the river dry over the summer of 2002 and affected river flows well into New Hampshire (Low Flow Inventory 2004). North of Manchester, the upper Merrimack River watersheds (fine scale system 12) have a much lower rate of water withdrawals.

Invasive Species

There are 12 known invasive aquatic plant infesta-

tions in fine scale system 11 and 7 infestations in fine scale system 12. Not only do these systems have a relatively high number of infestations, but they also have the widest variety of invasive species, including variable milfoil (*Myriophyllum heterophyllum*), Carolina fanwort (*Cabomba caroliniana*), water chestnut (*Trapa natans*), and Brazilian elodea (*Egeria densa*).

Many non-native fish species, such as the common carp (*Cyprinus carpio*), smallmouth bass (*Micropterus dolomieu*), largemouth bass (*Micropterus salmoides)*, and black crappie (*Pomoxis nigromaculatus*), have become naturalized in water bodies throughout low non-tidal watersheds. The long-term effects of these species on native populations are poorly understood. Most non-native fish introductions result from illegal private stocking of sport fish (Estuarine and Freshwater Working Group 2005).

The state of New Hampshire is working on a comprehensive plan for the management of aquatic nuisance species (Estuarine and Freshwater Working Group 2005). The plan lists a number of species of exotic fish, including species from the snakehead family (Channidae), which have not yet established populations in New Hampshire. Exotic species are more often introduced when people release private aquarium fish into a lake or river. Urban areas tend to have higher incidences of exotic species introductions. The urban communities of Concord and Manchester on the mainstem of the Merrimack River, and Nashua on the Nashua River, present a great risk for the introduction of exotic species.

2.5 Habitat Patch Protection Status

The lower Merrimack River watersheds (fine scale system 11) and upper Merrimack River corridor (fine scale system 12) have the lowest percentages of unfragmented blocks of land (46.0% and 57.5%, respectively) compared to the other 13 systems. Of the total amount of unfragmented blocks of land, 13.6% are protected in fine scale system 11 and 18.6% in fine scale system 12. Public conservation land comprises 8.2 % of the total land area in fine scale system 11 (the lowest in the state) and 13.7% of fine scale system 12.

Both the upper sections of the Merrimack River (from the confluence of the Winnipesaukee and Pemigewasset Rivers in Franklin to Garvins Falls in Bow) and the lower sections (from the Bedford/Merrimack town line to the New Hampshire/Massachusetts state line) are designated river reaches in the Rivers Management and Protection Program (RSA 483).

2.6 Habitat Management Status

Management activities for aquatic habitats in low non-tidal watersheds include water quality monitoring, hydrological research and management, and anadromous fish restoration. The Merrimack River Watershed Council (MRWC) coordinates over 30 volunteer water quality monitoring groups through the Volunteer Environmental Water Quality Network (VEMN). The MRWC has also funded a number of studies, including an assessment of the Powwow River watershed and an analysis of water use throughout the Merrimack River watershed (Monnelly and Strauss 2001, MRCW 2001). Management plans have been developed for the upper and lower sections of the Merrimack River designated under the Rivers Management and Protection Act (RSA 483). While the mainstem of the Merrimack River receives considerable attention, there has been less focus on the smaller Merrimack River tributaries, such as the Spickett River and Beaver Brook, which join the main stem of the Merrimack River in Massachusetts.

There is an ongoing effort to restore anadromous fish populations in the Merrimack River watershed. Recent work has focused on improving downstream fish passage at hydroelectric dams (Jon Greenwood, NHFG Fisheries Biologist, personal communication). Returns of adult anadromous fish to the Merrimack River watershed in New Hampshire are limited by the effectiveness of upstream fish passages in Massachusetts. Relicensing of the Amoskeag, Hooksett, and Garvin Falls Dams, owned by Public Service of New Hampshire, provide opportunities to install or improve fishways. A fishway on the Hooksett Dam would provide access to excellent habitats in the Soucook and Suncook Rivers.

2.7 Sources of Information

Data from NHFG, volunteer water quality reports (VRAP reports coordinated through NHDES), watershed management plans (under the Rivers Management and Protection Program, RSA 483), and conversations with local watershed organizations were used to assess the status and relative quality of watershed groups.

2.8 Extent and Quality of Data

An evaluation of the Upper Merrimack Monitoring Program data validates the work of the volunteers who monitor water quality in the upper Merrimack River watershed (Landry and Tremblay 2002). Most monitoring has occurred along the mainstem of the Merrimack River. There is very little information about the smaller tributaries that feed into the Merrimack River.

2.9 Condition Assessment Research

While the New Hampshire Natural Heritage Bureau has identified rare and exemplary shoreline plant communities, there has been little work to identify rare or unique aquatic communities. Future surveys should attempt to identify aquatic communities indigenous to the low non-tidal watersheds, document the current ranges of invasive species, and assess the extent of habitat degradation in these watersheds.

Element 3: Species and Habitat Threat Assessment

Threats to aquatic habitats in low non-tidal watersheds are related to the rapidly increasing population density. Nonpoint source pollution will worsen with further increases in impervious surface area. The risk of invasive species introductions will increase with the number of people using and living near the water bodies in these drainages. Dams and poorly designed culverts are restricting the amount of habitat available to some species. Many other species are impacted by unnatural fluctuations in water level. Refer to the general threats section for: Transportation Infrastructure, Development (Fragmentation and indirect effects), Non-Point Source Pollution (Runoff and Sedimentation), Acid Deposition, Introduced Species, Altered Hydrology, Recreation, Unsustainable Harvest (Forestry Operations and Management), and Agriculture.

Element 4: Conservation Action

While land protection can help prevent further aquatic habitat degradation in low non-tidal watersheds, many heavily impacted areas will require restoration. A coordinated effort is needed to reduce fragmentation and impervious surface area in these watersheds. Setting limits on water withdrawals or water level fluctuations will have long-term benefits for fish and wildlife.

Refer to the general strategies section for: Transportation Infrastructure, Development (indirect effects), Fragmentation, Pollutants (Acid Deposition), Invasive Species, Altered Hydrology, Sedimentation, Recreation, Forestry, Pollutants (Stormwater runoff), and Agriculture.

Element 5: References

5.1. Literature

Dunn, J.W. Jr. 2002. Merrimack River five-year watershed action plan. Executive Office of Environmental Affairs – Massachusetts Watershed Initiative. Devens, MA.

Estuarine and Freshwater Working Group. 2005. State of New Hampshire Comprehensive Management Plan for the Prevention and Control of Aquatic Nuisance Species, Unpublished draft. Concord, New Hampshire, USA.

Evers, D. 2005. Mercury Connections: The extent and effects of mercury pollution in northeastern North America. Biodiversity Research Institute. Gorham, ME. 28 pgs.

Landry, S.C. and M.L. Tremblay. An Evaluation of the Statistical Power of Volunteer-Generated Data Compiled by the Upper Merrimack Monitoring Program. Upper Merrimack Monitoring Program

Landry, S.C. and M.L. Tremblay. 2000. State of the Upper Merrimack 1995-1997, a river quality report. Upper Merrimack Monitoring Program

Low Flow Inventory [Internet]. 2004. Merrimack River Basin. Massachusetts Executive Office of Environmental Affairs. Cambridge, MA. Available: http://www.mass.gov/dfwele/river/rivlow_flow_inventory/merrimack.html

New Hampshire Department of Environmental Services [NHDES]. 2000. State of New Hampshire 2000 section 305(b) water quality report. Concord, New Hampshire.

New Hampshire Department of Environmental Services [NHDES]. 1999. New Hampshire nonpoint source management plan. Concord, New Hampshire.

Northeast Aquatic Nuisance Species Panel [NEANS].

2003. Rapid Response to Aquatic Species in the Northeast: Developing an Early Detection and Eradication Protocol - Workshop Proceedings. May 20-21, 2003 Bar Harbor, Maine.

Merrimack River Watershed Council [MRCW]. 2001. Water demand analysis on the Merrimack River watershed: Data and literature on the water use of the Merrimack River watershed. Prepared for the Merrimack Watershed Team.

Monnelly, A., and J. Strauss. 2001. Powwow River watershed assessment final report. Merrimack River Watershed Council (MRCW). Lowell, MA.

Society for Protection of New Hampshire Forests [SPNHF]. 2005. Population growth and land use changes: what they mean for the granite state. Society for the Protection of NH Forests, Concord NH.

The Nature Conservancy (TNC). 2005. New Hampshire Lakes Classification. Unpublished draft submitted to the New Hampshire Fish and Game Department.

United States Army Corps of Engineers [USACE]. 2004. Merrimack River Watershed Assessment Study: Screening Level Model. Prepared for Merrimack River Basin Communiy Coalition.

United States Fish and Wildlife Service [USFWS]. 2000. Strategic Plan for the Restoration of Anadromous Fish to the Merrimack River. Central New England Fishery Resources Complex. Nashua, NH.

Warren, Jr., M.L. and M.G. Pardew. 1999. Road crossings as barriers to small-stream fish movement. Transactions of the American Fisheries Society 127: 637-644.

HABITAT PROFILE

Pine Barrens

Associated Species: frosted elfin butterfly (Callophyrus [Incisalia] irus), Karner blue butterfly (Lycaeides melissa samuelis), Persius duskywing (Erynnis persius persius), Sleepy duskywing (Erynnis brizo brizo), wild indigo duskywing (Erynnis baptisiae), barrens xylotype (Xylotype capex), broad-lined catophyrra (Catopyrrha coloraria), cora moth (Cerma cora), Phyllira tiger moth (Grammia phyllira), pine barrens itame (Itame sp 1), pine barrens zanclognatha moth (Zanclognatha martha), pine pinion moth (Lithophane lipida lipida), black racer (Coluber constrictor), eastern hognose snake (Heterodon platirhinos), smooth green snake (Lioclonorophis vernalis), eastern box turtle (Terrapene carolina), Fowler's toad (Bufo fowleri), common nighthawk (Chordeiles minor), eastern towhee (Pipilo erythrophthalmus), whip-poor-will (Caprimulgus vociferus), New England cottontail (Sylvilagus transitionalis).
Global Rank: Globally Not Ranked
State Rank: Pitch pine-scrub oak woodland (S1S2)
Author: Goulet, Celine
Affiliation: New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

Pine barrens are early-successional habitats occurring on northeastern coastal sand plains or on sandy, glacial outwash deposits of major river valleys (Howard et al 2005). Soils are acidic, droughty, nutrient-poor, and excessively well-drained. In New Hampshire, pine barrens are dominated by pitch pine (Pinus rigida) and scrub oak (Quercus ilicifolia) and form a matrix of dense scrub oak thickets and heath barrens interspersed with pockets of pitch pine forest and grassy openings (Sperduto and Nichols 2004). This structural and compositional heterogeneity is in constant flux, a process maintained by frequent disturbances such as wildfire. Fires occur naturally and regularly in pine barrens, with lightning serving as the primary ignition source (Howard et al 2005). These fires are able to spread rapidly across the community's flat expanse of dry, fire-prone vegetation (Howard et al 2005). Lee sides of habitat features, such as eskers, rivers, and slopes act as natural firebreaks, creating variation in species composition as well as vegetational age distributions (Howard et al 2005).

The two variants of the pitch pine-scrub oak woodland community occurring in New Hampshire are the Merrimack Valley variant and the Ossipee variant (Sperduto and Nichols 2004). The Merrimack Valley variant occurs in the Concord pine barrens and occupies Windsor sandy loams and Hinckley cobbly sandy loams (VanLuven 1994), both deposits of the post-glacial Lake Merrimack (Sperduto and Nichols 2004). This variant is characterized by a high diversity of both common and rare vascular plants, including blue lupine (Lupinus perennis), blunt-leaved milkweed (Asclepias amplexicaulis), and New Jersey tea (Ceanothus americanus) (Sperduto and Nichols 2004). The Ossipee variant occurs in the Ossipee pine barrens, occupying deep outwash deposits between Ossipee and Silver Lake (Sperduto and Nichols 2004). Less diverse than the southern variant, the Ossipee variant is instead associated with more northern plant species such as bearberry (Arctostaphylos uva-ursi), three-toothed cinquefoil (Potentilla tridentata), and savin-leaved clubmoss (Diphasiastrum sabinifolium) (Sperduto and Nichols 2004).

1.2 Justification

Pine barrens are among the most imperiled communities in the world (Raleigh et al 2003). Throughout

the thousands of years of their existence, pitch pine-scrub oak woodlands have significantly contributed to the biological diversity of the northeast (Howard et al 2005). These communities support a suite of species that are regionally and globally rare (Howard et al 2005). Of the rare fauna occurring within them, the largest assemblage is Lepidoptera, as demonstrated in New Hampshire (VanLuven 1994). Of the 726 Lepidoptera species collected in the Concord pine barrens, 4 are globally imperiled and 37 are rare to the state, including the federally and state endangered Karner blue butterfly (Lycaeides melissa samuelis) as well as the state endangered frosted elfin (Callophyrus [Incisalia] irus) and persius duskywing skipper (Erynnis persius persius) (VanLuven 1994, Chandler 2001, Sperduto and Nichols 2004). A large proportion of these Lepidopteran fauna are exclusively dependent on blue lupine and other plants restricted to pine barrens (Sperduto and Nichols 2004). The Ossipee pine barrens lacks the level of Lepidopteran diversity found in its southern counterpart, although it does support the only New England occurrences of the pine pinion moth (Lithophane lepida lepida), pink-edged sulphur (Colias interior), and the noctuoid moth Xylena thoracica (Sperduto and Nichols 2004).

Pine barren communities also serve a role in the life histories of a number of vertebrates as well, a relationship based on edaphic and structural features, not host plant specificity as attributed to Lepidopteran endemism (Howard et al 2005). Such species include approximately 50% of northeastern birds, almost 60% of northeastern mammals, and a number of reptiles and amphibians (Howard et al 2005).

Historically, pine barrens provided the array of distinctive habitat features required by their associated fauna (Howard et al 2005). However, with increased fire suppression during the last half-century, this habitat's natural course of succession was severely disrupted (Howard 2003). Reduced intensity and frequency of natural disturbance caused the pitch pine-scrub oak woodland to advance into a closed pitch pine-scrub oak forest, eliminating structural elements critical to the long-term viability of indigenous populations (Raleigh et al 2003, Howard et al 2005). Moreover, urban development has added to the effects of fire suppression, further reducing the extent of pitch pine-scrub oak woodland communities (Howard et al 2005). The result has been significant habitat loss and fragmentation in systems that were historically large and contiguous (Howard et al 2005).

3.3 Protection and Regulatory Status:

Federal
National Plant Protection Act: promotes the preservation of blue lupine, blunt-leaved milkweed, and golden heather (Hudsonia ericoides) on state lands, but provides no protection on private property (VanLuven 1994)
Local
Concord Municipal Airport Development and Conservation Management Agreement: restricts development within designated conservation zones, authorizes the New Hampshire Fish and Game Department, the Department of Resources and Economic Development, the New Hampshire Army National Guard, and the United States Fish and Wildlife Service to undertake management actions to provide and enhance essential habitat for federally and state listed threatened and endangered species of Lepidoptera.

1.4 Population and Habitat Distribution

Pine barrens are predominantly restricted to New Jersey, though regionally rare examples occur in Maine, New Hampshire, Massachusetts, Pennsylvania, and New York (Howard 2003). In New Hampshire, this habitat is limited to the Sebago-Ossipee and Gulf of Maine Coastal Plain ecoregion subsections (Sperduto and Nichols 2004). The Ossipee pine barrens is located within the towns of Ossipee, Tamworth, Freedom, Madison, and Effingham, at an elevation range of 137-152m (Howard 2003). Its estimated historic extent encompassed over 2,833 ha (7,000 ac), which has since been reduced to about 1,214 ha (3,000 ac) (Howard 2003). The Concord pine barrens occurs within the city of Concord at an elevation of 105m. Its distribution once covered approximately 1,821 ha (4,500 ac) along the Merrimack River from Concord south to Nashua, of which only 227 ha (563 ac) remain today (VanLuven 1994).

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

Potential pine barrens habitat was mapped using known pine barrens occurrences (New Hampshire Natural Heritage Bureau 2005). Six variables were measured for pixels within known occurrences: elevation, slope, landcover, drainage, texture, and a composite index of drainage and texture indicating the location of the pixel relative to large, contiguous areas of appropriate soils conducive to fire spread. For each variable, the range of values that encompassed 85-93% (depending on the variable) of the pixels was selected. Throughout the state, pixels that fell within these value ranges for all six variables were selected as potential pine barrens habitat. Known habitat patches as well as historically known patches were then added to the map.

Limitations of Data

The pine barrens map was heavily dependent on the accuracy of soils data and elevation data. While there are some errors in the elevation data, there are likely to be more errors in the soils data. County soil surveys often do not show small inclusions of different soil types within larger polygons. In addition, digital county soil surveys are not available for Belknap and Merrimack Counties or the White Mountains, and drainage and texture data is absent from some polygons of Coos County. For these areas, the STATSGO data set was used (Natural Resources Conservation Service 1994). STATSGO is a map of soil data at a much coarser scale than county soil surveys, and thus is much more prone to error at the fine scales required for accurate habitat maps. Thus, the pine barrens map will be most inaccurate in these areas.

1.7 Sources of Information

Information on pine barrens distribution and status was collected from habitat management plans, technical field reports, agency data, and scientific journals.

1.8 Extent and Quality of Data

The pine barrens habitat and associated fauna have been studied extensively in New Hampshire and adjacent states. Although life history data on certain species could be improved, general habitat associations, particularly of Lepidoptera, are well known. See limitations in section 1.6 above.

1.9 Distribution Research

Areas requiring further research include historical distribution, geologic and ecological processes contributing to the formation of pitch pine-scrub oak woodland communities, distribution and condition of populations of pine barrens-dependent fauna, and the role of land-use history in maintaining and/or promoting the establishment of pitch pine-scrub oak woodland habitat.

Element 2: Species/Habitat Condition

2.1 Scale

2.2 Relative Health of Populations

Good examples of pitch pine-scrub oak woodlands in New Hampshire occur in the Concord pine barrens (Concord) and the Ossipee pine barrens, (Madison, Ossipee, and Tamworth), with the Ossipee pine barrens being considered the largest and most pristine pitch pine-scrub oak woodland community in the state (Howard 2003, Sperduto and Nichols 2004). A small, heavily managed population of Karner blue butterflies exists in the Concord pine barrens, and populations of other lepidopteran species associated with this habitat are found in both the Concord and Ossipee pine barrens.

3.3 Population Management Status

Not required for habitat profiles.

2.4 Relative Quality of Habitat Patches

The Concord pine barrens are extremely fragmented. Mean patch size of existing pine barrens in the Concord area is 10.2ha, and of predicted patches is 2.9ha. Patches in the Ossipee area are much larger; current pine barrens patches average 44.2ha, while predicted patches are still small, averaging 2.4ha. Predicted patches elsewhere in the state are similarly quite small. The pine barrens at the Concord airport are surrounded by less than 40% unaltered land within 250m. In contrast, the pine barrens in the Ossipee

region have from 67-93% unaltered land within 250m. Road density, however, is higher in the Ossipee barrens.

Although the Concord pine barrens are more fragmented and developed, they have the highest known density of rare plants and animals relative to other pine barrens in New Hampshire. Thus, the landscape context of the Ossipee barrens is more favorable, but the biodiversity of the Concord barrens is of critical importance.

2.5 Habitat Patch Protection Status

Approximately 227 ha (560 ac) of the remnant Concord pine barrens is protected through the Concord Municipal Airport Development and Conservation Management Agreement (2000). The majority of the land (210 ha) occurs on the Concord Municipal Airport and is owned by the city of Concord. Eight conservation zones made up of 57 management units have been established on this land, with management working towards enhancing and restoring the pitch pine-scrub oak woodland community, a critical habitat for the Karner blue butterfly as well as a suite of other rare species. Of the remaining land, 11 ha (27 ac) is held as a conservation easement granted to the United States Fish and Wildlife Service. The easement is open to the public but wheeled vehicles are forbidden. The 4 ha (10 ac) of the historic main site, located along a powerline right-of-way, is privately owned and maintained by Public Service of New Hampshire.

Thirty percent of the existing Ossipee pine barrens are in fee ownership protection. Tweve hundred acres of pitch pine is on protected land, within a larger contiguous area of 5000 acres, owned by the Nature Conservancy. Additional small parcels are owned by the towns of Freedom and Madison.

2.6 Habitat Management Status

Current habitat management and restoration techniques used in the Concord pine barrens include native plant propagation, vegetation management using specialized mowers and feller bunchers, and prescribed fire. These techniques are used to create sandy and herbaceous openings within a matrix of heath, scrub-shrublands, and woodlands. Habitat monitoring is completed before and after management implementation. The goal is to create a shifting mix of native grassland, shrubland, and woodland features (Fuller et al. 2003).

Similarly, The Nature Conservancy is currently exploring various management options to implement within the Ossipee pine barrens, including mechanical treatments to create firebreaks and remove unwanted vegetation, as well as some level of prescribed burning (Howard 2003). The intent is to maintain, enhance, and restore ecological processes vital to the overall function of the pitch pine-scrub oak woodland community (Raleigh et al 2003).

2.7 Sources of Information

Pitch pine-scrub oak woodland habitat protection and management information was obtained from habitat management plans, agency agreements, and personal communication.

2.8 Extent and Quality of Data

The GIS data used to create the predicted pine barrens map does contain some errors, primarily in the soil data. The map is less accurate in Belknap and Merrimack Counties, the White Mountains, and small portions of Coos County, due to a lack of fine scale soil data. The delineation of known pine barrens and the conservation data are fairly accurate.

2.9 Condition Assessment Research

Predicted pine barrens patches need to be verified on the ground as existing pine barrens or potential patches for restoration. Evaluation of the suitability and feasibility of restoration in these patches is necessary.

Element 3: Species and Habitat Threat Assessment

1.1.1 Development (Habitat Loss and Conversion)

(A) Exposure Pathway:

It has been asserted that one of the major threats to pine barrens is habitat loss, primarily as a result of development (Howard et al 2005). Habitat features associated with these communities, such as level terrain, sandy soils, high stability, high perme-

ability, and low compaction, make them optimal for commercial and residential development. Some species of vertebrates that use pine barrens can travel significant distances, requiring large blocks of contiguous habitat. A half-century of constant growth has resulted in a severe loss of habitat in communities that were historically large and contiguous (Howard et al 2005).

(B) Evidence
Throughout the northeast, nearly half of all known pitch pine-scrub oak woodland communities have been lost as a result of development and fire suppression (Jordan et al 2003). New Hampshire had at one time supported 4 such communities, including the Nashua, Manchester, Concord, and Ossipee pine barrens (The Nature Conservancy 2004). As in the remainder of the region, increased development and urban sprawl throughout the state drastically reduced the extent of these communities. Both the Nashua and Manchester pine barrens have been entirely altered, while a mere 10% of the historic Concord Pine Barrens and 30% of the Ossipee remain today (Helmbolt and Amaral 1994, The Nature Conservancy 2004).

3.1.2 Altered Natural Disturbance (Fire Suppression)

(A) Exposure Pathway
Due to the xeric soil, flammable pine litter, and flat terrain on which they occur, pine barrens have been subject to frequent wildfires (Howard 2003). The absence of such disturbance, combined with the natural processes associated with succession, have caused the community composition of pitch pine-scrub oak woodlands to shift into a closed-canopy forest dominated by fire intolerant hardwoods (Howard et al 2005). Additionally, without a regular fire regime, fuels have accumulated, increasing the risk of high intensity wildfires inappropriate to pine barrens regeneration

(B) Evidence
In the northeast, pitch pine-scrub oak woodland communities require periodic fire to persist (Wagner et al 2003). Fire suppression has been a major factor contributing to the decline of disturbance-dependent habitats throughout the northeast (Raleigh 2003). In the last half-century, natural fire disturbance has been eliminated from both the Concord and Ossipee pine barrens systems, leading to a significant shift in community composition and structure (VanLuven 1994, Howard 2003). In Concord, the distinguishing mosaic of grassy openings, heath barrens, scrub oak thickets, and pitch pine woodlands no longer exists, as it has been replaced by medium-fire tolerant white pine and fire intolerant hardwoods (VanLuven 1994). Similarly, white pine and fire-intolerant hardwoods have substantially increased over the last 50 years in the Ossipee pine barrens and are predicted to soon be the dominant canopy species (Howard et al 2005).

3.1.3 Development (Fragmentation)

(A) Exposure Pathway
Continuity of pine barren communities has been severely interrupted by infrastructure and road development. Currently, most communities are fragmented into relatively small habitat patches (Howard et al 2005). Such fragmentation serves to alter both microclimatic conditions and biogeographical distribution of pine barrens (Saunders et al 1991). As a result, total available habitat is reduced, ecological processes are disrupted, edge effects are increased, and the intrusion of invasive species is promoted, all of which serve to jeopardize overall community composition and structure (Saunders et al 1991, VanLuven 1994, Howard et al 2005).

(B) Evidence
Fragmentation of pine barrens on the modern landscape has had far reaching effects, altering both this community's ecological function and its physical environment. Of the affected ecological processes, the interference with a natural fire regime has had the greatest impact. Without large, continuous areas of unfragmented habitat, the occurrence of natural fires of sufficient frequency, intensity, and extent is reduced (Wagner et al 2003). Such reduction hinders pitch pine-scrub oak woodland vegetation recruitment, thereby affording the introduction of new, unnatural elements into the biota (Webb 2000, Howard et al 2005). Additionally, fragmentation creates artificial edges which have been shown to alter microclimate by elevating light, decreasing humidity, increasing wind exposure, and introducing airborne materials such as dust, further disrupting natural eco-

logical processes and facilitating the establishment of invasive species (Saunders et al 1991, Webb 2000).

3.1.4 Light Pollution

(A) Exposure Pathway:
Light pollution has adverse effects on much of the insect fauna associated with pine barrens (Frank 1988). Lepidopterists have long attributed population declines to light pollution, especially in moths (Frank 1988). Artificial lighting disturbs flight, navigation, vision, migration, dispersal, oviposition, mating, feeding, and crypsis in some moths (Frank 1988). It also increases their susceptibility to predation by birds, bats, and spiders (Frank 1988). The result may be either changes to behavioral patterns or an alteration in species composition of moths inhabiting illuminated environments (Frank 1988).

(B) Evidence:
Outdoor lighting has sharply increased over the last half century (Frank 1988). It has been suggested that declines in North American moth populations, especially northeastern Saturniids, is a direct result of light pollution (Frank 1988). The impacts of light pollution are amplified in small populations threatened by other disturbances, particularly in habitats fragmented by urban development (Frank 1988).

3.2 Sources of Information

Information on threats affecting pine barrens was acquired from the Concord Pine Barrens Habitat Management Plan, scientific journal articles, and personal communications and observations.

3.3 Extent and Quality of Data

Much study has been conducted regarding threats impacting pine barrens habitat. This information is documented in management and conservation plans as well as scientific journals.

3.4 Threat Assessment Research

Community-level effects of fire suppression and fragmentation should be further investigated. Research should focus on vegetation responses to fire suppression based on specific land-use and ecological histories, effects of microclimatic alterations on community composition, and habitat patch isolation. In addition, research should be conducted regarding the long-term effects light pollution has on insect populations and species composition, especially in reference to species inhabiting fragmented communities. Further research on invertebrate – host plant relationships and life cycles will aid in determining the influence of these threats on various species.

Element 4: Conservation Actions

4.1.1 Habitat Management

Category: Restoration and Management

(A) List of Direct Threats Affected
Habitat Loss, Habitat Fragmentation, Succession

(B) Justification:
1) Habitat management will increase the distribution and abundance of pine barrens within their existing and historical range by reverting closed-canopy stands to an early-successional structure. Standard habitat management techniques including forestry, fire, and herbicide have well-documented efficacy in reducing the cover of canopy-forming, shade-tolerant, and fire-sensitive species.
2) Early-successional plant species abundance increases in response to a broad range of vegetation management techniques (Smallidge et al. 1996). Management simulates natural and anthropogenic disturbance, creating areas of open or semi-open habitat interspersed with closed woodlands. In addition to maintaining open habitat structure, management releases scarce nutrients, exposes bare mineral soil, and stimulates flowering, germination, and seedling establishment of fire-adapted species, while serving to promote and maintain connectivity across the landscape (Wagner et al 2003). This continually changing heterogeneous landscape satisfies the microhabitat needs of a suite of indigenous species.
3) Habitat management is necessary to prevent the loss of protected habitat to succession, but is not adequate to secure unprotected remnants and buffer existing conservation land from development.

4) Restorative management intensity is high in the short-term, but can be reduced to a sustainable maintenance level in the long-term. Depending upon the intensity of management, beneficial responses can be observed in 0-3 years, and maintained with management on a 5-10 year rotation.
5) Pine barren vegetation can be controlled and maximized by adjusting the frequency and intensity of habitat management to modify current densities of canopy species and scrub oak. The prescription may be adapted to guide management in new areas.

(C) Conservation Performance Objective
The habitat management performance objective is to create a matrix of interconnected grasslands, shrublands, and woodlands by manipulating the densities of woody species in key vegetative strata. Progress toward target levels (i.e., reduction in canopy and shrub strata) will indicate the performance of habitat management.

(D) Performance Monitoring
Densities of woody species will be monitored as prescribed in Fuller et al. (2003) prior to implementation of management and in subsequent years.

(E) Ecological Response Objective
The habitat management response objective is to increase the densities of pitch pine-scrub oak woodland plant species in proportion to their associated early successional vegetative strata. Target levels for management units by strata and species are described in Fuller et al. (2003). Progress toward target levels (i.e., increase in density of pitch pine-scrub oak woodland plant species in proportion to sand, herbaceous, and heath strata) will indicate a beneficial response to habitat management.

(F) Response Monitoring
The density of key habitat plants will be monitored as prescribed in existing management plans such as Fuller et al. (2003) prior to implementation of management and in subsequent years.

(G) Implementation:
The New Hampshire Fish and Game Department, the New Hampshire Department of Resources and Economic Development, the New Hampshire Army National Guard, the United States Fish and Wildlife Service, the Federal Aviation Administration, and the city of Concord will cooperate to implement habitat management as per the Concord Municipal Airport Development and Conservation Management Agreement (2000) and the Management Plan (Fuller et al., 2003) under the guidance of the management team.
The Nature Conservancy has also developed a management plan for the Ossipee pine barrens which mechanical thinning, constructing fire breaks, and some prescribed burns (Jeff Lougee, personal communication).
Most management of pine barrens to this point has focused on Karner blue butterflies. Management procedures for other rare species should also be developed.

(H) Feasibility:
These restoration plans have successfully been implemented in the Concord pine barrens, and have begun to be implemented in the Ossipee pine barrens. Future feasibility is limited only by funding, which for the Concord site is secure through 2012.

4.1.2 Backyard Habitat Program

Category: Education and Outreach

(A) List of Direct Threats Affected
Habitat loss, Fragmentation, Succession, Isolation

(B) Justification:
1) Engaging the public to propagate pine barrens habitat plants on public and private land, and encouraging landscape professionals to adopt native plant landscaping will increase the availability of native plants for pine barrens-dependent species and provide stepping-stone habitat in highly fragmented areas.
2) Karner blue butterflies have been documented ovipositing and feeding on blue lupine planted by schoolchildren. Studies have shown that Karner blue butterflies use commercial and residential landscape plants to augment 'natural' habitat. Other species may also have similar responses to cultivated

host plants.

3) Habitat restoration efforts are currently restricted to Concord, New Hampshire. Similar strategies could be implemented in other pine barrens throughout the state. Efforts will be targeted towards decision-makers, professionals, landowners, and school children.
4) Habitat restoration is an ongoing process and the importance of this work needs to be addressed in both the short and long term. Students that plant blue lupine today will provide an immediate benefit, and may support recovery efforts as adults.
5) Education and outreach can be molded to meet different target audiences (landowners vs. school children) or habitat areas (private land vs. public land), and evolve as new techniques are developed. Content of educational materials can be geared towards specific threats to pine barren habitat.

(C) Conservation Performance Objectives:
In the Concord pine barrens, increase the number of blue lupine plants planted by schoolchildren and other volunteers to more than 500 plants per year for the next 5 years. Within 5 years, increase the proportion of landowners adopting pine barrens-friendly management and landscaping practices within the Concord pine barrens area to more than one-half for new developments and existing buildings within the potential habitat area. Increase volunteer participation in restoration activities to more than 20 per year for the next 5 years.

(D) Performance Monitoring:
Performance may be monitored via: documentation of the number of blue lupine plants planted each year by school children and other volunteers; random surveys of landowners to determine current land management practices; documenting the number of approved development plans that adopt pine barrens-friendly landscaping and management practices; and documenting the number of competent and reliable volunteers.

(E) Ecological Response Objective:
The desired ecological response is to increase the availability of blue lupine and nectar plants within and between habitat restoration areas. Successful education and outreach will be indicated by pine barrens lepidoptera using plants propagated by school children and using developed landscapes managed under pine barrens-friendly programs.

(F) Response Monitoring:
The use of plants propagated by school children will be documented during structured pine barrens population monitoring as described in the Concord pine barrens management plan (Fuller et al. 2003). As suitable plants are cultivated in the landscape surrounding restoration areas, monitoring will be adapted (with landowner permission) to document the movement of Karner blue butterfly and other pine barrens species through habitat between restoration areas.

(G) Implementation:
Hire education and outreach staff to:

Target nursery operators, landscape professionals and contractors to raise awareness of native plants, receive training on propagation, develop a supply of native plants, and advocate native plant landscaping in the community. Identify a training structure and present information at landscaping association meetings. Implement green landscaping certification.

Target landowners to disseminate educational materials, raise awareness, cultivate a demand for native plants, and implement landowner incentives. Train landowners to preserve existing native plant resources and adopt native plant landscaping. Encourage land managers to adopt Best Management Practices that incorporate native plant restoration.

Give presentations to the community and create informational materials such as kiosks, brochures, demonstration sites, etc.

(H) Feasibility
The limiting factor to educational implementation is funding and personnel resources. The New Hampshire Fish and Game Department is limited in staff and funding to carry out restoration and recovery work. More integration with the Public Affairs Division is needed to focus on education and outreach. Resources must be made available for developing education materials and training. The National Wildlife

Federation has assisted with blue lupine planting by school children and will continue to do so.

4.1.3 Artificial Light Reduction

Category: Education and Outreach

(A) List of Direct Threats Affected
Light Pollution

(B) Justification:

1) Reducing the amount of light pollution in pine barrens habitat will remove external artificial light that can compromise the behavior of nocturnal Lepidoptera.

2) Nocturnal pine barrens Lepidoptera will be better able to continue their life cycles in natural conditions without light pollution.

3) Light reduction would only be implemented in areas where nocturnal Lepidoptera are demonstrated to occur.

4) Light reduction would only be implemented during those times of the year when target Lepidoptera are active.

5) If new occurrences of nocturnal Lepidoptera are found, light reduction can be implemented in those areas as well.

(C) Conservation Performance Objective
The performance objective will be a reduction in artificial light to levels that do not affect nocturnal Lepidoptera, as demonstrated in available literature.

(D) Performance Monitoring
Reduction in light will be monitored by periodic site visits. Residences and commercial establishments that do not conform to acceptable light levels will be noted.

(E) Ecological Response Objective
Nocturnal activity of target Lepidoptera will be uninterrupted and behavior will not change from expected levels based on available literature. Populations of target species will not decline.

(F) Response Monitoring
Visits to known nocturnal Lepidoptera sites in areas of restricted artificial light will be made. Samples of target species will be taken and populations monitored. Nondeclining populations will indicate an effective ecological response. Observations of activity in target species will be used to determine if normal behavior is occurring.

(G) Implementation
Artificial light-free reserves will be established, such as sheltered hollows shielded from lighting (Frank 1988). To reduce lighting impact in habitats already exposed to lamps, low-pressure sodium lamps may replace other lamps when illumination is essential (Frank 1988). Filters to block ultraviolet light may be installed over mercury vapor lamps, and shields may be placed around lamps to block stray light (Frank 1988). Landowners will be presented with information and encouraged to use alternative lighting as outlined in Frank 1988.

(H) Feasibility
Staff time and funding will be necessary to implement this strategy. Effective light reduction will depend on the willingness of landowners to adopt light reduction practices.

4.1.4 Habitat Restoration

Category: Habitat Management

(A) List of Direct Threats Affected
Habitat loss, Fragmentation, Succession, Isolation

(B) Justification:

1) Restoring habitats that are no longer pine barrens to a pine barrens state will increase the amount of pine barrens habitat available, thus increasing connectivity between patches, reducing fragmentation, and mitigating habitat loss.
2) Increasing the amount and connectivity of pine barrens communities will provide more suitable habitat for pine barrens species and more opportunity for fire spread and seed dispersal, thus ensuring the continuity of pine barrens.
3) Pine barrens habitats are rare in the northeast; thus, any restoration of habitat to a pine barrens state will increase the spatial distribution of this habitat throughout the region.
4) Pine barrens habitats are becoming increasingly rare. Immediate restoration of potential habitat is needed to prevent extinction of local popula-

tions of pine barrens species.

5) As new potential sites become available, restoration can be implemented and adapted to those sites. Restoration measures can be changed to include the most effective methods as more information is gained.

(C) Conservation Performance Objective:
The objective is to increase the amount of pine barrens vegetation throughout its historical range.

(D) Performance Monitoring:
Performance will be monitored by site visits before restoration and at intervals afterwards to determine if pine barrens vegetation is increasing and surving at restored sites.

(E) Ecological Response Objective:
The objective is to create habitat suitable for pine barrens fauna.

(F) Response Monitoring:
Response will be monitored by site visits to survey for pine barrens fauna. The use of restored sites by pine barrens fauna, as well as the existence of pine barrens vegetation, will indicate successful restoration.

(G) Implementation:
Potential sites for restoration will be selected, with a focus on historical sites where remnant patches may occur. Emphasis will be primarily on open, bare sites and secondarily on sites occupied by white pine. Open sites will be seeded with pine barrens vegetation and monitored. Upon successful generation and growth of these species, typical pine barrens management will be implemented. Sites occupied by white pine will be cut and an appropriate fire regime and other pine barrens management strategies will be implemented. Sites will be monitored for the growth of pine barrens vegetation.

(H) Feasibility:
Site restoration will require staff and funding. Existing management plans could be adapted to incorporate restoration. Cooperation with willing landowners will be necessary for restoration on privately owned sites.

4.2 Conservation Action Research

Because each geographically isolated pitch pine-scrub oak woodland community has been subject to a unique combination of ecological and anthropogenic influences, knowledge of such factors is critical to the design of management plans (Howard et al 2005). In addition, research should be conducted regarding vegetational responses to the various management techniques, intensities, and frequencies. Focus should be specifically on key pitch pine-scrub oak woodland species.

Element 5: References

5.1 Literature

Chandler, D. S. 2001. New Hampshire Army National Guard butterfly and moth survey, Concord, New Hampshire. University of New Hampshire, Durham, New Hampshire, USA.

Frank, K. D. 1988. Impact of outdoor lighting on moths: an assessment. Journal of the Lepidopterists' Society. 42: 3-93.

Fuller, S. G., Goulet, C. and D. Hayward. 2003. New Hampshire Army National Guard Annual Report. Habitat Management and Monitoring Plan for the Concord Municipal Airport. Prepared by the New Hampshire Fish and Game Department, Concord New Hampshire, USA.

Helmbolt, K and M. Amaral. 1994. Status of the Karner blue butterfly in New Hampshire. Pages 123-128 in D.A. Andow, R.J. Baker, and C.P. Lane, eds. Karner blue butterfly: a symbol of a vanishing landscape. Minnesota Agricultural Experiment Station. St. Paul, Minnesota, USA.

Howard, L. F. 2003. Factors affecting plant community composition and dynamics in Ossipee Pine Barrens, New Hampshire. Dissertation, University of New Hampshire, Durham, New Hampshire, USA.

Howard, L. F., J. A. Litvaitis, T. D. Lee, and M. J. Ducey. 2005. Reconciling the Effects of Historic Land Use and Disturbance on Conservation of Biodiversity in Managed Forests in the Northeastern United States: part 1—pine barrens. National Commission on Science for Sustainable Forestry. Washington, DC, USA.

Jordan, M. J., W. A. Patterson III, and A. G. Windisch. 2003. Conceptual ecological models for the

Long Island pitch pine barrens: implications for managing rare plant communities. Forest Ecology and Management. 185: 151-169.

Raleigh, L., J. Capece, and A. Berry. 2003. Sand barrens habitat management: a toolbox for managers. The Trustees of Reservations. Vineyard Haven, Massachusetts, USA.

Saunders, D. A., R. J. Hobbs, and C. R. Margules. 1991. Biological consequences of ecosystem fragmentation: a review. Conservation Biology. 5: 18-32.

Smallidge, P. J., Leopold, D J. and C. M. Allen. 1996. Community characteristics and vegetation management of Karner blue butterfly (Lycaeides melissa samuelis) habitats on right-of-way in east-central New York, USA. Journal of Applied Ecology 33: 1405-1419.

Sperduto, D. D., and W. F. Nichols. 2004. Natural communities of New Hampshire. New Hampshire Natural Heritage Bureau. Concord New Hampshire, USA.

The Nature Conservancy. 2004. Exploring management options: the Ossipee pine barrens. <http://nature.org/wherewework/northamerica/states/newhampshire/science/> Accessed 2005 March 31.

VanLuven, D. E. 1994. Site conservation plan for the Concord Pine Barrens, Concord New Hampshire. The Nature Conservancy, Concord, New Hampshire, USA.

Wagner, D. L., M. W. Nelson, and D. F. Schweitzer. 2003. Shrubland Lepidoptera of southern New England and southeastern New York: ecology, conservation, and management. Forest Ecology and Management. 185: 95-112.

Webb, S. 2000. The pitch pine community of Mount Everett: ecological context and importance. Drew University. Madison, New Jersey, USA.

Element 5.2 Data Sources

Natural Resources Conservation Service. 1994. STATSGO. http://www.ncgc.nrcs.usda.gov/products/datasets/statsgo/metadata/nh.html#Metadata_Reference_Information Accessed 12 March 2001.

New Hampshire Natural Heritage Bureau. 2005. Database of rare species and exemplary natural community occurrences in New Hampshire. Department of Resources and Economic Develop-

HABITAT PROFILE

Tidal Coastal Watersheds

Associated Species: Alewife (Alosa pseudoharengus), American Brook Lamprey (Lampetra appendix), American Eel (Anguilla rostrata), American Shad (Alosa sapidissima), Atlantic Salmon (Salmo salar), Atlantic Sturgeon (Acipenser oxyrhynchus), Banded Sunfish (Enneacanthus obesus), Blueback Herring (Alosa aestivalis), Bridle Shiner (Notropis bifrenatus), Burbot (Lota lota), Brook Trout (Salvelinus fontinalis), Rainbow Smelt (Osmerus mordax), Redfin Pickerel (Esox americanus americanus), Sea Lamprey (Petromyzon marinus), Shortnose Sturgeon (Acipenser brevirostrum), Swamp Darter (Etheostoma fusiforme)

Federal Listing: Not listed
State Listing: Not listed
Global Rank: Not ranked
State Rank: Not ranked
Author: New Hampshire Fish and Game and The Nature Conservancy

Element 1: Distribution and Habitat

1.1 Habitat Description

Tidal coastal watersheds include tidal rivers and their watersheds. These rivers support runs of diadromous fish, such as American shad, alewife, American eel, Atlantic salmon, and blueback herring. These basins are dominated by abundant tributaries that are at low and very low elevations, are connected to larger meandering mainstem rivers, flow over acidic bedrock, and have extensive areas of deep and coarse sediment. There are a few moderate gradient tributaries in the upper headwaters of some of these watersheds, but the majority are low-gradient rivers. Most of these low-gradient tributaries have warmwater fish communities. Colder, groundwater-fed systems rarely occur. Instream habitats are dominated by riffle-pool habitats in the low gradient and unconfined valleys. In the low or very low gradient and highly sinuous channels with coarse sediments and sands, dune-ripple habitats may also occur. Dune-ripple habitats are dominated by sand-sized substrates and lack riffle-pool structure (Kline 2005).

The tributaries and mainstems in the lowest portions of these watersheds occur in areas of deep and extensive fine marine clay, which provides additional buffering capacity. Finer streambed substrates and connected wetland and floodplain communities are common in these areas of deep, fine surficial geological deposits. Low tidal watersheds are unique with tidal marsh/estuary ecosystems and small tidal tributaries at their mouth, in addition to the abundant freshwater stream and river habitats.

Fine scale system 13 was the only fine scale system in this analysis that was so ecologically distinct as to merit its own major watershed group. Although low gradient streams and mainstem tidal rivers dominate this watershed group, there is some variation with the two northernmost watersheds encompassing more moderate elevations and substantial amounts of moderate and a few high gradient streams along side slopes and summits.

1.2 Justification

Tidal aquatic ecosystems and their tributaries offer unique habitats for New Hampshire's wildlife. They are relatively uncommon in New Hampshire, and the rivers and estuary system at Great Bay are unique in the Northeast. Many rare species congregate in these coastal areas and may occur nowhere else in New Hampshire. In addition to the estuarine and diadromous fish species listed in section 1.1, species such as bald eagle, osprey, common tern, American black duck, saltmarsh specialist songbirds (e.g. saltmarsh

sparrow, marsh wren, Nelson's sharp-tailed sparrow), and congregatory species groups such as waterfowl, wading birds, and shorebirds use Great Bay and other coastal waters throughout the breeding and migratory seasons.

The gradients between salt, brackish, and fresh water occur uniquely within this watershed group. Restoring or enhancing marine and aquatic connectivity is paramount to ensuring stable and viable populations of riverine, estuarine, diadromous, and many marine species.

1.3 Protection and Regulatory Status

1.4 Habitat Distribution

Low tidal watersheds occur in seven watersheds in New Hampshire's coastal region, including all of the watersheds draining into Great Bay Estuary and New Hampshire's Atlantic Ocean coastline. They extend west of TNC's North Atlantic Coast Ecoregion, and into the Southern New England Coastal Hills and Plains subsections of southeastern and south-central New Hampshire. They sit entirely within the Merrimack-Saco-Charles River Ecological Drainage Unit (EDUs)[1]. The southeastern-most watershed contains rivers draining into the mouth of the Merrimack River, including the Powwow River. The rivers in this watershed are not tidally influenced, but represent the headwaters of these southern Merrimack River tributaries.

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

1.7 Sources of Information

1.8 Extent and quality of data

This pattern sometimes caused these watersheds to group with fine scale system 14 in some of the underlying TWINSPAN runs. Although the critical tidal connection and low gradient systems of their lower mainstems were felt to be overriding factors to keep these watersheds ultimately included in this Group, future research could examine whether certain watersheds should group with more northern system Groups (such as Salmon Falls River, for example). Overall, this system has one of the strongest ecological signatures of any in this analysis. TWINSPAN identified this area early in the splitting as a unique type, no matter what combination of variables were used. The strength of this type is further supported by its overlap with other regional land and water classifications (e.g. Ecoregions, EDUs, etc.).

Element 2: Species/Habitat Condition

2.1 Scale

Due to the large land area covered by the major watershed groups (Figure 3), a fine scale classification (Figure 4) was used, when possible, to assess the relative condition of aquatic habitats across the state. The low tidal watershed group is fine scale system 13 for this comparison.

2.2 Relative Quality

The total area of the low tidal watershed group is 2918.9 km^2. Approximately 103.5 km^2 of this area is surface water. Headwater streams (watershed area <48.28 km^2) are the most dominant stream/river type, comprising 84% of the total riverine habitat. Small rivers (watershed area of 77.70-518.00 km^2), medium rivers (watershed area of 518.00-2589.99 km^2), and large rivers (watershed area >2589.99 km^2) comprise 12%, 1%, and 2%, respectively, of riverine habitats.

There are 137 lakes greater than 10 acres in the low tidal watershed group. Most of these lakes (109 lakes) are less than 100 acres in size. Only two lakes, Pawtuckaway Lake and Bow Lake, are greater than 1000 acres, and the size of both of these lakes was increased by the creation of dams. There are over 2,455 small ponds less than 10 acres, ranging from shallow wetland systems with less than one acre of open water to relatively deep ponds with rocky or sandy shorelines. Where the coastal watersheds meet the Atlantic Ocean, New Hampshire contains approximately 354 km of tidal shoreline and 46 km^2 of estuary at high tide (Jones 2000).

The coastline of New Hampshire, though small, has a surprising diversity of habitats. Various combinations of rock, sand, and mud substrates along the coast support different communities of marine spe-

cies. Salt marshes, tidal flats, shellfish beds, and submerged aquatic vegetation in the estuaries of Great Bay and Hampton Harbor are essential to countless species of fish, birds, and invertebrates.

Freshwater habitats in the coastal watersheds are equally diverse. The Lamprey River watershed is perhaps the best example, with at least 25 different habitat characteristics required by New Hampshire wildlife species of concern (SPNHF 2002). A survey by the National Park Service found the Lamprey River contains 6 of 9 mussel species known to New Hampshire, including the state-endangered brook floater (*Alasmidonta varicosa*) (LRAC 1990).

Although freshwater and marine ecosystems are often considered separately, coastal watersheds are better viewed as a complex network of interdependent habitats. Many species move between marine, estuarine, and freshwater ecosystems at different stages of their life cycles. Submerged aquatic vegetation, such as the eelgrass beds (*Zostera marina*) in the Great Bay estuary, is an important nursery habitat for many species of invertebrates and juvenile fish (ASMFC 1997). Some of these species, such as Atlantic menhaden (*Brevoortia tyrannus*) and American lobster (*Homarus americanus*), will spend most of their adult lives in coastal waters, while others, such as alewives (*Alosa pseudoharengus*) and juvenile American eels (*Anguilla rostrata*), will migrate upriver and contribute nutrients to freshwater rivers (MacAvoy et al. 2000). The water quality of these rivers is critical to the health of shellfish beds and submerged aquatic vegetation in the estuaries. Protecting wildlife in the coastal watersheds will require maintaining and restoring continuity between freshwater, estuarine, and marine habitats.

2.3 Population Management Status

N/A

2.4 Relative Health

Land Use

Despite a rapidly increasing population, much of the land in low tidal watersheds remains natural. Approximately 69% of the land cover is unfragmented natural land, 5% is agricultural land, and 8% has been developed. In 2001, there were 282 blocks of unfragmented land greater than 250 acres, although only 15 of these blocks were greater than 2,500 acres (New Hampshire Estuaries Project (NHEP) 2003). Impervious surfaces are increasing rapidly in southeastern New Hampshire. In 43 towns in the coastal watersheds, impervious surface area increased from 4.3% to 6.3% between 1990 and 2000 (Justice and Rubin 2002). During this period, the average amount of impervious surface area per person increased from 1.5 acres to 2 acres, which suggests a growth pattern typical of urban sprawl (NHEP 2003).

Hydrology and Connectivity

There are approximately 514 active dams in the coastal watersheds. Dams range from hydroelectric facilities to small earthen dams used to create wildlife habitat. The number of dams per total river length in the low tidal watershed group is 0.065 dams/km, which is the third highest in the state.

There are 8 fishways (one on the Salmon Falls, Cocheco, Oyster, Lamprey, Winnicut, and Taylor Rivers and two on the Squamscott River) designed to provide access to spawning habitats used by anadromous fish in coastal rivers. While these fishways have helped restore populations of river herring and sea lampreys, they have been less effective for other species (Trowbridge 2003a). The coastal fishways are typically open only during spring spawning runs. For most of the year, dams at the head of tide act as barriers between freshwater and estuarine systems. Restoring connectivity by removing dams and installing more effective fishways will benefit many species.

Poorly designed culverts and stream crossings result in the fragmentation of freshwater ecosystems (Warren and Pardew 1999). The density of maintained and unmaintained roads (1.67 and 0.67 km/km^2, respectively) is second only to low nontidal watersheds where Interstate 93 crosses into New Hampshire.

Invasive Species

The Piscataqua River and Great Bay are at a high risk of invasive species invasion from the release of ballast water by foreign ships transporting oil, coal, and other commercial goods to the shipping ports along the Piscataqua River (Buck 2004). Invasive species have caused a number of major community shifts in the coastal ecosystem (Harris and Tyrell 2001). The green crab (*Carcinus maenas*), the common periwinkle (*Littorina littorea*), and, most recently, the Japanese shore crab (*Hemigrapsis sanguineus*), are just a few examples

of non-native species that have become abundant in coastal waters.

There are 4 infestations of freshwater invasive aquatic plants in low tidal watersheds, a number that is surprisingly low compared to other watersheds with high population density. This number does not include wetland and shoreline species such as purple loosestrife (*Lythrum salicaria*) and common reed (*Phragmites australis*), which may have an indirect effect on aquatic ecosystems. There are many non-native fish species that have become naturalized in the rivers, lakes, and streams of low tidal watersheds, including black crappie (*Pomoxis nigromaculatus*) and smallmouth bass (*Micropterus dolomieu*). The impact of these species on native freshwater communities is poorly understood.

Water Quality

Water quality data collected by Great Bay Watch from 1990 to 2000 indicate good overall water quality in Great Bay and its tributaries (Konisky et al. 2000). Fecal coliform levels show a decreasing trend at most sites and dissolved oxygen levels generally exceed class B standards of 75% saturation (Konisky et al. 2000, NHDES 2000). Stormwater runoff remains a problem as elevated fecal coliform levels are correlated to rainfall (Konisky et al. 2000). The elevated levels of bacteria in shellfish following heavy rains provide further evidence for nonpoint source pollution (Konisky et al. 2000). Approximately 63% of shellfish beds in New Hampshire are permanently closed due to bacterial contamination (Jones 2000). An overall increase in water quality between 1990 and 2000 suggests a decrease in point source pollution from industrial sources and wastewater treatment facilities (Konisky et al. 2000). However, an increase in polyaromatic hydrocarbons (PAH) in shellfish tissue is evidence that oil and gasoline is entering coastal waters through stormwater runoff and/or boat spills (NHEP 2003).

2.5 Habitat Patch Protection Status

Only 9.7% of the total land in low tidal watersheds is conserved. Of the 355,406 acres of unfragmented land in these watersheds, 12.7% is protected. A greater proportion of tidal shorelines is protected (21%) compared to freshwater shorelines (14%), but tidal shorelines are more developed (Trowbridge 2003a). It is difficult to purchase large pieces of property in the coastal watersheds because of rapidly increasing property values.

2.6 Habitat Management Status

There is an incredible amount of funding for the restoration of coastal ecosystems, yet there is surprisingly little monitoring to determine whether restoration projects have achieved their goals (Cornelison 1998). Most work in New Hampshire has focused on marine and estuarine habitats. Over 176 acres of salt marsh have been restored since 2000 (NHEP 2003). The University of New Hampshire's Seagrass Ecology Group has been mapping eelgrass beds in the Great Bay since 1986. There are at least 35 ongoing coastal water quality and biological monitoring programs in New Hampshire (NHEP 2003).

Land protection is the main strategy for conserving coastal watersheds. The Great Bay Resource Protection Partnership has protected 4,100 acres of land as of 2003 (NHEP 2003). Restoration efforts on coastal rivers have recently focused on dam removal. A timber crib dam was removed on the Bellamy River in 2004, providing access to more freshwater spawning habitat for anadromous fish. A nature-like fishway has been proposed to improve fish passage at the Wiswall Dam on the Lamprey River. An inactive dam on the Winnicut River is also under review for removal. Comparatively little work has been done to identify and restore degraded headwater streams.

2.7 Sources of Information

The relative quality of watershed groups was assessed using GIS data from various sources, including NHDES, TNC, and The New Hampshire Geographically Referenced Analysis and Information Transfer System (NH GRANIT), as well as reports and management plans from both private and government organizations.

2.8 Extent and Quality of Data

While useful for assessing general trends, GIS data may not be completely accurate at finer scales. Much detail is lost with such a broad scale approach. Information on long-term trends is scarce. Most of the indicator data used in the status reports produced by

NHEP has only been collected in the last 10 to 20 years (NHEP 2003).

2.9 Condition Assessment Research

The NHEP developed a number of indicators for ecosystem health in coastal watersheds. Their work has developed a baseline upon which to compare the future health of low tidal watersheds in New Hampshire. Refining and expanding the data used as environmental indicators will allow for a better assessment of future trends. Additional indicators should incorporate data on the status of headwaters and other underrepresented areas in coastal watersheds.

There should also be an effort to identify natural processes needed by the species in coastal watersheds. Certain variations in seasonal flows, nutrient concentrations, or sediment transport may be critical for these species. Understanding these connections will help preserve the natural processes needed by many species, rather than taking a reactive approach to the declines of individual species.

Element 3: Species and Habitat Threat Assessment

The effects of rapid development, including habitat conversion, non-point source pollution, and altered hydrology, are the most pressing threats to coastal watersheds. Fragmentation due to dams and stream crossings restricts the amount of habitat available to many species and could have a negative impact on their genetic integrity. Restoring connectivity between marine, estuarine, and freshwater habitats will have a positive, long-term effect on the health of the coastal ecosystem. While the entire coastal watershed is at risk of future invasive species introductions, the greatest risk is from foreign ships that enter the Piscataqua River. Heavy ship traffic in the Piscataqua River also puts the Great Bay and coastal areas at risk from oil spills. In 1979 an oil spill from the tanker *New Concord* during an incoming tide contaminated sites in the Piscataqua River, the Bellamy River, and the Great Bay (NHFG 1979). Oil and toxic chemical spills will continue to threaten the coastal ecosystem, although oil containment technology has improved significantly over the past 10 years (UNH 2004).

Refer to the general threats section for: Transportation Infrastructure, Development (Fragmentation and indirect effects), Non-Point Source Pollution (Runoff and Sedimentation), Acid Deposition, Introduced Species, Altered Hydrology, Recreation, Unsustainable Harvest (Forestry Operations and Management), Oil Spills, and Agriculture.

Element 4: Conservation Actions

Salt marsh and river restoration will largely continue through a cooperative process with the New Hampshire Natural Resource Conservation Service (NHNRCS), which coordinates efforts to restore coastal salt marshes, and the NHDES, which has a River Restoration Coordinator (focused largely on removing dams).

The NHFG purchases property and assists with conservation easements throughout the state as opportunities arise. The NHFG is also part of the CORD review process, and thus can acquire land for little or no fee. Much of the land obtained through the CORD process was originally acquired by the New Hampshire Department of Transportation for road or road infrastructure projects.

Refer to general strategies for: Transportation Infrastructure, Development (indirect effects), Fragmentation, Pollutants (Acid Deposition), Invasive Species, Altered Hydrology, Sedimentation, Recreation, Forestry, Pollutants (Stormwater runoff and oil spills), and Agriculture.

Element 5: References

5.1 Literature

Atlantic States Marine Fisheries Commission (ASMFC). 1997. Atlantic Coastal Submerged Aquatic Vegetation: a review of its ecological role, anthropogenic impacts, state regulation and value to Atlantic coastal fisheries. ASMFC Habitat Management Series #1. C.D. Stephan and T.E. Bigford eds.

Buck, B.H. 2004. Ballast water management to combat invasive species. Congressional Research Report, Library of Congress. Order code: RL32344

Cornelisen, C.D. 1998. Restoration of Coastal Habitats and Species in the Gulf of Maine. Prepared for the Gulf of Maine Council on the Marine Environment.

Harris, L.G., and M. Tyrrell. 2001. Changing com-

munity states in the Gulf of Maine: Synergism between invaders, overfishing, and climate change. Biological Invasions 3:9-21

Jones, S.H. (editor). 2000. A Technical Characterization of Estuarine and Coastal New Hampshire, Durham, NH: Jackson Estuarine Laboratory.

Justice, D., and F. Rubin. 2002. Developing impervious surface estimates for coastal New Hampshire. A Final Report to The New Hampshire Estuaries Project. Complex Systems Research Center: Institute for the Study of Earth, Oceans and Space. University of New Hampshire, Durham, NH.

Konisky, R., B. Pagum, A. Reid, J. Schloss, and D. Burdick. 2000. Great Bay Coast Watch 1990-1999: A Ten Year Report on the Volunteer Water Quality Monitoring of the Great Bay Estuarine System. UNH Cooperative Extension/Sea Grant Technical Report UNH MP-AR-SG-00-12

Lamprey River Advisory Committee [LRAC]. 1990. Lamprey River Management Plan for the towns of Durham, Epping, Lee and Newmarket. A report to the New Hampshire Department of Environmental Services under the Rivers Management and Protection Act.

MacAvoy, S.E., S.A. Macko, S. P. McIninch, and G.C. Garman. 2000. Marine nutrient contributions to freshwater apex predators. Oecologia 122: 568-573.

New Hampshire Department of Environmental Services [NHDES]. 2000. State of New Hampshire 2000 section 305(b) water quality report. Concord, New Hampshire, USA.

New Hampshire Estuaries Project [NHEP]. 2003. State of the Estuaries Report 2003. New Hampshire Office of State Planning and Energy Programs.

New Hampshire Fish and Game Department [NHFG]. 1979. Annual Report: Division of Inland and Marine Fisheries.

Society for the Protection of New Hampshire Forests [SPNHF]. 2005. New Hampshire's changing landscape 2005: Population growth and land use change: what they mean for the granite state.

Society for the Protection of New Hampshire Forests [SPNHF]. 2002. Wildlife Habitat GIS Modeling Study: Piscassic and lower Lamprey watersheds of New Hampshire. Technical report prepared for the Great Bay Resource Protection Partnership (GBRPP), funded by the New Hampshire Estuaries Project (NHEP)

Trowbridge, P. 2003a. Environmental indicator report: species and habitats. New Hampshire Estuaries Project

Trowbridge, P. 2003b. Summary of coastal and estuarine monitoring programs in New Hampshire. New Hampshire Estuaries Project

University of New Hampshire [UNH]. 2004. Coastal Response Research Center [Internet]. Durham, New Hampshire. Available: http://www.crrc.unh.edu/RFP_2004.htm

Warren, Jr., M.L. and M.G. Pardew. 1999. Road crossings as barriers to small-stream fish movement. Transactions of the American Fisheries Society 127: 637-644.

[1] EDUs in New England were qualitatively delineated by the TNC Freshwater Initiative program in 1999 using USFS Fish Zoogeographic Subregions, USFS Ecoregions and Subsections, and major drainage divisions (Bryer and Smith 2001). The EDUs were defined by grouping 8-digit US Geological Survey Hydrologic Units watersheds into units that were thought to contain aquatic systems with similar patterns of physiography, drainage density, hydrologic characteristics, connectivity, and zoogeography (Bryer and Smith 2001).

HABITAT PROFILE

Marsh and Shrub Wetlands

Associated Species: American Black Duck, American Bittern, American Woodcock, Blanding's Turtle, Common Moorhen, Eastern Red Bat, Great Blue Heron, Least Bittern, New England Cottontail, Northern Harrier, Osprey, Pied-Billed Grebe, Ringed Boghaunter, Rusty Blackbird, Sedge Wren, Silver Haired Bat, Spotted Turtle

Federal Listing: Not listed
State Listing: Not listed
Global Rank: Not ranked
State Rank: Tall graminoid emergent marsh (S4), Northern medium sedge meadow marsh (S3), Peaty marsh (S4), Short graminoid – forb emergent marsh/mud flat (S4), Medium-depth emergent marsh (S4), Deep emergent marsh aquatic bed (S4S5), Cattail marsh (S4), Aquatic bed (S4S5), Herbaceous seepage marsh (S3), Mixed tall graminoid- scrub- shrub marsh (S4S5), Highbush blueberry – winterberry shrub thicket (S4), Buttonbush basin swamp (S4), Alder alluvial shrubland (S3), Alder - dogwood arrowwood alluvial thicket (S4), Meadowsweet alluvial thicket (S3), Alluvial mixed shrub thicket (S4), Seasonally flooded red maple swamp (S4S5), Seasonally flooded boreal swamp (SU), Meadowsweet - robust graminoid sand plain marsh (S3S4), Meadow beauty sand plain marsh (S1), Threeway sedge - manna-grass mud flat marsh (S2S3), Spike-rush- floating- leaved aquatic mud flat (S1), Sharp-flowered manna-grass shallow peat marsh (S1), Montane sandy basin marsh (S1)
Author: Michael N. Marchand, New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

The marsh and shrub wetland habitat described here corresponds to the emergent marsh-shrub swamp and sand plain basin marsh ecological systems described by NHNHB (NHNHB, Sperduto 2004). Emergent marsh and shrub swamp systems have a broad flood regime gradient that is often affected by the presence or abandonment of beaver (*Castor canadensis*) activity (Sperduto 2004). Generally, the trophic regime of these systems is moderately to strongly minerotrophic, with soils consisting of poorly drained decomposed muck and mineral with a pH between 5 and 6 (Sperduto 2004).

The emergent marsh-shrub system is often grouped into three broad habitat categories: wet meadows, emergent marshes, and scrub-shrub wetlands. Wet meadows often are dominated by herbaceous vegetation (especially sedges) often less than 1 m in height and saturated for long periods during the growing season, but seldom flooded (Pedevillano 1995, NHDES Wt 101.91). Because wet meadows are a subset of an overall herbaceous emergent vegetation category, they will be discussed in this profile along with marshes unless stated otherwise. NHNHB terminology will be used to describe different wet meadow communities (Sperduto 2004, Sperduto and Nichols 2004). Examples of 'wet meadow' natural communities in New Hampshire may include tall graminoid emergent marsh, northern medium sedge meadow marsh, and short graminoid-forb emergent marsh/mud flat (Sperduto and Nichols 2004). Representative wildlife that use wet meadows include ribbon snake (*Thamnophis sauritus sauritus*), sedge wren (*Cistothorus platensis*), northern harrier (*Circus cyaneus*), northern leopard frog (*Rana pipiens*), king rail (*Rallus elegans*), common moorhen (*Callinula*

chloropus), and spotted turtle (*Clemmys guttata*; Benyus 1989).

Marshes are dominated by emergent herbaceous vegetation and have a water table that is generally at or above the surface throughout the year, but can fluctuate seasonally (Pedevillano 1995, NHDES Wt101.51). Examples of marsh natural communities in New Hampshire include cattail marshes and deep-emergent marsh-aquatic beds (Sperduto and Nichols 2004). Wildlife associated with emergent marshes include Blanding's turtle (*Emydoidea blandingii*), spotted turtle (*Clemmys guttata*), pied-billed grebe (*Podilymbus podiceps*), American black duck (*Anas rubripes*), northern harrier (*Circus cyaneus*), American bittern (*Botaurus lentiginosus*), king rail (*Rallus elegans*), Virginia rail (*Rallus limicola*), sora (*Porzana carolina*), least bittern (*Ixobrychus exilis*), common moorhen (*Callinula chloropus*), great-blue heron (*Ardea herodias*), red-winged blackbird (*Agelaius phoeniceus*), muskrat (*Ondatra zibethica*), mink (*Mustela vison*), and spring peeper (*Pseudacris crucifer*) (Benyus 1989, Pedevillano 1995).

Woody vegetation, predominantly saplings and shrubs, dominates shrub-swamps. They frequently flood in the spring or contain pockets of standing water (Pedevillano 1995). Examples of natural communities in New Hampshire include: highbush blueberry-winterberry shrub thicket, buttonbush basin swamp, and alder-dogwood-arrowwood alluvial thicket. Wildlife associated with shrub swamps includes Blanding's turtle (*Emydoidea blandingii*), spotted turtle (*Clemmys guttata*), New England cottontail (*Sylvilagus transitionalis*), Canada warbler (*Wilsonia canadensis*), American woodcock (*Philohela minor*), gray catbird (*Dumetella carolinensis*), moose (*Alces alces*), and many breeding amphibians (Benyus 1989, Pedevillano 1995).

Although no invertebrate species are discussed here specifically (see ringed boghaunter profile under Peatlands habitat), numerous groups of invertebrates use marsh and shrub wetlands for one or all life stages including but not limited to worms (e.g., leaches, flatworms, earthworms), mollusks (snails, clams, and mussels), crustaceans (e.g., scuds, decapods), mayflies, caddisflies, dragonflies and damselflies, and water beetles.

1.2 Justification

Eighteen species of conservation concern addressed in the New Hampshire Comprehensive Wildlife Strategy depend on this habitat and a number of other species use this habitat for foraging, nesting, breeding, and cover. Also, several state or federally rare natural communities are associated with this habitat (Taylor et al. 1996).

Wetlands are rich habitats that provide a number of critical functions such as flood control, pollutant filters, shoreline stabilization, sediment retention and erosion control, food web productivity, wildlife habitat, recreation, and education (Tiner 1984, North American Waterfowl Management Plan 1986, New Hampshire Office of State Planning 1989). Expenditures related to waterfowl alone generate several billion dollars annually in North America (North American Waterfowl Management Plan 1986).

Although the number of wetlands filled in New Hampshire has been small compared to the overall amount of wetlands available in the landscape, impacts to 'non-impacted' wetlands from surrounding land use is of great concern, especially in southern New Hampshire. New Hampshire's population grew by 17% between 1990 and 2004, double the rate of all other states in New England, and growth is projected to continue at a rapid rate (Society for the Protection of New Hampshire Forests 2005). Protecting landscapes with relatively undisturbed freshwater wetlands will be critical for maintaining biodiversity and ecological functions in the Northeast (Sundquist and Stevens 1999, Hunt 2005).

1.3 Protection and Regulatory Status

The following rules, regulations, and acts represent those that are most likely to affect freshwater marshes and shrub wetlands in New Hampshire. This is not intended to be a complete list of all possible regulations.

International

- North American Wetlands Conservation Act (1989): enacted to support the goals of the North American Waterfowl Management Plan of 1986.

Federal

- Clean Water Act-Section 404; administered by the USACE and USEPA: regulates discharge of dredge or fill material into "waters of the United States" including wetlands.
- Migratory Bird Treaty Act (1918)
- Migratory Bird Conservation Act (1929): authorizes federal acquisition of land for migratory waterfowl refuges.
- Emergency Wetlands Resources Act (1986): requires the Secretary of Interior (through USFWS) to produce updated reports every ten years on the status and trends of wetlands and deepwater habitats in the conterminous United States (Dahl and Johnson 1991); Section 303- requires inclusion of wetlands in statewide comprehensive outdoor recreation plans (SCORP).

State

- Fill and Dredge in Wetlands; NHDES (NHDES, RSA 482-A)- requires applicant to obtain a permit to fill or dredge jurisdictional wetland habitats. The NHDES has placed emphasis on preserving bogs and marshes based upon rarity and difficulty in restoration of value and functions (NHDES Wt 302.01). For all major (> 1,800 m^2) and minor (270- 1,800 m^2) impact projects, the applicant must assess impacts to plants, fish, and wildlife including rare, special concern species, state and federally listed threatened and endangered species, species at the extremities of their ranges, migratory fish and wildlife, and exemplary Natural communities identified by the NHNHB (NHDES Wt 302.04). The NHDES Wetlands Bureau does not require construction setbacks from non-tidal freshwater wetlands (except under RSA 485-A).
- Water Pollution and Waste Disposal Statute (RSA 485-A)- subsurface wastewater disposal systems must be greater than 15 m (50 ft) from poorly drained (hydric B) soils and 23 m (75 ft) from very poorly drained (hydric A) soils.
- Exotic Aquatic Weeds (RSA 487:16-a), NHDES - the sale, distribution, importation, purchase, propagation, transportation, or introduction of exotic aquatic weeds into the state is prohibited.
- New Hampshire Endangered Species Conservation Act (RSA 212-A)
- Nongame Species Management Act (1988) (RSA 212-B)—the NHFG Nongame and Endangered Species Program has responsibility and authority to conduct research, management, and education related to those species not hunted, fished, or trapped.
- Waterfowl Conservation Program (RSA 214: 1-d) - funds from the NHFG Waterfowl Conservation account may be used for the development, management, preservation, conservation, restoration, acquisition, and maintenance of migratory waterfowl habitat.
- Native Plant Protection Act (RSA 217-A); NHNHB

Local

- Designation of Prime Wetlands (RSA 482: a-15): towns may designate individual wetlands as 'prime' based on NHDES protocol (NHDES Wt 700). Projects located in or adjacent to designated prime wetlands under RSA 482-A:15 are considered major impact projects and require a full application to NHDES.
- Local wetland regulations and zoning vary considerably. Recommended buffer distances are summarized in Chase et al. (1995).

1.4 Population and Habitat Distribution

Emergent marsh-shrub swamp systems are widespread throughout New Hampshire (Sperduto 2004), although the White Mountain region likely has a lower density than other areas. Sand plain basin marsh systems occur mostly east-central and southern New Hampshire but may occasionally occur further north (Sperduto 2004). For the distribution of natural communities in each Ecoregion subsection, see Sperduto and Nichols (2004).

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

Marsh and Shrub Wetland maps were completed by the NHNHB as part of the CWCS. Wetlands from the National Wetlands Inventory (NWI) layer were selected based on comparing vegetation classes and subclasses as well as water regimes with descriptions for the natural communities within the marsh and shrub habitat (Sperduto and Nichols 2004), as well as expert review (D. Sperduto, NHNHB, personal communication). Wetlands on tidal flat organic or peat soils, and those described as acidic, excavated, and partially drained or ditched were excluded. Individual wetlands were assigned to natural communities based on their proximity to streams, isolation, elevation, ecoregion subsections, vegetation and hydrology. Wetlands that overlapped known peatlands from NHNHB surveys were eliminated from the layer (see Peatlands Profile-Element 1.6). Various attributes (e.g., quality, protection status, size, etc.) were assigned to the completed habitat map by NHFG and NHNHB.

Limitations: NWI classifications may be erroneous, particularly in underestimating peatlands; this would result in some peatlands included in the Marsh and Shrub Wetlands map. Also, incorrect water regime classifications in the NWI layer would result in incorrect natural community predictions. Mapped wetlands need some field survey to assess the quality of natural community predictions. Digital soil data were only available for part of the state, excluding Merrimack and Belknap counties as well as the White Mountains. Thus, any elimination of wetlands using soil data did not occur in these regions, so the habitat may be overpredicted in these regions.

1.7 Sources of Information

NHNHB publications, State and Federal agency web sites, NatureServe website, textbooks and peer-reviewed literature, and GIS layers from various sources (e.g., GRANIT, Complex Systems at UNH) were used for habitat mapping.

1.8 Extent and Quality of Data

Marsh and Shrub wetlands are distributed statewide. Natural communities that make up this system often have a more refined distribution. See mapping limitations in section 1.6.

1.9 Distribution Research

- Field-verify the prediction of mapped wetlands, especially for high priority sites and where rare natural communities may occur (e.g., meadow beauty sand plain marsh (S1), spike-rush - floating-leaved aquatic mud flat (S1), sharp-flowered manna-grass shallow peat marsh (S1), montane sandy basin marsh (S1)). Rare and at-risk wildlife should be incorporated into habitat-based inventories.
- The Marsh and Shrub Wetland mapping could be potentially improved as new and updated GIS layers become available. Periodic updating and refining of this layer will be necessary to ensure appropriate conservation actions are being taken for the highest priority wetlands and update changes to wetland communities due to natural (e.g., succession) or anthropogenic (e.g., wetland filling) causes.
- Beaver impoundments are of particular value for a variety of wildlife species. Although these habitats may be included in the mapped Marsh and Shrub wetlands, they also may be found in forested wetlands and open water habitats. Because these habitats are extremely valuable and existing layers such as NWI maps are probably insufficient, a specific effort to assess these habitats is worthwhile. Satellite imagery, color infrared aerial photographs, and other existing GIS data layers could be used to assess the current and potential (based on landscape modeling) distribution and abundance of beaver flowages in New Hampshire.

Element 2: Species/Habitat Condition

2.1 Scale

Mapped Marsh and Shrub Wetland polygons (see section 1.6) were combined into 'marsh complexes'. Individual marsh polygons were included in a complex if they were less than 250 m from an adjacent marsh. Marshes that were bisected by a major road (e.g., interstate, state route) were not considered part of the same complex. The condition and quality of Marsh and Shrub wetlands were assessed within these complexes based on available GIS data.

Marsh and Shrub wetlands have a statewide distribution and are relatively abundant, making it impossible to discuss each marsh complex separately. Therefore, the abundance of these habitats was summarized at a larger scale (e.g., Ecoregion subsections).

2.2 Relative Health of Populations

Marsh area (ha) was greatest in the Gulf of Maine Coastal Plain and least abundant in the Vermont Piedmont, White Mountains, and Northern Connecticut River Valley ecoregion subsections (figure 2).

2.3 Population Management Status

Waterfowl, beaver, muskrat, and other furbearers are managed by the NHFG.

2.4 Relative Quality of Habitat Patches

Because of the number and complexity of Marshes found in New Hampshire, complexes were assessed based entirely on available or easily created GIS data layers. For example, wetland size may be important for some area-sensitive birds (Hunt 2005). For amphibians, hydroperiod is an important factor influencing both species richness and abundance (Babbitt et al. 2003). Therefore, we grouped wetland complexes that had ephemeral wetlands, semipermanent and permanent wetlands, or both ephemeral and semipermanent wetlands. Because of the number of attributes assigned to polygons, individual variables will not be discussed here.

Southeastern New Hampshire is part of the middle-upper Atlantic coast waterfowl area, which stretches from South Carolina north along the Atlantic coast through Nova Scotia (North American Waterfowl Management Plan 1986). The Atlantic Coast Joint Venture, a subgroup of the North American Waterfowl Management Plan, has identified 3 waterfowl focus areas for New Hampshire: Lake Umbagog region, Great Bay area, and a 5 km area adjacent to and including the Connecticut River (North American Waterfowl Management Plan 1986). These areas are likely to be significant habitat areas for many other species as well. Wetlands associated with the Merrimack River and its tributaries are important areas for wildlife and priority areas for future protection efforts.

2.5 Habitat Patch Protection Status

Protection status was calculated for areas within 250 m of each marsh complex statewide and summarized for each Ecoregion subsection. The total mean area protected in the buffered complexes was 13 percent ± 27 SD (range 0-100%); mean fee ownership was 10 percent ± 13 SD (0-100%) and land in easement was 3 percent ± 13 SD (0-100%). Only 30 % of individual buffered complexes had greater than 5 % land area protected, 11% of complexes had greater than 50 % protected, and 8% of complexes had greater than 70% land protected statewide.

The percent protection among buffered complexes varied among ecoregion subsections (figure 3). The White Mountains subsection had the greatest percentage of buffered complex land in protection (58%); however, this subsection has the lowest percentage of overall marsh complex area (9%). Conversely, the Gulf of Maine Coastal Plain Lowland had the greatest percent of overall land consisting of marsh buffered complex (55%), but the percent in protection was low (14%).

2.6 Habitat Management Status

From 1997 to 2004, 121 ha of wetlands were created, restored, or enhanced as part of mitigation for 397 ha of wetlands impacts (S. Crystall, NHDES, personal communication). Restoration of freshwater wetlands in New Hampshire has been largely a result of wetland violation enforcements (L. Sommer, NHDES, personal communication). Most mitigation resulted from protection of uplands and wetlands through conservation easements (S. Crystall, NHDES, personal communication).

The NHFG owns and manages 19 waterfowl impoundments, and manages an additional 12 impoundments on other properties. Water control structures on each of these impoundments allow for aquatic vegetation manipulation. Most management consists of moist soil management where water is removed every 7-10 years, from approximately 20 June through mid-September with the goal to enhance the growth of aquatic plants (E. Robinson, NHFG, personal communication). In addition, some forest

management has occurred to encourage beaver occupation on state-owned properties (B. Lemire, NHFG, personal communication).

According to RSA 210:9, no person shall destroy or disturb or interfere in any manner with the dams or houses of beaver, without first obtaining a special permit from the executive director of the NHFG; an exception is allowed for the protection of property from damage or submersion. For several years, the NHFG provided technical assistance to landowners in order to maintain beaver flowages and reduce concerns over property damage, but funding for this assistance has not been available recently. A handout describing beaver control techniques (e.g., install beaver piping) is available at NHFG and the UNH Cooperative Extension.

In the coastal watershed, a management plan was completed that identified action plans for water quality, land use, habitat protection and restoration, and public outreach and education (New Hampshire Estuaries Project 2000). This management plan has set the groundwork for many of the actions that will be addressed for other habitats and areas of New Hampshire. Also, the Great Bay Resource Protection Partnership has protected 84 properties and 2,628 ha (6,494 acres) in the coastal watershed (R. Stevens, Great Bay National Estuarine Research Reserve, personal communication). Many of these protected properties provide habitat for at-risk wildlife species including Blanding's and spotted turtle and American black duck. Management plans are being developed for each of the properties.

2.7 Sources of Information

Condition of wetlands was based largely on available GIS analyses.

2.8 Extent and Quality of Data

Condition of wetlands was based largely on available GIS analyses.

2.9 Condition Assessment Research

- Conduct GIS analysis to identify quality of marsh complexes (e.g., high, moderate, low). Attributes have been assigned to marsh complexes but weighting of these variables needs to be completed as a next step. A subset of sites that are identified as high quality should be field verified. Marsh sampling should include an assessment of habitat availability for at-risk wildlife. This work can be conducted by NHFG with assistance from other wetland and wildlife experts. Ranked marsh complexes should be incorporated into NHDES wetland permit review and mitigation prioritization and selection.
- Develop and implement a bioassessment program for freshwater wetlands in New Hampshire (e.g., King et al. 2000, D. Neils, NHDES, personal communication).

Element 3: Species and Habitat Threat Assessment

3.1.1 Development (Habitat Loss and Conversion)

(A) Exposure Pathway

Most wetlands are filled for residential and commercial developments, road development or maintenance, agriculture and recreation (e.g., athletic fields). Direct filling has catastrophic and immediate impacts to the wetland habitat and the species that use it. Wetland alterations that do not result in complete filling also may have substantial impacts to wetlands and associated fauna, but effects may not be detected immediately.

(B) Evidence

The loss and degradation of wetland habitats is a major threat to most groups of wildlife including waterfowl (North American Waterfowl Management Plan 1986, 2000) and other birds (Hunt 2005), and reptiles and amphibians (Mitchell 2003).

More than 50% of original wetland acreage in the United States has been lost (Dahl 1990). In New Hampshire, Dahl (1990) estimated 9% (8,000 ha) of wetlands were lost between 1780 and 1980, the lowest percent of any state in the conterminous United States. In the conterminous United States between 1986 and 1997, urban and rural development accounted for 51% of freshwater wetland losses, followed by agriculture (26%), and silviculture (23%) (Dahl 2000). For freshwater emergent wetlands

converted to uplands during 1986-1997, 51% were on agricultural lands, 22 % were lost to development, 25 % to unidentified land use manipulations, and 2 % to silviculture (Dahl 2000). Freshwater emergent wetlands declined by 4.6 % during that time (Dahl 2000). Freshwater shrub wetlands, in contrast had a 6.6 % increase in acreage over this time period, largely because of emergent marsh and forested wetland conversion (Dahl 2000). However, the interaction between emergent marsh and shrub wetlands should not be misinterpreted. There was a net loss to freshwater wetlands, and 79,600 ha of shrub wetland were converted to uplands (Dahl 2000).

NHDES currently has regulations that limit the amount of wetland filling (RSA 482-A). Wetlands impacts averaged 50 ha per year from 1997 to 2004 in New Hampshire, with a low of 22 ha in 1997 and highs of 65 (2000) and 64 ha (2004) (S. Crystall, NHDES, personal communication). Wetland types were not described in impact totals and impacts to wildlife resulting from loss of uplands were not considered. Under NHDES regulations, marshes receive some priority for protection and large marshes are not likely to be filled. However, driveway and road crossing placement in wetlands in order to gain access to developable uplands occurs frequently (M. N. Marchand, NHFG, personal observation). New Hampshire is the fastest growing state in the northeast, and future rates of development and associated wetland impacts are likely to continue (Sundquist and Stevens 1999).

Several exemptions in state regulations allow wetland habitats and associated wildlife to be disturbed. For example, NHDES does not require a permit for the "removal of a beaver dam by hand or machine provided machinery does not enter the water or create any disturbance by filling or dredging to the adjacent waters, wetlands, or their banks; all dredged materials are placed out of department jurisdiction; and removal of the dam is done in a gradual manner that does not allow a sudden release of impounded water to cause erosion or siltation." (NHDES Wt 303.05). Also, a reduced application (Minimum impact agricultural projects) may be filed for agricultural 'improvements' up to 1.2 ha (3 ac) of wet meadow (NHDES Wetlands Bureau Fact Sheet WB-6). Lake drawdowns are conducted in the fall and these drawdowns leave adjacent wetlands shallow or dry during the winter months (e.g., Northwood Lake).

3.1.2 Development (Fragmentation)

(A) Exposure Pathway

Depending on the extent of fragmentation and loss or degradation of upland habitat, wildlife may be affected differently. Most species associated with wetlands use a portion of surrounding uplands for foraging, dispersing, reproduction, egg laying, resting, cover, and overwintering (Semlitsch and Bodie 2003). Extent and area of upland use can vary widely among species. Impacts to upland habitats from development can result in direct mortality of individuals, create barriers to dispersal, fragment species populations, eliminate or reduce the quality of nesting or forage habitat, and increase predation of nests or young as a result of generalist predators benefiting from an abundance of forage.

(B) Evidence

Wildlife that uses a landscape of wetland and upland mosaics are not protected adequately by existing state regulations. Although wetlands are given special attention through state permitting and this activity is warranted, upland habitats are given little consideration. NHDES site-specific permits are required when 9,290 m^2 (100,000 ft^2) of terrain are altered, but there is currently no review for wildlife impacts, including rare or endangered species, during this process. Maintaining undisturbed terrestrial buffers around wetland habitats is critical to protecting water resources and maintaining population viability for many species (Semlitsch and Bodie 2003). For example, loss of nesting cover has contributed to long-term declines of some duck species (e.g., American black duck, North American Waterfowl Management Plan 1986). The NHFG requires at least a 91 m (300 ft) undeveloped upland buffer in areas protected for nesting waterfowl. In an analysis of appropriate buffer distances for protecting water resources in New Hampshire, Chase et al. (1995) determined that a 30 m (100 ft) vegetated buffer around wetlands is likely to protect many water resources and habitat for some wildlife species. However, many reptiles and amphibians require much larger buffers (e.g., 127-290 m) to prevent population declines (Semlitsch and Bodie 2003). Some species (e.g., Blanding's turtle) may travel several kilometers from occupied wetlands. Therefore, a landscape-level planning effort will be required to maintain the biodiversity of New

Hampshire's landscape.

3.1.3 Introduced Species (Introduced Plants)

(A) Exposure Pathway
Invasive plants are introduced to a wetland habitat, often following disturbance or soils being exposed (Weatherbee et al. 1999). Invasive plants compete with native vegetation, often dominating areas of wetlands by forming monotypic stands. Invasive plants often are less valuable to wildlife as habitat and may decrease the aesthetic, recreational, and monetary value of New Hampshire waterbodies (Pimentel et al. 2004, NHDES Environmental Fact Sheet BB-40). Harm to native flora and fauna may vary depending on the invasive species and needs further research.

(B) Evidence
Approximately 42% of federal threatened or endangered species primarily are at risk from alien-invasive species (Pimentel et al. 2004). Examples of invasive wetland plants known to occur in New Hampshire include purple loosestrife (*Lythrum salicaria*), common reed (*Phragmites austra*lis), Japanese knotweed (*Polygonum cuspidatum*), shining buckthorn (*Rhamnus frangula*), water chestnut (*Trapa natans*), variable milfoil (*Myriophyllum heterophyllum*), Eurasian milfoil (*Myriophyllum spicatum*), and fanwort (*Cabomba carolinina*). Over 40 surface waters (not including wetlands) in New Hampshire are affected by various species of exotic aquatic plants (NHDES Watershed Bureau). Numerous additional wetlands have been invaded by purple loosestrife or Phragmites. The exotic species program within the NHDES Watershed Management Bureau has largely focused on controlling or eliminating invasive plants from surface waters. Herbicides are currently used to treat some species (e.g., milfoil) that have been in lakes and ponds. Attempts to eradicate extensive areas using chemicals are rarely effective (NHDES Watershed Bureau). However, there is considerable interest in documenting new or established invasive species among terrestrial and aquatic habitats (e.g., Invasive Plant Atlas of New England, National Invasive Species Council)

Phragmites is native to coastal marshes in New England; however, it has expanded its range and benefited from salt applications along roadways (Weatherbee et al. 1999, Richburg et al. 2001). Purple loosestrife has been introduced to 48 states, including New Hampshire, and is tolerant of a range of environmental conditions. It forms dense stands and has no natural enemies in North America (Pimentel et al. 2004, NHDES Fact Sheet BB-45). Individual purple loosestrife plants can produce millions of long-lived and easily dispersed seeds annually, and can re-sprout from broken stems or roots (NHDES Environmental Fact Sheet BB-45). The reported ecological effects of purple loosestrife have varied (Farnsworth and Ellis 2001). For example, an experimental removal of purple loosestrife in New York resulted in reduced purple loosestrife density, but a corresponding increase in native species richness did not occur (Morrison 2002). Therefore, removal programs should clearly identify goals before initiation (Morrison 2002). Recommended criteria for physical control of purple loosestrife have been described by the NHDES Exotic Species Program (NHDES Fact Sheet BB-45). Biological control of purple loosestrife by introduced beetles (e.g., *Galerucella* spp.) has shown some promise (Malecki et al. 1993, Katovich et al. 2001, Blossey 2003). The ecological effect of non-native invertebrates introductions on wetland flora and fauna is not well known but biological control appears to have some support in New Hampshire as a substitute for chemical control (Lionel Chute, NHNHB, personal communication).

3.2 Sources of Information

Literature reviews, state and federal agency websites, fact sheets, and reports were used to assess the exposure pathway and evidence of threats to marsh and shrub wetlands in New Hampshire. GIS data layers were gathered from the Complex Systems Research Center at UNH (GRANIT), NHDES, and NH Division of Transportation to assess threats.

Initially, a list of threats was identified by NHFG and sent out for review. A group of wetland and wildlife experts met on 27 January 2005 to rank threats to Marsh and Shrub Wetlands (participants included Kim Babbitt, Kim Tuttle, Pam Hunt, Carol Foss, Chris Martin, Laura Deming, Heather Hermann, Benjamin Nugent, and Matthew Carpenter). Ranked threats were sent out for further review, comments were incorporated and ranks were adjusted based on further expert input.

3.3 Extent and Quality of Data

Some threats to marsh and shrub wetlands and the associated flora and fauna are well established (e.g., wetland filling). Other threats need further study (See Element 3.4) or regional coordination (e.g., contaminants).

3.4 Threat Assessment Research

- Support a regionally coordinated effort to assess impacts of various contaminants (including sodium chloride) on wetland habitats
- Support research that identifies effects of invasive species (e.g., purple loosestrife) on native freshwater wetland fauna and flora and monitor new invasions through coordinated efforts with local (e.g., garden clubs) and regional efforts (e.g., Invasive Plant Atlas of New England).

Element 4: Conservation Actions

Protecting Marsh and Shrub Wetland habitat and surrounding uplands will be the most important effort to maintain marsh dependent organisms in New Hampshire. Marsh protection strategies (e.g., land acquisition, prime wetland designation, zoning ordinances, etc.) are incorporated into the discussion of Habitat Protection under General Strategies

4.1.1 Maintain natural establishment, occupancy, and abandonment of beaver flowages in the landscape, Regulation, Habitat Protection

(A) List of Direct Threats Affected: Wetland loss

(B) Justification

- There is presently no regulation or monitoring of beaver dam removals. Any action will be an improvement over existing conditions.
- Beaver flowages are critical habitat for a number of wildlife species. Natural flood regimes have been limited by increasing development that restricts beaver activity. Existing beaver dams that maintain impoundments may be removed if on private property with no regulatory review, including if rare species are present, because NHFG is not necessarily notified.
- Beaver flowages should be maintained at a landscape level so natural abandonment and establishment can occur. Otherwise, existing beaver impoundments will need to be maintained by human-created dams as wetlands are abandoned by beavers. Otherwise, local populations of wildlife with poor dispersing abilities may be extirpated when embedded in a developed landscape. Development must be restricted in areas with future potential to become beaver flowages.
- Wetland filling is regulated by the NHDES for developers but large wetland complexes can be drained legally with little if any review. With the rapid loss of upland habitat in southern New Hampshire, landscapes that currently have the ability to maintain beaver flowages will be fragmented or lost. Therefore, regulations pertaining to managing and regulating beaver impoundments should be reviewed within 1 year of the completion of the New Hampshire Comprehensive Wildlife Strategy.
- Most regulations can be changed, although not easily, if determined to be ineffective.

(C) Conservation Performance Objective
To reduce or eliminate the loss of wetlands resulting from beaver dam removal and to maintain landscapes where potential flooding exists for the future.

(D) Performance Monitoring
Estimate the number and area of wetlands that are lost annually from removal of beaver dams and compare to the area of wetland filled because of NHDES Wetlands Bureau Dredge and Fill permitting. Assess the number of wetlands that are maintained through beaver piping or other water control structures.

(E) Ecological Response Objective
Maintain naturally functioning wetlands and connectivity for wildlife dispersal in the landscape.

(F) Response Monitoring
It is well established that beaver impoundments are important habitats for numerous wildlife spe-

cies. Therefore, monitoring individual wetlands is not necessary. However, species-specific monitoring (e.g., Blanding's turtle, pied-billed grebe), connectivity analyses, and satellite imagery wetland change detection analyses may indicate the importance and effectiveness of actions.

(G) Implementation

- Maintaining functional beaver flowages in the New Hampshire landscape will require several more specific actions.
- Identify staff and funding needed to coordinate the following actions.
- Use landowner incentive programs (e.g., LIP) to maintain water levels (e.g., beaver piping) on existing beaver impoundments where additional flooding may cause property damage.
- Educate public about the importance of beaver impoundments for wildlife and the risk of flooding if structures are built in areas with potential to become impounded.
- Model existing and potential beaver flowages and incorporate into environmental reviews and landscape level planning done by towns and regional planners.
- Evaluate NHFG and NHDES regulations to require a review process prior to any beaver dam removal. Work with Wildlife Control Officers to ensure that maintenance of beaver impoundments is a preferred option over removal.

(H) Feasibility
Wetlands are very expensive to create and ecological success is often not obtained. Maintaining landscapes with naturally fluctuating beaver impoundments will be a cost-effective way at maintaining high-quality wetlands in New Hampshire long-term. Changing existing regulations may be somewhat challenging because of concern over landowner rights.

4.1.2 Create a list of wetland restoration sites and implement high priority projects, Restoration and Management

(A) List of Direct Threats Affected: All threats listed under Element 3

(B) Justification
Creating a list of restoration sites is the first step in prioritizing wetland restoration actions.

- Restoration sites are those that are impacted by a threat listed on the Marsh and Shrub Wetland Threat Ranking Form. Creating a list of restoration sites will not in itself reverse the threat but will provide a mechanism to select and prioritize sites for limited restoration funding. Freshwater emergent wetlands can reestablish quickly under wet conditions and can be restored with some success (Dahl 2000), especially when compared to other wetlands types such as peatlands and forested wetlands.
- Restoration will be focused on specific impaired wetlands but selection and prioritization may be embedded within 10-digit watersheds that are classified as in need of restoration (NHDES Watershed analysis).
- Restoration can address any number of threats (e.g., roads as dispersal barrier, altered hydrology, invasive plant removal). State and federal wetlands permitting currently allows and encourages wetland restoration as part of mitigation for impacts. Selecting restoration sites can be difficult and time consuming for permit applicants and actions may not result in the best ecological project.
- Restoration sites should only be considered if removal of the threat likely would result in a positive ecological response. Lists of potential restoration sites can be updated on annual or continual basis.

(C) Conservation Performance Objective
To create and prioritize a list of impaired wetlands in New Hampshire in which ecological integrity will be improved.

(D) Performance Monitoring
The number of potential restoration sites submitted per town or watershed unit will be compiled. Each potential restoration site should clearly describe how the system is being impacted and what measures can be taken to improve ecological integrity. Sites will be prioritized and a portion will receive funding. The number of restoration projects that receive funding

will be summarized per town and watershed on an annual basis.

(E) Ecological Response Objective
To improve the functioning of wetland systems by restoring impaired wetlands. Improved wetland function will vary depending on the reason a wetland is impaired or not fully functioning. Successful ecological response thresholds will be developed for each group of threat (e.g., invasive species removal, restore hydrology, etc.)

(F) Response Monitoring
Response monitoring will be site-specific and relevant to meeting the objectives. Success will be determined by monitoring positive changes to the described impairment. Funding should include a monitoring component to ensure limited funds are effectively allocated.

(G) Implementation
(See Action RST-4, RST-5, RST-6 from the 2000 NHEP Management Plan)
Compiling a list of potential wetland restoration sites will likely involve several phases. Standardized information can be gathered from locations across the state through GIS analyses, many of which will result from New Hampshire's Comprehensive Wildlife Strategy mapping. Some of these mapping efforts may involve field visits as verification (e.g., ineffective road culverts for migratory wildlife). Inventory methodology was developed in the coastal watershed (NHEP 2003). Other regional and statewide monitoring efforts should be quarried for information. For example, the Invasive Plant Atlas of New England database can be searched for invasive species locations in New Hampshire and these sites can be assessed based on degree of infestation, significance of the habitat for wildlife, and likelihood of improving ecological integrity. A second phase may involve quarrying locals for their knowledge of potential restoration sites (town conservation commissions and planning boards, land trusts, conservation groups). A list that includes both sites predicted to need some restoration activity and those identified by locals must be compiled and prioritized. Types of impaired wetlands worthy of considering restoration might include: filled, excavated, graded, ditched, and drained wetlands, reduced water quality as result of runoff or pollutants, altered hydrology, barriers to wildlife dispersal (e.g., ineffective road culverts), and invasive species presence. Criteria for prioritizing potential sites need to be developed. If mitigation funds become available for this purpose (i.e., In-lieu wetlands mitigation, NHDES), a selection board that includes members from state agencies (e.g., NHFG, NHDES, NHNHB, NHDOT) and conservation groups (e.g., The Nature Conservancy, New Hampshire Audubon) would convene as needed. Top priority restoration projects would be funded and monitored for success. This list would also be available for towns or regional conservation groups to implement local restoration.

(H) Feasibility
A list of potential restoration sites was compiled for the coastal watershed as part of the NHEP management plan (NHEP 2000, 2003). Towns with more developed and active conservation commissions and planning boards are more likely to participate than some other towns with limited personnel or experience.

4.1.3 Assess the impacts of lake, pond, and wetland water level drawdowns on at-risk wildlife and plant assemblages in New Hampshire and implement any necessary changes to procedures, Restoration and Management.

(A) List of Direct Threats Affected: Wetland loss and alteration

(B) Justification

- Threats may vary depending on species and type of drawdown. Recommended procedure changes will be designed to reduce threats.
- Recommended procedure changes will occur when ecological responses are expected and can be measured.
- Water withdrawal procedures may be adjusted in specific areas where at-risk species are known or likely to occur. General recommendations can be incorporated into withdrawals statewide.
- With the loss of rapid rate of development in southern New Hampshire and the associated loss of wetlands as wildlife habitat, it is increasingly important to incorporate at-risk

species in managed systems.
- At-risk species and specific threats can be monitored and adjusted as appropriate.

(C) Conservation Performance Objective
To improve wetland ecosystem function and viability of at-risk species by implementing appropriate changes to current water withdrawal procedures.

(D) Performance Monitoring
Identify specific locations where hydrological alterations may impact at-risk wildlife. The number of wetland and lake drawdowns can be easily tracked, as well as the number of procedure changes that occur as a result of improved coordination among agencies and interested parties.

(E) Ecological Response Objective
Maintain or enhance marsh habitat for a diversity of species, especially at-risk wildlife.

(F) Response Monitoring
Wildlife surveys could be conducted before and after drawdown activities to determine potential impacts of current procedures and monitor long-term response of wildlife or communities to changing procedures. Specific monitoring (e.g., species presence, habitat use, productivity, survivorship, behavioral response) could occur for those species of the highest conservation concern (e.g., pied-billed grebe, Blanding's turtle) or those easily surveyed. Research may be encouraged in locations where the effects of existing procedures are not known.

(G) Implementation
Review procedures for wetland and lake drawdowns and identify sites where at-risk species may occur. Existing impoundments managed by NHFG are known and species maps can be used to identify wildlife that may occur on each area. Identify existing areas where management for at-risk wildlife can be improved. Future proposed impoundments should be reviewed by the NHFG Nongame and Endangered Species Program and incorporate at-risk species management. Lake and pond annual drawdowns are identified by NHDES. The effect of these drawdowns on adjacent marsh wildlife is expected to be detrimental. Use GIS to compare known lake drawdowns and rare species occurrences. Review procedures and justifications for drawdowns and identify areas for enhanced wildlife habitat.

Specific recommendations to consider might include: avoiding late fall drawdowns to prevent mortality of hibernating amphibians and reptiles, conducting drawdowns gradually to allow wildlife to disperse, maintain channels to adjacent wetlands to facilitate safe dispersal of threatened turtles and other wildlife (Hall and Cuthbert 2004), and ensure that water levels and timing are sufficient for at-risk birds that may be nesting at specific sites (e.g., pied-billed grebe).

(H) Feasibility
Altering existing drawdown schedules for lakes and ponds may be challenging in some cases due to local support for the action. Incorporating biodiversity considerations into state- managed impoundments should be possible in most cases, especially where waterfowl considerations are maintained. Future proposed drawdowns should be carefully evaluated by NHDES and NHFG for potential impacts to at-risk wildlife or system functions.

4.2 Conservation Action Research

- Restoration efforts will be prioritized according to likelihood of success. Degree of success will be incorporated in Ecological Response Monitoring.
- Model existing and landscapes where beaver flowages are likely in the future.

Element 5: References

5.1 Literature

Babbitt, K. J., M. J. Baber, and T. L. Tarr. 2003. Patterns of larval amphibian distribution along a wetland hydroperiod gradient. Canadian Journal of Zoology. 81:1539-1552.

Benyus, J. M. 1989. The field guide to wildlife habitats of the eastern United States. Simon and Schuster. New York, New York, USA.

Blossey, B. 2003. Purple loosestrife (*Lythrum salicaria*) management plan for the lower Hudson River Valley. Submitted to the New York State Department of Environmental Conservation.

Chase, V.P., L.S. Deming, and F. Latawiec. 1995.

Buffers for wetlands and surface waters: a guidebook for New Hampshire municipalities. Audubon Society of New Hampshire. Concord, New Hampshire, USA.

Dahl, T. E. 1990. Wetlands losses in the United States 1780s to 1980s. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C., USA.

Dahl, T. E. 2000. Status and trends of wetlands in the conterminous United States 1986 to 1997

U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C., USA.

Dahl, T. E., and C. E Johnson. 1991. Wetlands status and trends in the conterminous United

States mid-1970s to Mid-1980s. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C., USA.

Farnsworth, E. J. and D. R. Ellis. 2001. Is purple loosestrife (*Lythrum salicaria*) an invasive threat to freshwater wetlands? Conflicting evidence from several ecological metrics. Wetlands 21:199-209.

Hunt, P. 2005. A regional perspective on New Hampshire's birds of conservation priority: objectives, threats, research needs, and conservation strategies.

Hall, C. D. and F. J. Cuthbert. 2000. Impact of a controlled wetland drawdown on Blanding's turtles in Minnesota. Chelonian Conservation and Biology. 3:643-649.

Katovich, E. J. S., D. W. Ragsdale, L. C. Skinner, and R. L. Becker. 2001. Effect of Galerucella spp. Feeding on seed production in purple loosestrife. Weed Science 49:190-194.

King, R. S., K. T. Nunnery, and C. J. Richardson. 2000. Macroinvertebrate assemblage response to highway crossings in forested wetlands: implications for biological assessment. Wetlands Ecology and Management. 8:243-256.

Malecki, R. A., B. Blossey, S. D. Hight, D. Schroeder, L. T. Kok, and J. R. Coulson. 1993.

Biological control of purple loosestrife. Bioscience. 43: 680-686.

Mitchell, J.C. 2003 DRAFT Habitat management guidelines for amphibians and reptiles of the northeastern United States. Partners in Amphibian and Reptile Conservation.

Mitsch, W. J. and J. G. Gosselink. 1993. Wetlands 2nd edition. Van Nostrand Reinhold. New York, New York, USA.

Morrison, J. A. 2002. Wetland vegetation before and after experimental purple loosestrife removal. Wetlands 22:159-169.

North American Waterfowl Management Plan. 1986. A strategy for cooperation.

United States Department of the Interior Fish and Wildlife Service; Environment Canada, Canadian Wildlife Service.

North American Waterfowl Management Plan. 2004. Strengthening the biological foundation. Strategic Guidance. Secretary of Interior, United States; Minister of the Environment, Canada; Secretary of the Environment and Natural Resources, Mexico.

New Hampshire Estuaries Project. 2000. Management Plan. Portsmouth, New Hampshire, United States

New Hampshire Estuaries Project. 2003. Freshwater wetland mitigation inventory for nineteen coastal communities. A final report to the New Hampshire Estuaries Project. Submitted by West Environmental and Carex Ecosystem Sciences in cooperation with Doucet Survey, Inc.

New Hampshire Office of State Planning. 1989. New Hampshire wetlands priority conservation plan- an addendum to the New Hampshire State Comprehensive Outdoor Recreation Plan. 95 pp.

Pedevillano, C. 1995. Habitat values of New England wetlands. Edited by L. Morse. U.S. Army Corps of Engineers, Waltham, Massachusetts, USA and U.S. Fish and Wildlife Service, Hadley, Massachusetts, USA.

Pimentel, D., R. Zuniga, and D. Morrison. 2004. Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecological Economics 52:273-288.

Richburg, J. A., W. A. Patterson III, and F. Lowenstein. 2001. Effects of road salt and *Phragmites australis* invasion on the vegetation of a western Massachusetts calcareous lake-basin fen. Wetlands 21:247-255.

Semlitsch, R. D. and J. R. Bodie. 1998. Are small, isolated wetlands expendable? Conservation Biology 12:1129-1133.

Society for the Protection of New Hampshire Forests. 2005. New Hampshire's Changing Landscape. Population growth and land use changes: what they mean for the Granite State. Executive Summary. Concord, New Hampshire, USA.

Sperduto, D. D. 2004. Wetland ecological systems of New Hampshire. New Hampshire Natural Heritage Bureau. Concord, New Hampshire, USA.

Sperduto, D. D. and W. F. Nichols 2004. Natural communities of New Hampshire. New Hampshire Natural Heritage Bureau and The Nature Conservancy. Concord, New Hampshire, USA.

Sundquist, D. and M. Stevens. 1999. New Hampshire's Changing Landscape. Population growth, land use conversion, and resource fragmentation in the Granite State. The

Society for the protection of New Hampshire Forests and The Nature Conservancy, Concord, New Hampshire, USA.

Taylor, J., T. D. Lee, and L. F. McCarthy. 1996. New Hampshire's Living Legacy- the biodiversity of the Granite State. New Hampshire Fish and Game Department Nongame and Endangered Species Program, Concord, New Hampshire, USA.

Tiner, R.W. Jr. 1984. Wetlands of the United States: current status and recent trends. National Wetlands Inventory. U.S. Department of the Interior. Fish and Wildlife Service, Washington, D.C., USA.

Weatherbee, P. B., P. Somers, and T. Simmons. 1999. A Guide to Invasive Plants in Massachusetts. The Massachusetts Biodiversity Initiative. Massachusetts Division of Fisheries & Wildlife, Westborough, Massachusetts, USA.

5.2 Data Sources:

NH Natural Heritage Bureau. 2005. Database of Rare Species and Exemplary Natural

Community Occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

Element 6: List of Figures

Figure 1. Marsh & Shrub Wetlands are distributed throughout New Hampshire. For the distribution of natural communities in each Ecoregion subsection, see Sperduto and Nichols (2004).

Figure 2. Area (ha) of marsh, shrub, and mixed (marsh and shrub) wetland habitats in each Ecoregion subsection of New Hampshire, USA.

Figure 3. Percent of each ecoregion subsection area in New Hampshire that was mapped as a marsh or 250 m marsh buffer (hatched bars) and the percent of each buffered marsh complex that was protected by fee acquisition or easement for each ecoregion subsection (solid bars).

HABITAT PROFILE

Northern Upland Watersheds

Associated Species: American Eel (Anguilla rostrata), Atlantic Salmon (Salmo salar), Burbot (Lota lota), Brook Trout (Salvelinus fontinalis), Finescale Dace (Phoxinus neogaeus), Lake trout (Salvelinus namaycush), Northern Redbelly Dace (Phoxinus eos), Rainbow Smelt (Osmerus mordax), Round Whitefish (Prosopium cylindraceum), Slimy Sculpin (Cottus cognatus), Tessellated Darter (Etheostoma olmstedi)

Federal Listing: Not listed
State Listing: Not listed
Global Rank: Not ranked
State Rank: Not ranked
Author: New Hampshire Fish and Game and The Nature Conservancy

Element 1: Distribution and Habitat

1.1 Habitat Description

The landforms, elevations, and geology of northern upland watersheds watersheds are similar to moderate-south watersheds (Figure 3), but moderate-north watersheds are distinct because of their northern terrestrial communities, higher elevations, and separation from watersheds south of the White Mountains. Both the higher elevation and the northern climate result in rivers that support more coldwater fisheries compared to similar southern rivers.

Higher gradient, coldwater stream communities likely dominate this watershed group. Where there are wetlands, there may be some sinuous stream habitats with more stable water flows and warmer waters. There are few long reaches of mature rivers, which would tend to have slower water, deeper pools, and habitats within meanders and laterally varied substrates. The mainstem of the Androscoggin River may have some characteristics of slow and deep rivers, but it is still fairly high up in the watershed and even the wide sections in New Hampshire have characteristics of faster and colder streams.

Moderate-north watersheds contain the headwater networks that support coldwater ecosystems and fisheries in the New Hampshire portions of the Androscoggin and Connecticut River basins. In addition, this watershed group contains some of the largest impounded reservoirs in New Hampshire. Both the dammed sections of the Ammonoosuc and Connecticut River Lakes provide artificial but unique lake-like habitats.

Moderate-north fine scale systems: 5, 7
Like moderate-south watersheds, the distinction between fine scale systems is subtle. Both fine scale systems 5 and 7 have similar geology, landforms, and elevations, but fine scale system 5 has a greater area above 762 m. Fine scale system 7 has a higher percentage of "big water" features, including large reservoirs, Lake Umbagog, more wetlands, and the large mainstem sections of the Androscoggin River. Fine scale system 5, by contrast, contains more of the highest headwaters and river tributaries.

1.2 Justification

Like northern terrestrial ecosystems, the aquatic systems of the North Country may provide unique ecological and evolutionary contexts for species assemblages. Potentially remote native trout streams, remote lakes and ponds, Lake Umbagog, and the unusually large reservoir systems, managed for industry (hydropower and timber) and recreation, provide settings found nowhere else in New Hampshire. There are slow streams meandering through lowland spruce fir flats and coldwater streams cascading down steep slopes.

1.4 Habitat Distribution

Moderate-north watersheds occupy the northern tier of New Hampshire, north of the major White Mountains drainages. Large tributaries to the upper reaches of the Connecticut and Androscoggin Rivers include the Perry, Nash, Indian Stream, Mohawk, Israel, and Upper Ammonoosuc Rivers to the west, and the Dead Diamond, Swift Diamond, and Magalloway Rivers to the east. Smaller native brook trout streams, such as Gore, Cone, and Smarts Mill Brook (among others) also flow directly into the Connecticut River mainstem in and around Colebrook. This watershed group straddles the Penobscot-Kennebec-Androscoggin and Upper Connecticut Ecological Drainage Units (EDUs). This watershed group is entirely within TNC's Northern Appalachians Ecoregion.

1.8 Extent and quality of data

Moderate-north watersheds are unique and clearly distinguishable from New Hampshire's other major watershed groups based on aquatic connectivity and geography. The difference between the fine scale systems is more subtle. There are differences in elevation, geology, and landform, but these may not control or influence biological communities. Nevertheless, representing both fine scale systems 5 and 7 in conservation plans will ensure a broader array of environmental settings.

2.1 Scale

Due to the large land area covered by the major watershed groups (Figure 3), a fine scale classification (Figure 4) was used, when possible, to assess the relative condition of aquatic habitats across the state. The types and sources of information were extremely variable and covered many different scales, and so the following sections refer to both the major and fine scale systems. The actual scale at which the natural conditions and processes lead to differences in aquatic communities is uncertain.

Moderate-north watersheds are divided into two conservation planning units (Figure 4). Fine scale system 5 includes 5 watersheds of the Androscoggin and Connecticut Rivers in northern New Hampshire with greater amounts of high elevation features. Fine scale system 7 includes 6 watersheds, also of the Androscoggin and Connecticut Rivers, but with more flat landforms and large lakes.

2.4 Relative Quality of Habitat Patches

Fine scale system 5 encompasses 1,709 km^2 (422,314 ac). Headwater streams (watershed area <77.7 km^2) are the most common stream/river type within this system, comprising 75% of the total stream area. Small rivers (watershed area of 77.7-518.0 km^2), medium rivers (watershed area of 518.0-2590.0 km^2), and large rivers (watershed area >2590.0 km^2) comprise 16%, 9%, and 1%, respectively. Moderate elevations (244-518 m) and high elevations (518-762 m) are most dominant, at 44.8% and 42.7%. Very high elevations (762-1371.6 m) comprise 12.5% of this system.

In fine scale system 5, the Connecticut, Mohawk (Colebrook), and Upper Ammonoosuc Rivers provide habitat for several life stages (e.g. spawning, nursery, rearing) of Atlantic salmon (Connecticut River Salmon Commission 1998, USFWS 2005). There is quality wild brook trout habitat in Pond (Stratford/Odell), Long Mountain (Stratford/Odell), Alder (Second College Grant), Lamb Valley (Second College Grant), and Lomis Valley (Second College Grant) Brooks, as well as in the west branch of the Mohawk River and Little Greenough Pond (Wentworths Location) (NHFG, unpublished data).

Fine scale system 7 encompasses 1,611 km^2 (398,047 ac). Headwater streams are the most common stream or river, comprising 64% of the total stream area. Small rivers, medium rivers, and large rivers comprise 18%, 11%, and 7%. High elevations and moderate elevations dominate at 49.5% and 45.8%. Very high elevations comprise 4.7% of this system.

An Androscoggin River basin study identified Umbagog Lake in Errol as having significant habitat value for waterfowl (USACE 1980). Lake Umbagog provides diverse habitats with relatively low disturbance, making it an important breeding ground for common loons (*Gavia immer*). Lake Umbagog and the adjacent wetland complex also provides ideal habitat for American black ducks (*Anas rubripes*), great blue herons (*Ardea herodias*), ospreys (*Pandion haliaetus*), bald eagles (*Haliaeetus leucocephalus*), and ring-billed gulls (*Larus delawarensis*) (USACE 1980). The lake provides fisheries for warm and coldwater

fish species. Smallmouth bass were illegally introduced into the system in the 1980s (Noon 1999) and expanding populations threaten salmonid populations in tributaries to the lake (Rapid, Magalloway, and Diamond Rivers) (Reardon and Zinc 2004). Clear and Chickwolnepy Streams (tributaries to the Androscoggin River) have ideal spawning and nursery habitat for Atlantic salmon (DeRoche 1967). However, spawning runs by anadromous fish in the Androscoggin River are blocked downstream of the New Hampshire boarder in Maine (USACE 1980).

Most lakes and ponds in the northern section of New Hampshire have a surface area less than 4.05 ha (10 ac) (94% of the total number). There are relatively few larger lakes and ponds. There is an average of 1.37 lakes/ponds greater than 4.05 ha per 100 km^2. The 4 lakes greater than 405 ha (1,000 ac) are First Connecticut Lake (1,243 ha or 3,071 ac), Lake Francis (783 ha or 1,934 ac), Second Connecticut Lake (446 ha or 1,102 ac), and Umbagog Lake (2,456 ha or 6,068 ac). Sixty percent of lakes and ponds are at elevations between 243.84-518.16 m (800-1,700 ft) and 38% are at elevations between 518.16-762 m (1,700-2,500 ft). Only 2% of lakes and ponds have elevations greater than 762 m (2,500 ft).

2.2 Relative Health of Populations

Land Use

Fine scale system 5 has the highest percentage of unfragmented land (94%) and the lowest percentage of developed land (0.8%) in New Hampshire. Low percentages of developed land correspond with the lowest road density in New Hampshire. The density of roads maintained by NHDOT is 0.17 km/km^2 and the density of private/gravel roads is 0.19 km/km^2. The estimated population for 2005 is 13,249 people, with a relatively low population density of 6.8 people/km^2.

Fine scale system 7 also contains large areas of unfragmented land (92%). The amount of developed land is very low compared to other units in New Hampshire (1.1% of total land). The density of NHDOT roads is 0.21 km/km^2 and the density of private/gravel roads is 0.25 km/km^2, which are both low. The estimated population for 2005 is 9,677 people, or 3.8 people/km^2, the lowest population density in the state.

Land uses along the upper Connecticut River are rural and agricultural, with large areas of forested and undeveloped lands (NHDES 1991). The higher elevations of these areas may inhibit agricultural use. The total area of agricultural land is small compared to other parts of New Hampshire. Agricultural lands in fine scale system 5 and fine scale system 7 comprise 1.9% and 1.2% of the total land area.

Silviculture in northern New Hampshire can be intensive with various levels of regard for significant wildlife habitats and post-harvest effects to stream systems. Forestry management in the Second College Grant is implemented with the "highest standards of forestry practice" with goals of broad wildlife species and age class distributions (Dartmouth Outing Club 2005). Concern is growing as private companies purchase large tracts of land with the intent of heavy logging followed by reselling, without consideration for the subsequent effects on wildlife habitat. Current forestry policies in New Hampshire may encourage out-of-state logging companies to purchase land. Logging regulations in New Hampshire are less stringent than neighboring states, which have more regulations on clear cutting and the sale of woodlots post-cutting (Webster 2005).

Housing increases for census blocks adjacent to lakes and ponds in moderate-north watersheds were estimated using 1990 values and projected 2020 values (see Lake Type Classification for methods). Changes between rural (<0.063 housing units/ha), exurban (0.063 to 0.25 units/ha), and suburban (0.25 to 2.5 units/ha) housing densities could indicate increases in shoreline development, impervious surfaces, and nonpoint source pollution. Housing densities adjacent to lakes are not expected to change in this area by 2020.

Water Quality

The NHDES Volunteer Rivers Assessment Program (VRAP) reported on surface water quality of the Androscoggin River (NHDES 2004). Dissolved oxygen and turbidity levels at all sample sites met state requirements for class B waters. Turbidity levels increased near urban areas. The range of pH values (pH 6.37-6.79) was below state water quality standards for class B waters (standard is pH 6.50-8.0). Acidic precipitation and natural environmental conditions (e.g. soils, geology, wetland drainage) can lower pH values (NHDES 2004). Within the Androscoggin River watershed, there is mercury seepage from contaminated

groundwater and nonpoint source pollution caused by agriculture, stormwater runoff, and poorly managed timber harvests (C. Knox, Androscoggin River Watershed Council, personal communication).

On the upper Connecticut River, there are adequate amounts of dissolved oxygen, low levels of fine particles or organic matter embedded in sediments, and a variety of fish habitats (Francis and Mulligan 1997). The upper Connecticut River system provides a highly prized coldwater fishery. Sedimentation and turbidity are the two highest threats to this area (Francis and Mulligan 1997). Silviculture practices have catalyzed the rates of bank erosion, which introduces sediments and nutrients into the system (Francis and Mulligan 1997). High water temperatures in the summer, coupled with excessive nutrient levels, can significantly lower dissolved oxygen rates (Francis and Mulligan 1997).

Water discharges registered through NHDES are moderate in this area when compared to registered discharges throughout New Hampshire. The number of National Pollution Discharge Elimination System (NPDES) permits issued per river kilometer is 0.013 NPDES permits/river km for fine scale system 5 and 0.027 NPDES permits/river km for fine scale system 7.

Upstream forestry operations that cause sedimentation and increased turbidity can damage downstream fisheries. Siltation from timber harvesting in 1972 covered smelt eggs and decimated the smelt population in First Connecticut Lake (Francis and Mulligan 1997).

Invasive Species

There are no documented infestations of exotic aquatic invasive plants in either fine scale system 5 or fine scale system 7 (Smagula 2004). Several non-native fish populations have become naturalized within the watersheds of the Connecticut and Androscoggin Rivers. Increased water temperatures and altered habitats from the creation of large impoundments facilitate the proliferation of these species. Several non-native species provide sport-fishing opportunities. Largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), northern pike (*Esox lucius*), landlocked Atlantic salmon (*Salmo salar*), brown trout (*Salmo trutta*), and rainbow trout (*Oncorhynchus mykiss*) are examples of species that have naturalized populations (NHFG 2004, Estuarine and Freshwater Working Group 2005). Landlocked Atlantic salmon, brown trout, and rainbow trout are annually stocked by NHFG. The population of smallmouth bass in Umbagog Lake is perhaps the most infamous naturalized non-native fish population in New Hampshire. The well-established population is expanding into the inlets of the lake and displacing native brook trout populations (Maine Department of Inland Fisheries and Wildlife (MDIFW) 2005).

To assess the likelihood of intentional or accidental introductions of invasive fish and aquatic plants, the degree of remoteness of lakes and ponds was analyzed through GIS. The highest percent of remote lakes and ponds occurs in this area. There are 850 lakes and ponds (69%) within 500 m of a trail or road, 154 lakes and ponds (13%) enclosed by a protective buffer of 500-805 m without a mapped road or trail, 151 lakes and ponds (12%) with a buffer of 805-1609 m, and 74 lakes or ponds (6%) with a buffer greater than 1609 m.

Hydrology

There are approximately 71 active dams/impoundments within fine scale system 5. There are no active impoundments in the mainstem of the Connecticut River in this area. From West Stewartstown to Dalton, there is a 112.65 km stretch of the Connecticut River mainstem that is free flowing (Francis and Mulligan 1997).

There are approximately 51 active dams/impoundments within fine scale system 7, which vary from large river impoundments for hydroelectricity production to small stream impoundments for wildlife habitats. There are five active impoundments along the Connecticut River in this area (Francis and Mulligan 1997). Impoundments in Berlin have a high degree of adjacent industrial development and little natural habitat (USACE 1980). Impassable dams downstream of the New Hampshire border in Maine block spawning runs of anadromous fish in the Androscoggin River (USACE 1980).

The loss of food supplies and spawning or rearing habitat for fish in the upper Connecticut River can occur during low flow periods or after seasonal drawdowns of the Connecticut Lakes and Lake Francis. Modified flow rates further impact limited wintering habitat by influencing ice formation and dissolved oxygen levels (Francis and Mulligan 1997).

2.3 Population Management Status

N/A

2.5 Habitat Patch Protection Status

In fine scale system 5, 35.4% of the total land area is conserved and 37% of unfragmented land is protected through conservation. In fine scale system 7, 11.8% of total land area is conserved. Unfragmented land comprises a significant proportion of this system, but only 12% is protected through land conservation.

The Connecticut River is designated in the New Hampshire River Management and Protection Program (RMPP)(NHDES 2004). The RMPP regulates dam construction, instream water flow levels, channel modification, water quality, solid waste and hazardous waste storage/treatment facilities, and motorized boating traffic.

2.6 Habitat Management Status

It is difficult to assess efforts to restore and manage habitats at such a broad level. A database of conservation groups may enhance cooperative efforts and eliminate repetitive or redundant projects.

There is a conservation and management plan for the Connecticut River. The plan identifies ecologically significant areas and guides the human use and management (Francis and Mulligan 1997). Public outreach and education are identified as useful tools for conserving and restoring this watershed. The plan provides highly detailed information at local levels and should be used to help identify sensitive areas, local impacts, and management actions. The Connecticut River Management Plan (1997) is currently being revised. The Coldwater Fisheries Coalition has created a management plan for coldwater fisheries in the upper Connecticut River (Coldwater Fisheries Coalition 1998).

Several agencies are actively involved in habitat restoration and identifying potential areas of habitat enhancement or improvement. Ongoing or recently completed projects include riparian buffer stabilization, stream bank erosion inventories, creating a task force for dam removal, landowner education, annual river clean ups, NHDES fish biomonitoring, and other studies. There are targeted restoration efforts for Atlantic salmon and brook trout.

The United States Forest Service (USFS) has initiated several watershed restoration projects to address the negative effects of historical silviculture practices on riverine habitats. Two segments along the west branch of the Upper Ammonosuc River in Berlin now have improved bank stability, channel depth, fish and invertebrate habitat, and habitat structure with large woody debris (Jay Milot, United States Forest Service, personal communication).

In Lake Umbagog, the MDIFW is working to minimize the effects of an increasing smallmouth bass population that is expanding and displacing native brook trout populations. The MDIFW is continuing research on the habitats, movements, and foraging of smallmouth bass, brook trout, and landlocked salmon. Passage barriers have been repaired and smallmouth bass fishing regulations have been amended to provide further protection to brook trout populations (MDIFW 2005).

2.7 Sources of Information

A watershed classification based on geological, topographical, climactic, and connectivity attributes, developed by TNC, was used to define scale and habitat condition. Watershed management plans, GIS analyses, and anadromous fish restoration plans were used to identify significant habitats, relative condition, quality, and ongoing management and restoration efforts.

2.8 Extent and Quality of Data

Information on current habitat quality and restoration efforts was highly concentrated on larger rivers. Smaller rivers within this habitat were not well represented. Information obtained from GIS analyses may not accurately represent all physical features.

2.9 Condition Assessment Research

Surveys in moderate-north watersheds should focus on identifying high quality areas or unique aquatic habitats representative of the region. Sites with degraded habitats, such as eroded banks or poor water quality, should be identified and monitored to help target future restoration work.

Element 3: Species and Habitat Threat Assessment

Existing river management plans, local watershed associations, and GIS analyses indicate that the primary threats to this area are fragmentation, development, sprawl, and non-point source pollution, especially sedimentation and runoff from poorly managed logging operations, agricultural fields, and impervious surfaces in population centers like Berlin. Refer to the general threats section for: Transportation Infrastructure, Development (Fragmentation and indirect effects), Non-Point Source Pollution (Runoff and Sedimentation, Nutrients (Eutrophication)), Acid Deposition, Introduced Species, Altered Hydrology, Recreation, Unsustainable Harvest (Forestry Operations and Management), and Agriculture.

Element 4: Conservation Actions

Watersheds within high percentages of unfragmented land are unique to northern New Hampshire. Strategies to preserve connectivity must be developed to protect these large unfragmented land tracts. Fortunately, there is an opportunity for protection rather than restoration in this area. Several strategies for conservation action for this area can be found in the Connecticut River Management Plan. Refer to the general strategies for Transportation Infrastructure, Development (indirect effects), Fragmentation, Population Isolation, Pollutants (Pesticides/Fertilizers), Pollutants (stormwater runoff), Pollution (acid deposition), Sedimentation, Forestry, and Agriculture.

5.1 Literature

Coldwater Fisheries Coalition. 1998. Upper Connecticut River Strategic Fisheries Management Plan. Available http://www.nhcfc.org/conn.html#Connecticut%20River%20Fisheries%20Plan (Accessed March 2005).

Connect River Atlantic Salmon Commission. 1998. Strategic Plan for the Restoration of Atlantic Salmon to the Connecticut River. Available http://www.fws.gov/r5crc/documents/strplan.pdf (Accessed March 2005).

Dartmouth Outing Club. Management. Available http://www.dartmouth.edu/~doc/secondcollegegrant/management/?DOC=7170221af07fb5fdbab33a1b7feaa56a. (Accesed May 2005).

DeRoche S. 1967. Fishery Management in the Androscoggin River. Maine Department of Inland Fisheries and Game. No. 52. Augusta, Maine, USA.

Estuarine and Freshwater Working Group. 2005. State of New Hampshire Comprehensive Management Plan for the Prevention and Control of Aquatic Nuisance Species-Draft. Concord, New Hampshire, USA.

Francis F., Mulligan A. 1997. Connecticut River Corridor Management Plan. Connecticut River Joint Commission. Charlestown, New Hampshire, USA.

Maine Department of Inland Fisheries and Wildlife. 2005. Rapid River/Pond in the River Fact Sheet. Available http://www.maine.gov/ifw/fishing/fishreports/rapidriverfactsheet.htm. (Accessed April 2005).

New Hampshire Department of Environmental Services. 1991. The Connecticut River. Available http://www.des.state.nh.us/Rivers/connect.htm#Intro (Accessed March 2005).

New Hampshire Department of Environmental Services. 2004. Androscoggin River Water Quality Report. Volunteer River Assessment Program. Concord, New Hampshire, USA.

New Hampshire Department of Environmental Services. 2002. Rivers Management and Protection Program (RMPP). Available http://www.des.state.nh.us/Rivers/rsa483.htm (Accessed March 2005).

New Hampshire Department of Environmental Services. 2004. Designated Rivers. Available http://www.des.state.nh.us/Rivers/desigriv.htm (Accessed March 2005).

New Hampshire Fish and Game Department. Freshwater Fishing Guide. 2004. Available http://www.wildlife.state.nh.us/Fishing/Fishing_PDFs/FW_Fishing_Guide.pdf (Accessed April 2005).

Noon J. 1999. The Bassing of New Hampshire. Moose Country Press. Warner, New Hampshrie, USA.

Reardon J., Zinc T. 2004. The New England Brook Trout: Protecting a Fish, Restoring a Region. Trout Unlimited. Arlington, Virginia, USA.

Smagula A. 2004. Report of the New Hampshire Exotic Aquatic Species Program. New Hampshire Department of Environmental Services. Concord,

New Hampshire, USA.

United States Army Corps of Engineers. 1980. Water Resource Study Androscoggin River Basin Maine. New England Division. Volume 2. Concord, Massachusetts, USA.

United States Fish and Wildlife Service (USFWS) webpage. Land Protection Plan. Available http://www.fws.gov/r5soc/landprot.htm#38 (Accessed March 2005).

Webster K. 2005. New Hampshire Now Considers Logging Regulations. Associated Press. The Barre Montpelier Times Argus. Available (http://www.timesargus.com/apps/pbcs.dll/article?AID=/20050419/SERVICES02/50419001. (Accessed May 2005).

HABITAT PROFILE

Southern Upland Watersheds

Associated Species: Atlantic Salmon (Salmo salar), Burbot (Lota lota), Brook Trout (Salvelinus fontinalis), Lake Trout (Salvelinus namaycush), Northern Redbelly Dace (Phoxinus eos), Rainbow Smelt (Osmerus mordax), Round Whitefish (Prosopium cylindraceum), Slimy Sculpin (Cottus cognatus), Sunapee Trout (Salvelinus aureolus), Tessellated Darter (Etheostoma olmstedi)

Federal Listing: Not listed
State Listing: Not listed
Global Rank: Not ranked
State Rank: Not ranked
Author: New Hampshire Fish and Game and The Nature Conservancy

Element 1: Distribution and Habitat

1.1 Habitat Description

Southern upland watersheds are similar to northern upland waterhseds. They both have cold water, moderate to high gradient, confined valley streams, and medium to large rivers, although they differ in landscape setting. The rivers in moderate-south watersheds are typical, medium-sized tributaries of the southern New Hampshire. They represent the middle range of most attributes, lacking the extremes of elevation or gradient in other watershed groups. Moderate-south watersheds have features with considerably lower elevation than those of moderate-north and high elevation watersheds, but they have features with relatively high elevation when compared to the rest of New Hampshire. With the lowest average of enriched bedrock of all watershed groups in New Hampshire, the rivers in moderate-south watersheds likely have the lowest buffering capacity and highest natural acidities. As with other moderate and high elevation watersheds, moderate-south watersheds have a higher percentage of hills and side slopes and a relatively high percentage and mileage of medium-sized rivers.

Step-pool and riffle-pool habitats likely dominate the moderate to high gradient tributaries, with step-pool habitats occurring in the more confined river sections and riffle-pool habitats occurring in the more sinuous and unconfined river sections. In the higher elevations, aquatic ecosystems are subject to colder seasonal temperatures, relatively large daily variations in temperature, and relatively unstable hydrologic regimes due to snow melt or precipitation flowing over shallow soils.

The lower, warmer rivers in this watershed group share fisheries characteristics with the low-moderate watershed group. In the moderately sized streams and small rivers at mid-elevation, there may be transitional warm to coldwater communities dominated by blacknose dace, longnose dace, white sucker, creek chub, and common shiner. Moderate-south watersheds also contain the headwater networks that support coldwater ecosystems and fisheries for New Hampshire portions of the Merrimack and Connecticut River basins. Lake Sunapee and Newfound Lake occur in this watershed group. These two large lakes are similar to those in the Lakes Region (fine scale system 14), but are situated in watersheds with higher elevations and more acidic geology.

Moderate-south fine scale systems: 3, 9: These two fine scale systems are very similar in terms of moderate elevation and landform, but fine scale system 3 is slightly higher and steeper than fine scale system 9. Fine scale system 3 has larger areas of intermediate granitic bedrock and some small areas of moderately calcareous bedrock, both of which may contribute to a greater buffering capacity in its waters.

1.2 Justification

Moderate-south watersheds support many of the most

important headwater tributary habitats, ecosystems, and fisheries of the Connecticut and Merrimack Rivers. These rivers and their tributaries provide habitat for a full range of local and migratory species.

1.4 Habitat Distribution

Moderate-south watersheds contain the southern rivers and headwaters that drain east into the Merrimack River and west into the Connecticut River. The north-south trending highlands roughly define the ridge running from Cardigan to Monadnock Mountain and divide the Merrimack and Connecticut River basins. Rivers in the moderate-south watershed group include major tributaries to the Merrimack River, such as the Contoocook headwaters and its tributaries (the Warner and Blackwater Rivers, and the Smith and Baker Rivers), and major tributaries to the Connecticut River, including the lower reach of the Ammonoosuc, Mascoma, Sugar, and Cold Rivers, and the upper reaches of the Ashuelot River.

This watershed group straddles the Merrimack-Saco-Charles River and Upper Connecticut Ecological Drainage Unit (EDU). It primarily overlaps the New Hampshire-Vermont Upland subsections of TNC's Lower New England-Northern Piedmont Ecoregion.

1.8 Extent and quality of data

Moderate-south watersheds are unique and clearly distinguishable from New Hampshire's other major watersheds groups. The differences between fine scale systems 3 and 9 are more subtly based on aquatic connectivity and geography. The differences in elevation, geology, and landform are recognizable between these fine scale systems, but may not control or influence biological communities. Nevertheless, representing both fine scale systems 3 and 9 in conservation plans will ensure a broader array of environmental settings.

Element 2: Species/Habitat Condition

2.1 Scale

Due to the large land area covered by the major watershed groups (figure 3), a fine scale classification (figure 4) was used, when possible, to assess the relative condition of aquatic habitats across the state. The types and sources of information were extremely variable and covered many different scales, and so the following sections refer to both the major and fine scale systems. The actual scale at which the natural conditions and processes lead to differences in aquatic communities is uncertain.

The watersheds in the moderate elevation mountains and foothills of western New Hampshire are divided into two fine scale systems. Fine scale system 3 includes 4 watersheds of the Connecticut and Pemigewasset Rivers (figure 4). Fine scale system 9 includes 11 watersheds of the Connecticut, Merrimack, and Pemigewasset Rivers (figure 4).

2.4 Relative Quality of Habitat Patches

Fine scale system 3 encompasses 2,201.8 km^2. Headwater streams are the most dominant stream/river type, comprising 87% of the total area of riverine habitats .Small rivers and medium-sized rivers comprise 10% and 3%, respectively. Fine scale system 9 encompasses 3,463.9 km^2. Headwater streams and small rivers comprise 87% and 12% of the riverine habitats .

In moderate-south watersheds, lakes and ponds with surface areas less than 10 acres are the most abundant (94% of the total number of lakes and ponds). There are 3 lakes greater than 1000 acres, Mascoma Lake (1,161 ac), Newfound Lake (4,451 ac), and Sunapee Lake (4,136 ac). Twenty-five percent of lakes and ponds are at elevations of 6.096-243.84 m (200-800 ft) and 72% occur at elevations of 243.84-518.16 m (800-1,700 ft). Less than 3% of lakes and ponds have elevations greater than 518.16m (1,700 ft).

The Cold River watershed is recognized for its variety of natural resources (NHDES 1999). Along the mainstem of the Cold River, shorelines consist of undeveloped forests, wetlands, and agriculture. Peregrine falcons, bald eagles, osprey, Cooper's hawk, and sedge wrens have been observed within the watershed. The coldwater fishery provides suitable rearing habitat for juvenile Atlantic salmon. The resources, values, and characteristics of this mostly free-flowing river (99.3% free flowing), provided the grounds for its protection in New Hampshire's Rivers Management Protection Program (RMPP) (NHDES 1999).

The variety of resources of the Ashuelot River is also recognized through New Hampshire's RMPP.

The upstream reaches of the river are forested with minimal development. As the river progresses, shorelines consist of mixed forests, farmlands, wetlands, and development (commercial, residential, and industrial). The Ashuelot River provides essential habitat for a variety of wildlife. The United States Fish and Wildlife Service has designated the river as one of the top four refuges for the federally endangered dwarf wedge mussel. The north-south trajectory of the river provides a migration route for several raptors, waterfowl, and songbirds. Bald eagles (Haliaeetus leucocephalus), northern harriers (Circus cyaneus), blue-gray gnatcatchers (Polioptila caerulea), common loons (Gavia immer), common nighthawks (Chordeiles minor), and great blue herons (Ardea herodias) have been documented throughout the Ashuelot River. Water temperatures provide fisheries for warm and coldwater fish species (NHDES 1993).

2.2 Relative Health of Populations

Land Use

In fine scale system 3, the density of roads (expressed as km of road/km^2 of total land area) maintained by NHDOT is 0.68 km/km^2 and the density of private/gravel roads is 0.59 km/km^2 .Developed land comprises 3.3% of the total land area. The density of roads and developed land is low compared to the southeastern part of the state, but higher than in watersheds to the north. Over 78% of the total land area remains unfragmented , but despite the relatively low population density (25 people/km^2), unregulated growth is becoming a threat in some areas (Dan Lambert, Mascoma Watershed Association, personal communication). When compared to other systems in the state, fine scale system 3 has a relatively high percentage of agricultural land (5.1%) .

In fine scale system 9, the density of roads maintained by NHDOT is 0.79 km/km^2 and the density of private/gravel roads is 0.64 km/km^2 .Developed land comprises 3.7% of the total land area. Road density is slightly higher than in fine scale system 3. The amount of developed land remains relatively low, although the population is increasing rapidly along the Interstate 89 corridor (SPNF 2005). Over 75% of the total land area remains unfragmented .When compared to other systems in the state, fine scale system 9 also has a relatively high percentage of agricultural land (4.5%) .

Housing increases for census blocks adjacent to lakes and ponds in moderate-south watersheds were estimated using 1990 values and projected 2020 values (see Lake Type Classification for methods). Changes between rural (<0.063 housing units/ha), exurban (0.063 to 0.25 units/ha), and suburban (0.25 to 2.5 units/ha) housing density categories could indicate increases in shoreline development, impervious surfaces, and nonpoint source pollution. Census blocks are expected to change from exurban to suburban densities around 37 lakes and ponds, and from rural to exurban densities around 734 lakes and ponds. Moderate-south watersheds are predicted to have the greatest number of changes in housing densities adjacent to lakes and ponds.

Water Quality

Historical evidence of poor water quality illustrates the need for clean waters. Pollutants from point and nonpoint sources caused fish kills in the Mascoma River in 1966 and 1977, with mortality estimates as high as 5000 fish (NHFG, unpublished data). In 1977, a release of sulfuric acid (H_2S0_4) in the Sugar River lowered pH levels to a value of 1.6 and caused a documented fish kill (NHFG, unpublished data). Since that time, water quality has gradually improved from the implementation of the Clean Water Act. Water treatment facilities, lined landfills, septic systems approved by the Environmental Protection Agency, and continued monitoring have improved water quality for aquatic organisms.

Surface water quality reports from the NHDES Volunteer Rivers Assessment Program (VRAP) provide a general illustration of water quality in moderate-south watersheds. The Sugar River flows through a variety of areas from natural to somewhat urban. Reports on the Sugar River from 2000-2002 show that dissolved oxygen and turbidity levels met state requirements for class B waters during all three sampling years. The range of pH levels annually fell below state water quality standards for class B waters (state standard is pH 6.5-8.0). Fifty-five percent of pH samples were below state standards in 2000 (pH 4.04-7.36), 43% were below state standards in 2001 (pH 4.70-7.70), and 33% were below state standards in 2002 (pH 4.09-9.25) (NHDES 2000, NHDES 2001, NHDES 2002). There is no information on

specific sources that would explain the low pH values, although acidic precipitation and natural environmental conditions (e.g. soils, geology, and wetland drainage) can lower pH values.

Dissolved oxygen levels in the Cold River met state requirements for Class B waters in 2003 and 2004. Turbidity levels in 2003 also fell within state standards (NHDES 2003). In 2004, some turbidity levels (8%) exceeded state standards. Precipitation likely contributed to increased turbidity (NHDES 2004). The range in pH levels for 2003 and 2004 were below state water quality standards for class B waters (state standard is pH 6.50-8.0). Thirty-one percent of pH samples exceeded state standards in 2003 (pH 5.57-7.22) and 78% of pH samples were below state standards in 2004 (pH 5.31-7.09) (NHDES 2003, NHDES 2004).

In the Gridley River between 2002-2004, there were low dissolved oxygen and pH values in this Contoocook River tributary. Specific sampling sites exhibited very low dissolved oxygen levels in all three sampling years. Forty-two percent of dissolved oxygen samples were below state water quality standards for Class B waters (>5.0 mg/L) for all 3 years. Levels of dissolved oxygen ranged from 2.00 to 9.83 mg/L. Large, adjacent wetlands and slow moving water in some sampling locations are believed to contribute to low dissolved oxygen levels (NHDES 2002, NHDES 2003, NHDES 2004). Turbidity levels met state requirements for Class B waters during all three sampling years (NHDES 2002, NHDES 2003, NHDES 2004). The range in pH levels annually fell below state water quality standards for class B waters. All pH samples during all sample years were below state standards (pH 4.76-6.45). Moderate-south watersheds may be more vulnerable to the effects of acid deposition due to naturally acidic bedrock.

Fine scale system 9 has the lowest number of National Pollution Discharge Elimination System (NPDES) permits issued per river kilometer in New Hampshire (0.004 permits/river km). The number of NPDES permits issued by NHDES for fine scale system 3 is also low at 0.008 permits/river km .

Invasive Species

In fine scale system 3, Eurasian milfoil (Myriophyllum spicatum) was introduced at Mascoma Lake in 2000 and variable milfoil (Myriophyllum heterophyllum) was introduced at Sunapee Lake in 2001 (Smagula 2004). There are 8 documented infestations of exotic aquatic plants in fine scale system 9. Variable milfoil has been detected in Pearly Pond (1975), Contoocook Lake (1990), Cheshire Pond (1995), Massasecum Lake (1995), Monomonac Lake (2000), Powder Mill Pond (2000), the Contoocook River (2001), and Dublin Lake (2001) (Smagula 2004).

Several nonnative fish populations have become naturalized in the Connecticut River. Increased water temperatures and enhanced habitat from large impoundments facilitate proliferation of these species. Several of these fish provide sport-fishing opportunities. Largemouth bass (Micropterus salmoides), smallmouth bass (Micropterus dolomieu), black crappie (Pomoxis nigromaculatus), bluegill (Lepomis macrochirus), walleye (Sander vitreus), northern pike (Esox lucius), white perch (Morone americana), landlocked Atlantic salmon (Salmo salar), brown trout (Salmo trutta), and rainbow trout (Oncorhynchus mykiss) are examples of species that have naturalized populations (NHFG 2004, Estuarine and Freshwater Working Group 2005). Landlocked Atlantic salmon, brown trout, and rainbow trout are annually stocked by NHFG.

To assess the likelihood of intentional or accidental introductions of invasive fish and aquatic plants, the degree of remoteness of lakes and ponds was analyzed through GIS. The results indicate that 4,025 lakes and ponds (92%) are within 500 m of a trail or road, 225 lakes and ponds (6%) are enclosed by a protective buffer of 500-805 m without a mapped road or trail, and 110 lakes and ponds (3%) are enclosed by a protective buffer of 805-1609 m without a mapped road or trail. No lakes or ponds have a buffer greater than 1609 m (1 mile).

Hydrology

The primary stressors to the Ashuelot River are impacts from altered natural flows (Zankel 2004). Population growth in this area of New Hampshire could reduce the continuity of riverine habitats and lead to the isolation of aquatic species. Additional road/stream crossings from future development may further limit migration and dispersal of fish and amphibians (Zankel 2004). The presence of impassable dams has already significantly impacted diadromous species, such as Atlantic salmon, river herring (Alosa pseudo-

harengus and Alosa aestivalis), American shad (Alosa sapidissima), and sea lamprey (Petromyzon marinus).

There are approximately 290 active dams or impoundments in fine scale system 3 and 485 in fine scale system 9, varying from large river impoundments for hydroelectric production to small stream impoundments for wildlife ponds (NHDES 1999). The numbers of impoundments/river km in fine scale system 3 and fine scale system 9 are 0.046 and 0.055, respectively .

2.3 Population Management Status

N/A

2.5 Habitat Patch Protection Status

In fine scale system 3, conserved land comprises 19.0% of the total land area, and 23% of unfragmented land is protected through conservation. In fine scale system 9, conserved land comprises 17.7% of the total land area, and 20.7% of unfragmented land is protected through conservation .

The Ashuelot and Cold Rivers are designated in the New Hampshire River Management and Protection Program (RMPP) (NHDES 1993, NHDES 1999). The RMPP regulates dam construction, instream water flow levels, channel modification, water quality, solid and hazardous waste storage/treatment facilities, and motorized boating traffic.

2.6 Habitat Management Status

It is difficult to assess the efforts to restore and manage habitats at such a broad level. A database of conservation groups may enhance cooperative efforts and eliminate conflicting or redundant projects.

The Ashuelot River watershed has abundant natural resources in need of further protection. A watershed management plan for the Ashuelot River was completed in conjunction with TNC, the Society for the Protection of New Hampshire Forests, Monadnock Conservancy, and the Southwest Regional Planning Commission. The management plan identifies several ecologically significant communities and suggests conservation strategies to reduce threats to these communities (Zankel 2004).

Several organizations (both governmental and non-governmental) are actively involved in either habitat restoration projects or identifying potential areas of habitat improvement. Ongoing or recently completed projects include riparian buffer stabilization, stream bank erosion inventories, identifying impassable culverts, public outreach and education, shoreline development monitoring, exotic aquatic plant monitoring, creating a task force for dam removal, landowner education, NHDES biomonitoring, constructing sediment control devices, and annual river clean ups. Efforts that target individual species include the restoration of Atlantic salmon and brook trout habitat.

2.7 Sources of Information

A watershed classification based on geological, topographical, climactic, and connectivity attributes, developed by TNC, was used to define scale and habitat condition. Watershed management plans, GIS analyses, and anadromous fish restoration plans were used to identify significant habitats, relative condition, quality, and ongoing management and restoration efforts.

2.8 Extent and Quality of Data

Information on current habitat quality and restoration efforts was highly concentrated on the larger rivers and lakes of this watershed group. Smaller rivers, streams, and ponds were not well represented. Information from GIS analyses may not accurately represent all physical features.

2.9 Condition Assessment Research

Increased sampling of aquatic communities and water quality will provide more conclusive, long-term trend data. Additional monitoring would help identify the impacts of water flow alterations (e.g. erosion, changes in dissolved oxygen, and impoundments) on plants, fish, and other aquatic wildlife. Increased sampling of fish tissue throughout these watersheds may recognize areas affected by contaminants. Habitat assessments, water quality monitoring, and aquatic community data are needed for the headwater streams and small tributaries of these systems. The pilot projects initiated by The Nature Conservancy in the Ashuelot River watershed should be expanded to other watersheds in this group to identify and protect additional areas of significant habitat.

Element 3: Species and Habitat Threat Assessment

Existing river management plans and GIS analyses indicate that altered natural flow regimes, nonpoint source pollution (especially sedimentation and stormwater runoff), and invasive species are the primary threats to habitats in moderate-south watersheds.

Refer to the general threats section for: Transportation Infrastructure, Development (Fragmentation and indirect effects), Non-Point Source Pollution (Runoff and Sedimentation, Nutrients (Eutrophication)), Acid Deposition, Introduced Species, Altered Hydrology, Recreation, Unsustainable Harvest (Forestry Operations and Management), and Agriculture.

Element 4: Conservation Actions

Moderate-south watersheds are in a relatively natural state compared to watersheds in the southeastern part of the state. Conservation actions should focus on land protection, although restoration projects may be necessary in certain areas. Identifying and protecting high quality aquatic habitats should be a priority. Preventing the spread of invasive species will be important for maintaining the integrity of this watershed group. Several conservation strategies can be found in the Ashuelot River Management Plan and the Ammonoosuc Watershed Region Conservation Plan.

Refer to the general threats section for Transportation Infrastructure, Development (indirect effects), Fragmentation, Pollutants (Acid Deposition), Invasive Species, Altered Hydrology, Sedimentation, Recreation, Forestry, Pollutants (Stormwater runoff), and Agriculture.

Element 5: References

5.1 Literature

Estuarine and Freshwater Working Group. 2005. State of New Hampshire Comprehensive Management Plan for the Prevention and Control of Aquatic Nuisance Species-Draft. Concord, New Hampshire, USA.

New Hampshire Department of Environmental Services [NHDES]. 1993. The Ashuelot River. Available http://www.des.state.nh.us/Rivers/connect.htmIntro (Accessed March 2005).

New Hampshire Department of Environmental Services [NHDES]. 1999. The Cold River. Available http://www.des.state.nh.us/Rivers/connect.htmIntro (Accessed March 2005).

New Hampshire Department of Environmental Services [NHDES]. 1999. New Hampshire nonpoint source management plan. Concord, NH.

New Hampshire Department of Environmental Services [NHDES]. 2000. Sugar River Water Quality Report. Volunteer River Assessment Program. Concord, New Hampshire, USA.

New Hampshire Department of Environmental Services [NHDES]. 2001. Sugar River Water Quality Report. Volunteer River Assessment Program. Concord, New Hampshire, USA.

New Hampshire Department of Environmental Services [NHDES]. 2002. Gridley River Water Quality Report. Volunteer River Assessment Program. Concord, New Hampshire, USA.

New Hampshire Department of Environmental Services [NHDES]. 2002. Sugar River Water Quality Report. Volunteer River Assessment Program. Concord, New Hampshire, USA.

New Hampshire Department of Environmental Services [NHDES]. 2003. Cold River Water Quality Report. Volunteer River Assessment Program. Concord, New Hampshire, USA.

New Hampshire Department of Environmental Services [NHDES]. 2003. Gridley River Water Quality Report. Volunteer River Assessment Program. Concord, New Hampshire, USA.

New Hampshire Department of Environmental Services [NHDES]. 2004. Cold River Water Quality Report. Volunteer River Assessment Program. Concord, New Hampshire, USA.

New Hampshire Department of Environmental Services [NHDES]. 2004. Gridley River Water Quality Report. Volunteer River Assessment Program. Concord, New Hampshire, USA.

New Hampshire Fish and Game Department. Freshwater Fishing Guide. 2004. Available http://www.wildlife.state.nh.us/Fishing/Fishing_PDFs/FW_Fishing_Guide.pdf (Accessed April 2005).

Society for the Protection of New Hampshire Forests [SPNHF]. 2005. New Hampshire's changing landscape 2005: Population growth and land use change: what they mean for the granite state.

Smagula, A. 2004. Report of the New Hampshire

Exotic Aquatic Species Program. New Hampshire Department of Environmental Services [NHDES]. Concord, New Hampshire, USA.

Zankel, M. 2004. A Land Conservation Plan for the Ashuelot River Watershed. The Nature Conservancy. Concord, New Hampshire, USA.

HABITAT PROFILE

Montane Watersheds

Associated Species: Atlantic Salmon (Salmo salar), Brook Trout (Salvelinus fontinalis), Rainbow Smelt (Osmerus mordax), Slimy Sculpin (Cottus cognatus)

Federal Listing: Not listed
State Listing: Not listed
Global Rank: Not ranked
State Rank: Not ranked
Author: New Hampshire Fish and Game and The Nature Conservancy

Element 1: Distribution and Habitat

1.1 Habitat Description

Montane watersheds are characterized by high elevation and steep or very steep acidic streams that flow over granite bedrock in and around the White Mountains. This watershed group has a high percentage of the two highest elevation zones and the highest percentage of steep slopes, cliffs, ridge tops, slope crests, and small cove headwater streams. Tributaries flow off the White Mountains in all directions, draining into the Connecticut, Pemigewasset/Merrimack, Saco, and Androscoggin River watersheds. The bedrock is mostly acidic, with little buffering capacity.

These headwaters are primarily cold mountain streams with cascade and step-pool habitats. Stream channels are narrowly confined by valley walls, and streambeds consist of bedrock, boulders, and cobbles. Very shallow soils and geologic materials create streams with variable flow that responds to runoff events. In some cases, as the stream size increases, the main stems flow through areas of deep, coarse-grained sediments and become more sinuous within wider valleys. However, high watersheds also contain plane bed systems, where the stream runs directly on resistant bedrock, which creates long, featureless runs and the absence of discrete pools, riffles, and point bars.

High watersheds have multiple examples of pristine, coldwater fisheries. The very smallest high elevation coldwater streams often contain only brook trout (*Salvelinus frontinalis*). Slightly further downstream, slimy sculpin (*Cottus cognatus*) is found with brook trout, sometimes with the addition of blacknose dace (*Rhinichthys atratulus*). The above two stream types have cold, fast-moving water and rocky substrates.

High fine scale systems: 4, 6, 8
The relative extremes of elevation and landforms are the primary justification for splitting high watersheds into 3 fine scale systems. Fine scale system 6 is the most mountainous and steep in the state, followed by fine scale system 4, then fine scale system 8. Fine scale systems 6 and 4 are the only watersheds with landforms and streams above the elevation of 1,219 m (4,000 feet). All three fine scale systems also have relatively high percentages of steep slopes, ridge crests, and headwater streams, roughly in the same order as elevation (fine scale system 6 > fine scale system 4 > fine scale system 8).

Fine scale system 4 is transitional to the north, and fine scale system 8 is transitional to the south, although both contain substantial areas of high and very high elevation. Fine scale system 8 is quite mountainous, although at more moderate elevations because it includes the southern foothills of the White Mountains and some large coarse sediment deposits along the larger mainstems of the Pemigewasset and Saco Rivers. Fine scale system 4 is more acidic granitic than fine scale systems 6 and 8. It has a smaller extent of very steep landforms, more wet flats and wetlands, and larger meandering rivers that ultimately connect to the Connecticut River.

1.2 Justification

High watersheds are unique in New Hampshire and region-wide. The fisheries in these high mountain streams are not necessarily unique, but the environmental settings provide ecological and evolutionary contexts for fish and other aquatic species (particularly insects) that may only occur at these high elevations.

1.4 Habitat Distribution

The predominant defining feature of high watersheds is the granite of the White Mountain massif. The medium-sized tributaries and the upper reaches of the Connecticut (Ammonoosuc, Israel, and Johns Rivers), Pemigewasset (East Branch and Mad Rivers), Androscoggin (Peabody and Wild Rivers), Saco (East Branch, Ellis, and Swift Rivers), and Bearcamp River watersheds flow in a radiating pattern toward all points of the compass. High watersheds straddle the Upper Connecticut, Merrimack-Saco-Charles, and Penobscot-Kennebec-Androscoggin River Ecological Drainage Units (EDUs). This watershed group is entirely within TNC's Northern Appalachians Ecoregion.

1.8 Extent and quality of data

High watersheds are a clearly defined watershed group, but the differences between the three fine scale systems are more subtle. Specifically, fine scale systems 4 and 8 are transitional with their northern and southern watershed groups, but the majority of the watersheds in these systems have clear similarity with the high elevation watersheds in fine scale system 6. Representing the three fine scale systems in conservation plans will capture environmental settings across directional (north-south and east-west), topographic, and geographic gradients.

Element 2: Species/Habitat Condition

2.1 Scale

Due to the large land area covered by the major watershed groups (Figure 3), a fine scale classification (Figure 4) was used, when possible, to assess the relative condition of aquatic habitats across the state. The types and sources of information were extremely variable and covered many different scales, and so the following sections refer to both the major and fine scale systems. The actual scale at which the natural conditions and processes lead to differences in aquatic communities is uncertain.

High watersheds are divided into three fine scale systems (Figure 4). Fine scale system 4 includes 4 watersheds of the Connecticut River. All of these watersheds have elevations that are transitional from mountainous and steep to more moderate and low altitudes. As a result, streams consist of less confined headwater streams that flow down into foothills and eventually into larger rivers.

Fine scale system 6 includes 6 watersheds of the Androscoggin, Pemigewasset, and Saco Rivers. These watersheds contain extensive areas of moderate, high, and very high elevations and are the most mountainous and steep in New Hampshire. Streams are confined and high gradient.

Fine scale system 8 includes 4 watersheds of the Pemigewasset and Saco Rivers. All watersheds have low to moderate elevations with small areas of high elevations. These watersheds contain mountain and foothill streams or rivers with lower gradients and levels of confinement.

2.4 Relative Quality of Habitat Patches

Typical headwater streams within the WMNF are highly energetic with bedrock substrates and few fine sediments. There are low turbidity levels during most high flows, but tannins from the adjacent forest can create a yellow color in the water. As streams progress downstream, there are greater amounts of boulders and cobbles. Streams with lower gradients have bedrock, boulder, cobble and coarse gravel substrates. As stream size increases toward valley floors, there are sand and gravel bars mixed with the boulder and cobble substrates. During high flows, sediments move downstream and streams are scoured. Even during floods, turbidity is still considered low. Most fine sediments have already been washed downstream or deposited on adjacent stream banks (Spear et al. 2000).

Streams and rivers of the WMNF have low levels of dissolved nutrients and low abundances of aquatic organisms. Shifting sediments and granite bedrock cause streams to be sterile. The size of fish in these

systems reflects these sterile conditions. A study of wild brook trout in the Swift River (fine scale system 8) showed only 151 of 3,742 wild brook trout (4%) were longer than 6 inches (Spear et al. 2000).

There are some streams within the WMNF that are unaffected by historical logging, but these streams are not well documented. Streams in old growth forests contain high concentrations of large woody debris (LWD). Large woody debris creates pools, which attract organic matter, increase stream depths, and attracts aquatic organisms. Wonalancet Brook in fine scale system 8 was identified as an unaltered system within an old growth forest. Determining the LWD ratios of streams in old growth forests will help identify other non-impacted streams and facilitate restoration to natural conditions. There are also streams within old second growth forests in these watersheds, although it is difficult to differentiate between old growth and old second growth forests. Wilderness designations within the WMNF help restore stream habitat by naturally increasing LWD concentrations (Spear et al. 2000).

Fine scale system 4 encompasses 961 km^2 (237,516 ac). Headwater streams (watershed area <77.70 km^2) and small rivers (watershed area from 77.70-518.00 km^2) comprise 82% and 18% of all streams and rivers. Medium rivers (watershed area from 518.00-2589.99 km^2) and large rivers (watershed area >2589.99 km^2) are not present in this system .Moderate elevations (243.84-518.16 m) and high elevations (518.16-762 m) dominate, at 62.0% and 20.8% of total land area, respectively. Very high elevations (762-1371.6 m), alpine elevations (>1371.6 m), and low elevations (6.10-243.84m) comprise 15.2%, 1.6%, and 0.5% .

Fine scale system 6 encompasses 1,968 km^2 (486,249 ac). Headwater streams and small rivers comprise 82% and 11% of streams and rivers. Medium and large rivers are less prevalent, comprising 2% and 5% of streams and rivers .The Saco River is the only major river basin in New Hampshire that is currently meeting standards for the federal Clean Water Act (NHDES 1990). Land adjacent to the Saco River is undeveloped or in agriculture, with some clusters of residential housing. In the WMNF, large riparian buffers and continuous forest surround the upstream reaches and tributaries of the Saco River. In a 1983 study, there were 55 mammal, 165 bird, 32 amphibian and reptile, and 36 fish species present. There is spawning substrate for anadromous fish species, but these fish are blocked from this area by impassable downstream dams in Maine (NHDES 1990). The Swift River, a tributary to the Saco River, is free flowing and almost entirely within the WMNF. Its water quality is good to excellent (NHDES 1990).

Fine scale system 8 encompasses 1,304 km^2 (322,199 ac). Headwater streams are prevalent, comprising 82% of streams and rivers. Small and medium rivers comprise 11% and 7% .The Pemigewasset River is recognized for large areas of adjacent undeveloped land and high water quality (NHDES 1991). There are concentrations of developed land in Plymouth. There is adequate feeding and nesting habitat for a variety of bird species, including upland sandpipers (*Bartramia longicauda*), peregrine falcons (*Falco peregrinus*), sedge wrens (*Cistothorus platensis*), bald eagles (*Haliaeetus leucocephalus*), ospreys (*Pandion haliaetus*), northern harriers (*Circus cyaneus*), common loons (*Gavia immer*), common nighthawks (*Chordeiles minor*), Cooper's hawks (*Accipiter cooperii*), and purple martins (*Progne subis*). Red spotted newts (*Notophthalmus viridescens viridescens*), snapping turtles (*Chelydra serpentine*), and northern water snakes (*Nerodia sipedon*) are examples of the 19 amphibian and reptile species found along the river (NHDES 1991).

High watersheds contain the lowest number of lakes and ponds in the state. Lakes and ponds with surface areas less than 4.05 ha (10 ac) are the most abundant (93% of the total number of lakes and ponds). There is an average of 1.27 lakes/ponds greater than 4.05 ha per 100 km^2 of land. Conway Lake, at 1,316 ac, is the only lake greater than 1,000 ac. Forty-two percent of the lakes and ponds are at low elevations, 46% are at moderate elevations, 8% are at high elevations, and 4% are at very high elevations. This watershed group contains all lakes and ponds with elevations greater than 1,219.2 m (4,500 ft), which comprise less than 1% of the total number of lakes and ponds in high watersheds.

2.2 Relative Health of Populations

Land Use

Large portions of the WMNF are contained within these three fine scale systems. Road density, development, and the amount of unfragmented land are highly influenced by the presence of the WMNF and

high elevations. In fine scale system 4, the density of roads maintained by the New Hampshire Department of Transportation (NHDOT) is 0.50 km/km^2 (expressed as road km/km^2 of total land area) and the density of private/gravel roads is 0.30 km/km^2. In fine scale system 6, the densities of NHDOT roads and private/gravel roads are 0.29 km/km^2 and 0.21 km/km^2. In fine scale system 8, the densities of NHDOT roads and private/gravel roads are 0.54 km/km^2 and 0.50 km/km^2 .Developed land in fine scale systems 4, 6, and 8 comprises 2.3%, 1.4%, and 2.5% of total land area .Unfragmented land in fine scale systems 4, 6, and 8 comprises 86%, 93%, and 83% of the total land area .The population in high watersheds is very low compared to other watershed groups in New Hampshire. Estimated populations for 2005 in fine scale systems 4, 6, and 8 are 9,985 people (10.4 people/km^2), 11,451 people (5.5 people/km^2), and 22,577 people (13.9 people/km^2) .

The mountainous terrain inhibits agriculture within much of the high watersheds. Floodplains of larger rivers may provide the best areas for farming. Agricultural land in fine scale systems 4, 6, and 8 comprises 2.7%, 0.5%, and 2.1% of total land area .Because of the very high elevations in fine scale system 6, this system has the lowest percentage of agricultural land in the state.

Housing increases for census blocks adjacent to lakes and ponds in high watersheds were estimated using 1990 values and projected 2020 values (see Lake Type Classification for methods). Changes between rural (<0.063 housing units/ha), exurban (0.063 to 0.25 units/ha), and suburban (0.25 to 2.5 units/ha) housing densities could indicate increases in shoreline development, impervious surfaces, and nonpoint source pollution. Housing densities adjacent to 62 lakes and ponds are expected to change from exurban to suburban and from rural to exurban at 128 lakes and ponds.

Water Quality

In 2003, the NHDES Volunteer Rivers Assessment Program (VRAP) conducted surface water quality studies of Great Brook, Wildcat Brook, and the Ellis River. Dissolved oxygen and turbidity levels at all sites met state requirements for class B waters, which are adequate to support aquatic wildlife. The range of pH values (pH 5.67-7.05) was below state water quality standards for class B waters (standard is pH 6.50-8.0) and 85% of pH samples were below state water quality standards. Acid precipitation and natural environmental conditions (e.g. soils, geology, wetland drainage) can lower pH values (NHDES 2003). In 2004, water samples from Wildcat Brook and Ellis River were comparable to 2003, with dissolved oxygen and turbidity levels meeting water quality standards, but pH levels for 14 out of 15 samples (93%) below state water quality standards for class B waters (NHDES 2004).

The Androscoggin River was once considered one of the most polluted rivers in North America. Since the implementation of the Clean Water Act (1977), river water quality has dramatically improved with temperature and dissolved oxygen levels adequate for salmonids (Danner and Young 2002). For the Androscoggin River, dissolved oxygen and turbidity levels met state requirements for class B waters, which are adequate to support aquatic wildlife. Turbidity levels increased near urban areas. The range of pH values (pH 6.48-7.09) essentially met state water quality standards for class B waters. Acid precipitation and natural environmental conditions (e.g. soils, geology, wetland drainage) can lower pH values (NHDES 2004).

Water discharges registered through NHDES are relatively low when compared to the rest of New Hampshire. The number of National Pollution Discharge Elimination System (NPDES) permits issued per river kilometer for fine scale systems 4, 6, and 8 are 0.011, 0.007 and 0.005 NPDES permits/river km, respectively .

Invasive Species

There are no exotic aquatic plants in waterbodies in this area (Smagula 2004). Largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), landlocked Atlantic salmon (*Salmo salar*), brown trout (*Salmo trutta*), and rainbow trout (*Oncorhynchus mykiss*) are examples of fish species that have naturalized populations (NHFG 2004, Estuarine and Freshwater Working Group 2005). Landlocked Atlantic salmon, brown trout and rainbow trout are annually stocked by NHFG.

To assess the likelihood of recreation or stocking contributing to introductions of invasive fish and aquatic plants, the degree of remoteness of lakes and ponds was analyzed through GIS. There

are 953 lakes and ponds (89%) within 500 m of a trail or road, 60 lakes and ponds (6%) enclosed by a protective buffer of 500-805 m without a mapped road or trail, 40 lakes and ponds (4%) with a buffer of 805-1609 m, and 8 lakes or ponds (1%) with a buffer greater than 1609 m.

Hydrology
There are approximately 96, 77, and 88 active dams or impoundments in fine scale systems 4, 6, and 8 .Fine scale system 8 has the lowest number of impoundments per river km in New Hampshire (0.016 impoundments/river km). The number of impoundments/river km is 0.049 and 0.026 in fine scale systems 4 and 6.

2.3 Population Management Status

N/A

2.5 Habitat Patch Protection Status

The fine scale systems of high watersheds have the highest percentage of conservation land within the state. Conservation land comprises 52.3%, 82.3%, and 48.4% of the total land area in fine scale systems 4, 6, and 8 .The densities of unfragmented land with conservation status are also the greatest in New Hampshire. The amount of unfragmented land with conservation status is 58.4%, 86.5%, and 56% for fine scale systems 4, 6, and 8 .Designated wilderness areas within the WMNF further protect aquatic systems from the effects of roads and logging.

The Pemigewasset, Saco, and Swift Rivers are designated in the New Hampshire River Management and Protection Program (RMPP) (NHDES 2004). The RMPP regulates dam construction, in stream water flow levels, channel modification, water quality, solid waste and hazardous waste storage/ treatment facilities, and motorized boating traffic.

2.6 Habitat Management Status

It is difficult to assess the efforts to restore and manage habitats at such a broad level. A database of conservation groups may enhance cooperative efforts and eliminate repetitive or redundant projects.

There are conservation and management plans for the WMNF and Ammonoosuc River watershed. These plans identify ecologically significant areas and guide human use and management. Public outreach and education are identified as useful tools for conserving and restoring these watersheds. Because these plans provide highly detailed information at local levels, they should be used to help identify sensitive areas, local impacts, and management actions (Ammonoosuc Conservation Trust 2004, WMNF 2005).

Several agencies are actively involved in habitat restoration and identifying potential areas of habitat enhancement or improvement. Ongoing or recently completed projects include riparian buffer stabilization, stream bank erosion inventories, creating a task force for dam removal, landowner education, NHDES fish biomonitoring, and annual river clean ups. There are targeted restoration efforts for Atlantic salmon and brook trout.

Long-term data from the Hubbard Brook Ecosystem Study at the Hubbard Brook Experimental Forest in West Thornton provide information on several aquatic topics. Instantaneous stream flow, precipitation, temperature, chemistry, and limnology are examples of long-term data that are available. Trend data can help to form models and hypothesis and to provide information on ecosystem function and rare or severe events (Hubbard Brook Experimental Forest 2001). Studies of salamander occurrences in first order streams are being carried out at the Bartlett Experimental Forest (Stone 2004).

2.7 Sources of Information

A watershed classification based on geological, topographical, climactic, and connectivity attributes, developed by TNC, was used to define scale and habitat condition. Watershed management plans, GIS analyses, and anadromous fish restoration plans were used to identify significant habitats, relative condition, quality, and ongoing management and restoration efforts.

2.8 Extent and Quality of Data

Information on current habitat quality and restoration efforts was highly concentrated on larger rivers. Smaller rivers within this habitat were not well represented. Information obtained from GIS analyses may not accurately represent all physical features.

2.9 Condition Assessment Research

Increased sampling of aquatic communities and water quality will provide more conclusive, long-term trend data. Additional monitoring would help identify the impacts of water flow alterations (e.g. erosion, changes in dissolved oxygen, and impoundments) on plants, fish, and other aquatic wildlife. Increased sampling of fish tissue throughout these watersheds may recognize areas affected by contaminants. Habitat assessments, water quality monitoring, and aquatic community data are needed for the headwater streams and small tributaries of these systems. The pilot projects initiated by The Nature Conservancy in the Ashuelot River watershed should be expanded to other watersheds to identify and protect additional areas of significant habitat.

Element 3: Species and Habitat Threat Assessment

Existing river management plans, local watershed associations, and GIS analyses indicate non-point source pollution (especially sedimentation and runoff from poorly managed forestry operations and agricultural fields), acid deposition, development, sprawl, and fragmentation are the primary threats to habitats in high watersheds. Refer to the general threats section for Transportation Infrastructure, Development (Fragmentation and indirect effects), Non-Point Source Pollution (Runoff and Sedimentation), Acid Deposition, , Introduced Species, Altered Hydrology, Recreation, Unsustainable Harvest (Forestry Operations and Management), and Agriculture.

Element 4: Conservation Actions

Watersheds within high percentages of unfragmented land are unique to northern New Hampshire. Strategies to preserve connectivity must be developed to protect these large unfragmented land tracts. Fortunately, there is an opportunity for protection rather than restoration in this area. Several strategies for conservation action can be found in management and conservation plans for the WMNF and Ammonoosuc River watershed. Refer to the general strategies for Roads/Transportation Infrastructure, Development/Urban Sprawl, Fragmentation/Population Isolation, Pollutants, Acid Deposition, Water level Management, Nutrient and Sediment Loading, Forest Management, and Agriculture.

Element 5: References

5.1. Literature

Ammonoosuc Conservation Trust, Watersheds to Wildlife Inc., UNH Cooperative Extension. 2004. Ammonoosuc Watershed Region Conservation Plan-Draft. Ammonoosuc Conservation Trust. Sugar Hill, New Hampshire, USA.

Danner G., Young M. 2002. Androscoggin River Fish Health Survey (New Hampshire to Rumford Falls). Maine Department of Inland Fisheries and Wildlife. Available http://www.state.me.us/ifw/fishing/fishlab/andriverfishhealthsurvey.htm (Accessed April 2005).

Estuarine and Freshwater Working Group. 2005. State of New Hampshire Comprehensive Management Plan for the Prevention and Control of Aquatic Nuisance Species-Draft. Concord, New Hampshire, USA.

Hubbard Brook Experimental Forest. 2001. Overview. Available http://www.hubbardbrook.org/research/overview/hbguidebook.htm (Accessed March 2005).

New Hampshire Department of Environmental Services. 1990. The Saco River. Available http://www.des.state.nh.us/Rivers/saco.htm (Accessed March 2005).

New Hampshire Department of Environmental Services. 1990. The Swift River. Available http://www.des.state.nh.us/Rivers/saco.htm (Accessed March 2005).

New Hampshire Department of Environmental Services. 1990. The Pemigewasset River. Available http://www.des.state.nh.us/Rivers/pemig.htm (Accessed March 2005).

New Hampshire Department of Environmental Services. 2003. Great Brook/Wildcat Brook/Ellis River Water Quality Report. Volunteer River Assessment Program. Concord, New Hampshire, USA.

New Hampshire Department of Environmental Services. 2004. Wildcat Brook/Ellis River Water Quality Report. Volunteer River Assessment Program. Concord, New Hampshire, USA.

New Hampshire Department of Environmental

Services. 2004. Androscoggin River Water Quality Report. Volunteer River Assessment Program. Concord, New Hampshire, USA.

New Hampshire Department of Environmental Services. 2004. Designated Rivers. Available http://www.des.state.nh.us/Rivers/desigriv.htm (Accessed March 2005).

New Hampshire Fish and Game Department. Freshwater Fishing Guide. 2004. Available http://www.wildlife.state.nh.us/Fishing/Fishing_PDFs/FW_Fishing_Guide.pdf (Accessed April 2005).

Smagula A. 2004. Report of the New Hampshire Exotic Aquatic Species Program. New Hampshire Department of Environmental Services. Concord, New Hampshire, USA.

Spear P., Grindle A., Nowell H. 2000. Aquatic Biodiversity Issues in Forest Planning For the White Mountain National Forest. Natural Resources Consulting Services. Concord, New Hampshire, USA.

Stone T. 2004. Bartlett Experimental Forest. Ecology and Management of Northeastern Forest Ecosystems. USDA Forest Service, Northeastern Research Station. Available http://www.fs.fed.us/ne/durham/4155/bartlett.htm#INT (Accessed March 2005).

White Mountain National Forest. 2005. Forest Plan Revision. Available http://www.fs.fed.us/r9/white/3_WM_fpr_Web/forest_plan/revision/ (Accessed March 2005).

HABITAT PROFILE

Peatlands

Associated Species: Ringed Bog Haunter (Williamsonia lintneri), Palm Warbler (Dendroica palmarum), Mink Frog (Rana septentrionalis), Northern Bog Lemming (Synaptomys borealis)

Global Rank: Not ranked
State Rank: Atlantic white cedar – giant rhododendron swamp (S1), Atlantic white cedar – leather-leaf swamp (S1), Acidic northern white cedar swamp (S1), Atlantic white cedar – yellow birch – pepperbush swamp (S2), Black gum – red maple basin swamp (S1S2), Black spruce – larch swamp (S3), Bog rosemary – sweet gale – sedge fen (S3), Calcareous sedge – moss fen (S2), Circumneutral – calcareous flark (S1), Hairy-fruited sedge – sweet gale fen (S3), Highbush blueberry – sweet gale – meadowsweet shrub thicket (S4), Highbush blueberry – mountain holly wooded fen (S3S4), Highbush blueberry – winterberry shrub thicket (S4), Inland Atlantic white cedar swamp (S1), Large cranberry – short sedge moss lawn (S3), Leather-leaf – black spruce bog (S3), Leather-leaf – sheep laurel dwarf shrub bog (S1S3), Liverwort/horned bladderwort mud-bottom (S3), Marshy moat (S4), Montane alder – heath shrub thicket (S1?), Montane heath woodland (S2), Montane sloping fen (S1), Northern white cedar – balsam fir swamp (S2), Northern white cedar circumneutral string (S1), Northern white cedar – hemlock swamp (S2), Northern white cedar seepage forest (S2), Pitch pine – heath swamp (S1S2), Red maple – Sphagnum basin swamp (S4), Red spruce swamp (S3), Seasonally flooded Atlantic white cedar swamp (S2), Speckled alder wooded fen (S3S4), Sphagnum rubellum – small cranberry moss carpet (S3), Subalpine sliding fen (S1), Swamp white oak basin swamp (S1), Sweet gale – meadowsweet – tussock sedge fen (S4), Sweet pepperbush wooded fen (S2), Wet alpine/subalpine bog (S1), Winterberry – cinnamon fern wooded fen (S4), Wooded subalpine bog/heath snowbank (S1S2)
Federal Listing: Not listed
State Listing: Not listed
Author: Heather L. Herrmann, New Hampshire Natural Heritage Bureau

Element 1: Distribution and Habitat

Habitat Description

The peatland habitat described here includes 11 different natural communities as described by Sperduto (2004). Peatlands are defined by limited inputs of groundwater and surface runoff that result in low nutrient content and acidic water. A lack of nutrients causes slower decomposition of organic materials, resulting in the accumulation of peat. Some plant species are specifically adapted to low-nutrient, acidic conditions found in peatlands.

Open Peatlands
Open peatlands are dominated by *Sphagnum* mosses, sedges, and shrubs. Several open peatland systems are found in New Hampshire. Alpine/subalpine bogs and montane sloping fens are found at higher elevations, generally above 760 meters (2500 feet). Alpine bilberry (*Vaccinium uliginosum*) and black crowberry (*Empetrum nigrum*) are dominant plants in alpine/subalpine bogs, whereas sedges are dominant plants in montane sloping fens (Sperduto and Nichols 2004). These peatlands are small and can sometimes be found interspersed with dry subalpine heath/krummholtz systems or at the heads of old beaver drainages.

Calcareous sloping fens and patterned fens are two open peatland systems found in northern New Hampshire. Calcareous sloping fens are influenced by

groundwater seepage from bedrock high in calcium and other base cations. The diverse plant communities of calcareous fens include sedges, brown mosses, willow (*Salix* sp.) and dogwoods (*Cornus* sp.) (Sperduto 2004). Patterned fens are more common in northern regions and only three examples are known in New Hampshire. Also influenced by groundwater, patterned fens form a series of strings (linear, raised areas) and flarks (low, wet areas) that run perpendicular to the direction of groundwater flow. Strings have a typical bog species such as leather-leaf (*Chamaedaphne calyculata*), sheep laurel (*Kalmia angustifolia*), stunted black spruce (*Picea mariana*), and eastern larch (*Larix laricina*). Flarks have open pools and *Sphagnum* carpets (Sperduto and Nichols 2004). Poor level fen/bog systems and medium level fen systems are widespread and can be quite expansive. Poor level fen/bog systems have very little drainage and no input from groundwater, lakes or streams. Medium level fens can have stream and groundwater input, and therefore tend to be less acidic and more nutrient-rich than poor level fens/bogs. These two systems can often be found adjacent to each other. Vegetation in each includes open *Sphagnum*, tall or medium shrubs, and sparse black spruce (*Picea mariana*) or eastern larch (*Larix laricina*) (Sperduto 2004).

The kettlehole bog is an open peatland usually found in central and southern New Hampshire. These bogs are small patches where pieces of glacial ice melted, leaving holes that subsequently filled in from the edges with peat. Kettlehole bogs typically have a marshy border surrounding a tall shrub or black spruce (*Picea mariana*) swamp, within which is a boggy area of black spruce and leather-leaf (*Chamaedaphne calyculata*), and often an open *Sphagnum* carpet, sometimes with a pool of water, in the middle (Sperduto 2004).

Forested Peatlands

Several forested peatland systems are found in New Hampshire. The black spruce peat swamp is dominated by black spruce (*Picea mariana*) and eastern larch (*Larix laricina*). It often forms a border around more open peatlands such as the poor level fen/bog system or kettlehole bog system. Temperate peat swamps, found in central and southern New Hampshire, are dominated by red maple (*Acer rubrum*), red spruce (*Picea rubens*), eastern hemlock (*Tsuga canadensis*), and other hardwoods. This system is not as acidic as many other peatlands. Northern white cedar minerotrophic swamps, found in northern New Hampshire, contain more nutrients than other peatlands and are dominated by northern white cedar (*Thuja occidentalis*) and other conifers including balsam fir (*Abies balsamea*) and various spruces (*Picea* spp.). Coastal conifer peat swamps—dominated by Atlantic white cedar—are located in coastal New Hampshire with a few examples farther inland (Sperduto 2004).

1.2 Justification

Conservation of peatlands is vital to the continued existence of many rare species in New Hampshire. Changes in nutrients, water quality, or hydrologic inputs to peatlands can convert them to non-peatland wetlands that may not be suitable for original flora and fauna. Southern New Hampshire peatlands are susceptible to development, while northern peatlands require protection from potentially damaging forestry practices.

Peatlands play a vital role in carbon and nitrogen cycling (Moore 2002). However, peatlands across the globe may be at risk due to climate change, which may push these communities further north. The current range of many peatland communities barely extend southward into northern New Hampshire, making them, and the wildlife that depend on them, particularly vulnerable in this state.

1.3 Protection and Regulatory Status

Federal

Clean Water Act Sections 401 (USEPA 2005a), 402 (USEPA 2005b), 404 (USEPA 2005c): Requires a permit for discharge of pollutants, dredge, or fill material into navigable waters, such that the discharge will comply with water quality standards.

State

RSA 482-A, Fill and Dredge in Wetlands (New Hampshire General Court 2004): Requires a permit for any project involving dredge or fill impacts to wetlands.

Wt 303.02, Wetlands Bureau rules (NHDES 2004): Projects involving bogs, designated Prime Wetlands, rare or exemplary natural communities in wetlands, or endangered or threatened wildlife in wetlands are considered major impact projects.

RSA 485-A, Water Pollution and Waste Disposal (New Hampshire General Court 2004): subsurface wastewater disposal systems must be greater than 15 m from poorly drained (hydric B) soils and 23 m from very poorly drained (hydric A) soils.
RSA 217-A, Native Plant Protection Act (New Hampshire General Court 2004): Removing threatened, endangered or special concern plants from public land or land owned by another party is prohibited.

1.4 Population and Habitat Distribution

Peatlands are broadly distributed throughout the northeastern United States and Canada. However, many peatland types have a restricted distribution. New Hampshire is in a transition zone where peatlands typical of southern regions and northern boreal regions can be found. Medium level fens and poor level fens and bogs are widespread in New Hampshire. Kettlehole bogs and coastal conifer peat swamps reach their northern extent in southern and central New Hampshire. Patterned fens and calcareous sloping fens are restricted to northern New Hampshire, and alpine/subalpine bogs and montane sloping fens are restricted to high elevations of the White Mountains and northern New Hampshire. Peatlands are sparse in mountainous regions.

Many rare peatland plants are restricted to the northern or southern part of the state, or to higher elevations. Likewise, several wildlife species such as the ringed boghaunter, rusty blackbird (*Euphagus carolinus*), and northern bog lemming are restricted to only those peatlands in either the northern or southern part of the state. Several peatland Odonata and Lepidoptera reach their range limit in adjacent states or the province of Quebec but have not yet been found in New Hampshire (Herrmann et al. 2003, Paul Brunelle, personal communication), or have historic ranges extending into New Hampshire but have not recently been found (i.e., Hessel's hairstreak, *Callophrys hesseli*) (NatureServe 2005).

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

Potential peatlands were mapped beginning with the National Wetlands Inventory (NWI) GIS layer (Complex Systems Research Center 2001). Wetlands with broad-leaf evergreen (generally ericaceous), needle-leaf evergreen (conifer) or needle-leaf deciduous (larch) vegetation were selected initially. Water regimes were restricted based on expert review (Dan Sperduto, NHNHB). Any groups of wetlands adjacent to a river or lake were omitted. NWI classes were further classed as individual peatland systems, and landscape context (i.e., elevation, isolation from other wetlands, presence of inlets and outlets) was used to assign each polygon to a potential peatland system. Polygons of known rare or exemplary peatlands (NHNHB 2005) were then added to the map.

Limitations of Data
The model was designed to be inclusive. NWI maps can underpredict peatlands (Dan Sperduto, NHNHB, personal communication). To counter this tendency to underpredict, other non-peatland NWI classes adjacent to peatland classes were included. Combined with the inclusion of many coniferous and deciduous wetlands (as black spruce peat swamp and temperate peat swamp systems), this may have led to overprediction. Because many coniferous or deciduous forested wetlands in southern New Hampshire (Gulf of Maine Coastal Plain and Gulf of Maine Coastal Lowland ecoregion subsections) could be eastern hemlock (*Tsuga canadensis*) or red maple (*Acer rubrum*) swamps without a peatland component, it is likely that many of the predicted forested peatlands are not actually peatlands. Any interpretations or actions based on the map should consider this overprediction. Classification of wetlands into specific systems could also contain error based on the general nature of NWI categories and the lack of more detailed information to aid in the classification.

1.7 Sources of Information

Information was gathered from literature review, GIS data, NHNHB data (2005), and expert review.

1.8 Extent and Quality of Data

Peatlands have been surveyed more extensively in New Hampshire than have many other natural community groups. An extensive landscape analysis and field inventory of peatlands was conducted in 2000

(Sperduto et al. 2000). See limitations of predicted peatlands in element 1.5 above.

1.9 Distribution Research

Surveys should be conducted for peatland species that are found in adjacent states and provinces, and to confirm and update New Hampshire's rare species records. Targeted species could include northern bog lemming, Hessel's hairstreak, bog elfin (*Callophrys lanoraieensis*), and a number of peatland odonates. Habitat records need to be field-verified, especially forested peatlands in southern New Hampshire and rare peatland communities in northern New Hampshire.

Element 2: Species/Habitat Condition

2.1 Scale

Wetlands within 250 m of each other were grouped into complexes of wetlands, except that wetlands separated by a major road (interstate, US or state route) were assigned to different complexes. Wetland complexes numbered in the thousands, and so rather than identify or analyze each complex individually, they were summarized statewide and by ecoregion (TNC 1998).

2.2 Relative Health of Populations

There are 4,113 ha of peatlands known in New Hampshire, and 18,996 ha of predicted peatlands. Total peatland area is less than 1% of New Hampshire's total land area. The majority of known peatland area falls within 5 ecoregions (Figure 1): the two coastal ecoregions, the two northernmost ecoregions, and one central ecoregion (Sebago-Ossipee Hills and Plain). Predicted peatlands generally follow the same pattern of distribution (Figure 1), except that a sixth ecoregion (Hillsboro Inland Hills and Plain) was also predicted to have a large peatland area.

Of the known peatland in New Hampshire, approximately 57% is open peatland and 43% is forested peatland. Forested peatlands are most common in coastal areas and northern New Hampshire. For example, 85% of the peatlands in the Connecticut Lakes subsection are forested. Elsewhere in the state, open peatlands are more abundant. It should be noted, however, that known peatlands are those that include rare or exemplary peatland communities and may not reflect the true distribution of peatlands across the state. At least 75% of the total predicted peatland area was forested (Figure 1). This is likely an overestimate (see element 1.6); however, because forested peatlands may be less obvious on the ground than open peatlands, these areas should all be considered potential peatlands until field verification shows otherwise.

2.3 Population Management Status

N/A

2.4 Relative Quality of Habitat Patches

The largest peatland complexes occurred in the Connecticut Lakes, Mahoosuc-Rangeley Lakes, and Gulf of Maine Coastal Lowland ecoregion subsections (however, note the potential for overprediction of peatlands in southern New Hampshire discussed in element 1.5). Within each ecoregion, an average of at least 75% of the area within a 250m radius of the complexes was undisturbed landscape (forest, wetland, or open water) . Twenty percent of all peatland complexes were surrounded by undisturbed landscape. However, the majority (62%) of these undisturbed complexes were small (less than 1 ha). Peatlands in northern New Hampshire averaged lower densities of roads within 250 m than did peatlands in the southern part of the state, with coastal peatlands having more than 1 km of road per km^2 of land area.

2.5 Habitat Patch Protection Status

Protection status was calculated for all the land area within 250m of each peatland complex, and summarized by ecoregion subsection (figure 2) using the Conservation Lands data layer (Complex Systems Research Center 2005). Total peatland buffer conservation land in fee ownership throughout the state was 34,605 ha, while total peatland buffer conservation land in easements was 8,896 ha. With the exception of the Northern Connecticut River Valley ecoregion, fee ownership conservation area was greater than easement conservation area throughout the state.

The highest level of protection is in the White Mountains, where 72% of total peatland buffer area

is protected. In other ecoregion subsections, protection was less than 30% of peatland buffer area (figure 2). Within the White Mountains subsection, 62% of peatland complexes were entirely protected within 250m of the peatland, and 72% of complexes had at least 50% protection. However, this subsection had the smallest total peatland area of all subsections. The second highest level of protection was in the Connecticut Lakes ecoregion subsection, where only 23% of complexes had at least 50% protection. The two ecoregion subsections with the highest predicted peatland area—the Gulf of Maine Coastal Lowlands and Gulf of Maine Coastal Plain—also had the lowest level of protection, with less than 1% of complexes having at least 50% protection.

2.6 Habitat Management Status

Habitat management of peatlands is generally limited to land protection (see element 1.3). Restoration of peatlands is difficult and more commonly practiced in areas where peat is frequently mined or where forestry activities regularly occur on peatlands. These activities are not known to occur in New Hampshire at a large scale. Consequently, there is little active management of peatlands and there are few management strategies more effective than simply protecting land and allowing natural processes to occur. Several peatlands occur on lands managed for wildlife (i.e., Umbagog National Wildlife Refuge) where the primary management goals are for other habitats or wildlife and may involve water level management that is not conducive to peatlands. These areas may provide opportunities to study whether current management strategies could be improved for peatland habitats.

2.7 Sources of Information

Information was gathered from databases, GIS analysis, and expert review.

2.8 Extent and Quality of Data

The GIS data used to assess habitat condition are relatively detailed, coming primarily from satellite imagery, topographic maps, and well-defined conservation boundaries. The primary errors in assessing condition are in the predicted habitat itself, which depends partly on NWI maps, which can lead to errors in wetland classification.

2.9 Condition Assessment Research

- Aerial photo analysis and field surveys of predicted peatlands (particularly in the 2 southeastern and 2 northern subsections) to facilitate better boundaries and landscape analyses
- Evaluate effects of current wildlife management strategies (i.e., those focused on waterfowl or fish) on peatlands in wildlife management areas and national wildlife refuges

Element 3: Species and Habitat Threat Assessment

3.1.1 Development (Fragmentation, Habitat Loss and Conversion)

(A) Exposure Pathway
Construction near peatlands, which may involve dredging and filling, reduces available habitat for peatland-dependent species. Wildlife using peatlands, such as turtles, may also use uplands for part of their life cycle or for migration. Species that are restricted to peatlands may require connectivity between patches for occasional genetic exchange and maintenance of genetic diversity. Loss of upland habitat isolates peatlands and makes travel between them difficult for wildlife. Thus, fragmentation results in a loss of both genetic exchange and functional upland habitat.

(B) Evidence
In 2004, NHNHB reviewed 655 proposals requiring a permit for impacts to wetlands (NHNHB, unpublished data). Although projects with impacts to "bogs" are considered major impact projects in New Hampshire (NHDES 2004) and thus are reviewed more critically, some forested peatlands may not be recognized as such. Peatlands take a long time to develop due to the slow accumulation of peat; thus, lost peatlands are not easily restored (Rochefort et al. 2003). Peatlands can only develop within certain topographic and hydrologic settings (Crum 2000, Damman and French 1987), so artificial creation of

new peatlands is generally not possible.

Habitat fragmentation can influence many species including those with limited mobility (Mader 1984, Reh and Seitz 1990, Herrmann et al. 2005). Peatland and other wetland taxa are more likely to disperse through forested uplands than non-forested uplands (deMaynadier and Hunter 1999, Nekola et al. 2002), so habitat fragmentation could alter the upland to the extent that individuals are no longer able to migrate. Peatlands and other wetlands are patchy habitats within an upland landscape, and the wildlife that depend on them often exhibit little migration between patches (Gibbs 2000). With this limited migration and limited genetic exchange, any further hindrance to migration between habitats could render local populations vulnerable to extinction.

3.1.2 Altered Hydrology

(A) Exposure Pathway
Impoundments downstream from peatlands can raise the peatland water level to the point that nutrients previously transported past the peatland, via groundwater or a stream channel, are now in contact with the peatland. This increase in nutrients can alter the plant communities and the rate of peat decomposition. With more decomposition, the peat structure will change, affecting the topography of the peatland surface. The resulting wetland may no longer be suitable for peatland-dependent plants and animals.

(B) Evidence
Peatlands typically develop in places where the vegetation is not (or is minimally) in contact with groundwater or upland runoff (Damman and French 1987). As a result, they are very nutrient-poor compared to other wetlands and decomposition occurs at a very slow rate. Peat is the partially decomposed vegetative matter that accumulates beneath the surface vegetation and further separates plants from the underlying groundwater. In some cases, peatlands lie on either side of a deep-cut stream channel through which nutrient-carrying water flows and bypasses the peatland. Downstream impoundments may raise the water level and cause water that had previously bypassed the peatland to flow across the peatland surface, bringing more nutrients into contact with the vegetation and peat (Dan Sperduto, NHNHB, personal communication). Peat decomposes quickly under higher nutrient conditions (Aerts et al. 2001), and non-peatland vegetation will begin to grow under these conditions. Several non-peatland natural communities in New Hampshire are documented to occur on former peatlands that have been flooded by beavers (Sperduto and Nichols 2004).

3.1.3 Non-Point Source Pollution (Nutrients (Eutrophication))

(A) Exposure Pathway
Increased nutrient input through runoff, decaying woody debris, or hydrologic alterations changes the nutrient content of the water in peatlands. This increases the rate of peat decomposition, which in turn affects water transport through the peat and nutrient availability. All of these factors contribute to changes in the structure of the peat surface and the composition of the plant community. Generally, increases in nutrient levels change the peatland to a non-peat wetland that may not be suitable for peatland plants and animals.

(B) Evidence
Peatlands are nutrient poor systems where organic decomposition is very slow and organic matter (peat) accumulates over time. Peat accumulates as long as the rate of plant growth exceeds the rate of decay (Johnson 1985, Damman and French 1987). Peatlands are inhabited by a suite of plants adapted to nutrient-poor conditions (Sperduto and Nichols 2004). Increases in nutrient concentrations will change the plant community and the rate of organic decomposition (Aerts et al. 2001), resulting in a loss of peatland habitat. Land conversion and other human activities near peatlands can alter natural nutrient regimes through the combined effects of erosion, runoff, fertilizers, or hydrologic alteration. The rate of land conversion in New Hampshire, particularly in the two southeastern ecoregions, is quite high (NHNHB, unpublished data).

3.1.4 Unsustainable Harvest (Forestry Operations and Management)

(A) Exposure Pathway
Timber harvesting in forested peatlands changes the vegetation structure and the amount of decaying

woody debris in the peatland. It can also increase compaction of the peat and nearby soil, leading to increased runoff and nutrient inputs. In addition, forestry activities too close to peatlands could disturb peatland wildlife, leading to decreased nesting success of birds and other changes to wildlife populations.

(B) Evidence
In New Hampshire, any activity that involves dredging material from or adding material to a wetland requires a permit (NHDES 2004). However, forestry activities can occur in peatlands under frozen conditions, since neither dredge nor fill occurs under such circumstances. Forested wetlands are not always properly delineated, particularly on NWI maps (Dan Sperduto, NHNHB, personal communication), so attempts to avoid wetlands during timber harvesting may not be successful. Although peatland species such as black spruce, northern white cedar, and eastern larch are harvested in much lower volumes than are most other species in New Hampshire (Frieswyk and Widmann 2000), harvesting may still occur, particularly near the edges of peatlands. Forestry activities can also compact soil, particularly organic soils such as peat (New Hampshire Forest Sustainablility Standards Work Team 1997), leading to increased runoff. Decomposition of slash left near the edge of a peatland can alter the structure and density, and thus the water transport abilities, of the peat (Damman and French 1987).

3.1.5 Recreation (Off Road Vehicles)

(A) Exposure Pathway
The use of off-road vehicles in peatlands could cause severe destruction of vegetation and peat, and possibly erosion and channelization that would alter the flow of water and nutrients through the peatland.

(B) Evidence
Off-road vehicle use is increasing rapidly in the Northeast. The total number of registered off-road vehicles is predicted to reach 37,000 by the year 2008, an increase of 42% (New Hampshire Trails Bureau 2003). Unregulated, these vehicles can have devastating impacts on ecosystems (Taylor no date). Even though it is illegal to ride off-road-vehicles in any wetland in New Hampshire (NHFG 2005), individuals may leave trails and ride in peatlands or other wetlands if a trail passes within sight of one.

3.2 Sources of Information

Information was gathered from literature review, expert consultation, and databases.

3.3 Extent and Quality of Data

- There is a wide body of research on the ecology, hydrology, nutrient processes, and restoration of peatlands in northern Europe and Canada. Less research has been conducted in the northeastern United States, where peatlands are less abundant. The rarity of many peatland types in New Hampshire is well documented.
- The effects of habitat fragmentation on wetland-dependent wildlife have also been widely studied, but not as much research has been done on peatland-specific taxa. However, the high rate of human development and fragmentation in New Hampshire is well documented.
- The effects of forestry on soils, wetlands, hydrology, and nutrient dynamics are fairly well known for other regions, but this information is not as well known for New Hampshire peatlands.
- There is a good body of research indicating the severe impacts of off-road vehicles on ecosystems. There is also substantial anecdotal evidence (through newspaper articles) of off-road vehicle users violating laws and regulations. Thus, concern that New Hampshire off-road vehicle users may be violating wetland regulations is justified.

3.4 Threat Assessment Research

- Assess the level of timber harvesting in peatlands occurring during the winter. Assess the influence of forestry on coarse woody debris, soil compaction, nutrient cycles, and peatland habitat structure at various distances from peatland borders.
- Monitor use of off-road vehicle trails near wetlands to determine to what extent users are leaving trails and riding in wetlands. Monitor erosion, sediment, and nutrient inputs in peatlands near off-road vehicle trails.

Element 4: Conservation Actions

4.1.1 Conservation Action: Establish buffers around peatlands

Category: Regulation

(A) List of Direct Threats Affected
Development (Fragmentation, Habitat Loss and Conversion), Non-Point Source Pollution (Nutrients (Eutrophication)), Recreation (Off Road Vehicles), Unsustainable Harvest (Forestry Operations and Management)

(B) Justification

- Creating buffers will prevent some of the upland fragmentation surrounding peatlands, and will protect peatlands from increased nutrient input from forestry activities, erosion through off-road vehicles, or other land uses, through allowing surface water to infiltrate the ground rather than running directly into the peatland.
- Reducing these threats will facilitate maintenance of the water chemistry levels needed by peatland plants and provide suitable migration habitat for wildlife.
- Habitat fragmentation occurs primarily in the southern part of New Hampshire, while forestry and off-road vehicle impacts can occur throughout the state. Thus, the implementation of peatland buffers needs to occur statewide.
- The current rate of development in New Hampshire, as well as the growing use of off-road vehicles, suggests that the upland surrounding peatlands needs to be protected immediately to prevent further impacts.
- Buffer distances can be increased as necessary if data shows that peatland water chemistry or wildlife populations are still negatively affected by surrounding land uses.

(C) Conservation Performance Objective:
Establishing permanent buffers around peatlands will eliminate development, timber harvest, and off-road vehicle use, and will reduce increases in runoff from these activities within the buffer. Success will be measured by monitoring compliance with the buffer restrictions.

(D) Performance Monitoring
Projects occurring near the designated peatland buffer area will be monitored. Any project that involves land conversion (timber harvest, road or off-road trail building, construction) within a peatland buffer will be considered non-compliant with buffer restrictions.

(E) Ecological Response Objective
The desired ecological response to buffers around peatlands is no change in the water chemistry or vegetation composition of any peatland, and no decline in populations (averaged over time) of peatland-dependent wildlife or plant species.

(F) Response Monitoring
Populations of peatland-dependent plants and wildlife will be monitored, including ongoing monitoring of rare species. Water chemistry (pH and nutrient levels) will be periodically monitored (at intervals to be determined) in a random set of peatlands throughout the state. If water chemistry, vegetation, or wildlife population changes occur when land conversion activities occur immediately outside the buffer, increases in the buffer distance should be considered.

(G) Implementation

- An appropriate buffer distance will be determined, based on hydrology research and wildlife migration distances. Included in the buffer requirements will be the stipulation that off-road vehicle trails will be located at least 100 feet from any peatland to reduce visibility of the peatland and deter drivers from entering them.
- Delineate peatlands throughout the state (preferably all peatlands, but if not, then a significant number of important peatlands distributed throughout the state and across community classifications).
- Establish through regulation either a required buffer distance or strong incentives to include buffers in place (e.g., project restrictions or a high fee for non-compliance) during construction, road, and off-road vehicle

trail building, and other land conversion activities. Compliance with the buffer may be overseen by the New Hampshire Department of Environmental Services (NHDES) as part of the wetland review process.

(H) Feasibility
Enacting a regulation for a peatland buffer will require the agreement of various state agencies including NHDES, NHFG, and the New Hampshire Department of Resources and Economic Development (NHDRED) as well as legislators, which could slow the process. Buffering selected peatlands may be more feasible initially than buffering all peatlands. Once a peatland buffer is in place, enacting the buffer will be a regular part of the ongoing wetland review process of NHDES. If incentives are used rather than a strict buffer requirement, monitoring and enforcing buffers will require more time and effort.

4.1.2 Conservation Action: Delineate forested peatlands in northern New Hampshire and notify large landowners

Category: Education and Outreach

(A) List of Direct Threats Affected
Forestry activities in/near peatlands, Increased nutrient input

(B) Justification

- Mapping and notifying large landowners of the locations of forested peatlands on their properties will reduce winter harvesting in or near peatlands that are not properly mapped in existing GIS layers.
- Reducing harvesting in or near peatlands will protect the vegetation structure, reduce nutrient changes due to forestry activities, eliminate soil compaction, and increases woody debris around peatlands.
- Most large-scale timber harvesting occurs in northern New Hampshire; thus, delineation of peatlands in this region would be the most efficient way to target the highest number of unprotected peatlands affected by forestry practices. Prompt delineation of peatlands in northern New Hampshire will protect them before they are inadvertently damaged.
- Peatland delineations can be changed as beaver activities alter the landscape or if new peatlands are discovered. Landowners can be updated when any changes are made.

(C) Conservation Performance Objective
Delineating and notifying landowners about forested peatlands in northern New Hampshire will reduce the harvesting of timber in and near peatlands. Success will be measured by the number of delineated peatlands in northern New Hampshire that are harvested.

(D) Performance Monitoring
Opportunistic field checks and updated aerial photo analysis will allow for assessment of whether delineated peatlands have been cut. Peatland delineations will also be given to NHDES, who will process permit requests wetland impacts and can determine if harvest activities are likely to occur near a peatland.

(E) Ecological Response Objective
The ecological response objective is to eliminate changes to peatland structure, vegetation, and ecological processes from cutting.

(F) Response Monitoring
Opportunistic field checks of peatlands in northern New Hampshire will determine if vegetation and structure have changed.

(G) Implementation
Through color infrared aerial photo interpretation supplemented by field surveys, the predicted peatland map (element 1.6) will be refined in the Connecticut Lakes and Mahoosic-Rangeley Lakes ecoregion subsections, to create a detailed map of forested peatlands by community or system. Portions of the peatland map corresponding to different ownerships will be distributed to the landowners of commercial timberland. For this distribution process, a GIS layer of ownerships may need to be created if landowners cannot provide shapefiles of their holdings. In the event that GIS ownership data cannot be obtained, tax maps or other ownership maps will need to be used with care due to their lack of spatial accuracy. The entire map will be given to the NHDES Wetlands Bureau for use in the environmental review process.

(H) Feasibility
Finalizing the peatland map in northern New Hampshire through aerial photo analysis and field checking will require 1-2 people several months to complete, and landowner permission will be required for field visits. Obtaining accurate spatial data about ownerships will depend on the availability of this data, and if accurate digital data is not available, more time will be required to either digitize ownerships or select peatlands based on hardcopy maps.

4.2 Conservation Action Research

Determine an appropriate buffer distance for maintaining ecological functions of peatlands

Element 5: References

5.1 Literature

Aerts, R., B. Wallen, N. Malmer, and H. de Caluwe. 2001. Nutritional constraints on *Sphagnum*-growth and potential decay in northern peatlands. Journal of Ecology 89:292-299.

Crum, H. 2000. A focus on peatlands and peat mosses. The University of Michigan Press, Ann Arbor, Michigan, USA.

Damman, A. W. H., and T. W. French. 1987. The ecology of peat bogs of the glaciated northeastern United States: a community profile. United States Fish and Wildlife Service Biological Report 85(7.16), Washington, DC., USA.

deMaynadier, P. G., and M. L. Hunter, Jr. 1999. Forest canopy closure and juvenile emigration by pool-breeding amphibians in Maine. Journal of Wildlife Management 63:441-450.

Frieswyk, T. and R. Widmann. 2000. Forest statistics for New Hampshire: 1983 and 1997. United States Department of Agriculture Forest Service, Northeastern Research Station, Resource Bulletin NE-146.

Gibbs, J. P. 2000. Wetland loss and biodiversity conservation. Conservation Biology 14:314-317.

Herrmann, H. L., K .J. Babbitt, M. J. Baber, and R. G. Congalton. 2005. Effects of landscape characteristics on amphibian distributions in a forest-dominated landscape. Biological Conservation 123:139-149.

Herrmann, H. L., T. P. Hodgman, and P. deMaynadier. 2003. A survey of rare, threatened, and endangered fauna in Maine: St. John Uplands and Boundary Plateau (2001-2002). Maine Department of Inland Fisheries and Wildlife, Bangor, Maine, USA.

Johnson, C. W. 1985. Bogs of the Northeast. University Press of New England, London.

Mader, H. J. 1984. Animal habitat isolation by roads and fields. Biological Conservation 29:81-96.

Moore, P. D. 2002. The future of cool temperate bogs. Environmental Conservation 29(1):3-20.

NatureServe. 2005. NatureServe Explorer. http://www.natureserve.org/explorer/. Accessed 30 March 2005.

Nekola, J. C., and C. E. Craft. 2002. Spatial constraint of peatland butterfly occurrences within a heterogeneous landscape. Oecologia 130:78-91.

New Hampshire Department of Environmental Services. 2004. Wetlands Bureau rules. http://www.des.state.nh.us/wetlands/rule-law.htm. Accessed 11 April 2005.

New Hampshire Forest Sustainability Standards Work Team. 1997. Good forestry in the Granite State: recommended voluntary forest management practices for New Hampshire. New Hampshire Division of Forests and Lands, Concord, NH and the Society for the Protection of New Hampshire Forests, Concord, NH.

New Hampshire Fish and Game Department. 2005. 2005 New Hampshire off highway recreational vehicle laws digest. http://www.wildlife.state.nh.us/OHRV/OHRV_laws.pdf. Accessed 12 April 2005.

New Hampshire General Court. 2004. Title L Water management and protection: Chapter 482-A fill and dredge in wetlands. http://www.gencourt.state.nh.us/rsa/html/indexes/default.asp. Accessed 14 April 2005.

New Hampshire Trails Bureau. 2003. A plan for developing New Hampshire's statewide trail system for ATV and trail bikes 2004-2008. New Hampshire Department of Resources and Economic Development Division of Parks and Recreation, Concord, NH.

Reh, W. and A. Seitz. 1990. The influence of land use on the genetic structure of populations of the common frog *Rana temporaria*. Biological Conservation 54: 239-249.

Rochefort, L., F. Quinty, S. Campeau, K. Johnson, and T. Malterer. 2003. North American approach

to the restoration of *Sphagnum* dominated peatlands. Wetlands Ecology and Management 11: 37-49.

Sperduto, D. D. 2004. Wetland ecological systems of New Hampshire. New Hampshire Natural Heritage Bureau, Concord, NH and The Nature Conservancy, Concord, New Hampshire, USA

Sperduto, D. D. and W. F. Nichols. 2004. Natural communities of New Hampshire. New Hampshire Natural Heritage Bureau, Concord, NH and The Nature Conservancy, Concord, New Hampshire, USA.

Sperduto, D. D., W. F. Nichols, and N. Cleavitt. 2000. Bogs and fens of New Hampshire. New Hampshire Natural Heritage Bureau, Concord, NH and The Nature Conservancy, Concord, New Hampshire, USA

Taylor, R. B. No date. The effects of off road vehicles on ecosystems. Texas Parks and Wildlife. http://www.tpwd.state.tx.us/texaswater/rivers/orvecosystempaper.pdf. Accessed 12 April 2005.

United States Department of Agriculture Forest Service. 2005. The Land and Water Conservation Fund. http://www.fs.fed.us/land/staff/LWCF/. Accessed 28 March 2005.

United States Department of Transportation. 2005. Navigable waterways and coastal zones. http://www.fta.dot.gov/transit_data_info/reports_publications/publications/environment/4805_5143_ENG_HTML.htm. Accessed 26 April 2005.

United States Environmental Protection Agency. 2005a. Clean Water Act, Section 401 certification. http://www.epa.gov/owow/wetlands/regs/sec401.html. Accessed 28 March 2005.

United States Environmental Protection Agency. 2005b. Clean Water Act, Section 402: National Pollutant Discharge Elimination System. http://www.epa.gov/owow/wetlands/laws/section402.html. Accessed 28 March 2005.

United States Environmental Protection Agency. 2005c. Section 404 of the Clean Water Act: an overview. http://www.epa.gov/owow/wetlands/facts/fact10.html. Accessed 28 March 2005.

United States Fish and Wildlife Service. 2005. Digest of federal resource laws of interest to the U.S. Fish and Wildlife Service, Emergency Wetlands Resources Act of 1986. http://laws.fws.gov/lawsdigest/emwet.html. Accessed 28 March 2005.

5.2 Data Sources

Complex Systems Research Center. 2005. Conservation Lands. University of New Hampshire.
http://www.granit.sr.unh.edu/data/datacat/pages/cons.pdf. Accessed 25 April 2005.

Complex Systems Research Center. 2001. National Wetlands Inventory. University of New
Hampshire. http://www.granit.sr.unh.edu/data/datacat/pages/nwi.pdf. Accessed 21 August 2000.

New Hampshire Natural Heritage Bureau. 2005. Database of rare species and exemplary natural
community occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands, Concord, New Hampshire, USA

The Nature Conservancy. 1998. Ecoregion Subsections. The Nature Conservancy (TNC)

Eastern Conservation Science and United States Forest Service. Accessed 28 March 2003.

HABITAT PROFILE

Salt Marshes

Associated Species: American Bittern, American Black Duck, Common Tern, Nelson's Sharp Tailed Sparrow, Salt Marsh Sharp Tailed Sparrow, Seaside Sparrow, Semipalmated Sandpiper, Willet

State Ranks: Salt marsh system: Low salt marsh (S3), High salt marsh (S3), Salt pannes and pools (S3), Brackish marsh (S2S3), Coastal salt pond marsh (S1); Brackish tidal riverbank marsh system: Low brackish tidal riverbank marsh (S1S2), High brackish tidal riverbank marsh (S1S2), Brackish marsh (S2S3); Sparsely vegetated intertidal system: Coastal shoreline strand/swale (S2), Intertidal rocky shore (S3), Saline/brackish intertidal flat (S3).

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Element 1: Distribution and Habitat

1.1 Habitat Description

Salt marshes are grass-dominated tidal wetlands existing in the transition zone between ocean and upland (Niering and Warren 1980). These marshes are among the most productive ecosystems in the world and are dominated by detritus-based food chains (Mitsch and Gosselink 2000).

Salt marsh plants are salt-tolerant and adapted to fluctuating water levels. Salt marshes are composed of 3 distinct vegetative zones in response to tidal regime: low marsh, high marsh, and marsh border. The low marsh, occurring as a narrow band along the seaward edge of the marsh, and along creeks and ditches, becomes flooded during most tides, but is exposed during low tide. Tall-form smooth cordgrass (*Spartina alterniflora*) is the predominant plant species found in the low marsh and can grow up to 2 meters.

The high marsh occurs between the low marsh and the marsh border. The high marsh becomes flooded usually only during extreme high tides, such as the new-moon and full-moon tides. Throughout the high marsh, grasses and rushes dominate. Species such as salt hay grass (*Spartina patens*), spike grass (*Distichlis spicata*), black grass (*Juncus gerardii*), short-form smooth cordgrass (*Spartina alterniflora*), salt marsh aster (*Aster tenufolius*), and sea lavender (*Limonium nashii*) are common. Pannes and pools found in the high marsh zone are also important salt marsh components. Pannes are shallow depressions of standing water that typically dry out during long, dry periods (e.g., end of summer). Only the most salt-tolerant plant species can occur at panne edges, such as common glasswort (*Salicornia europaea*), seaside plantain (*Plantago maritima*), and short-form smooth cordgrass. Pools are larger and deeper than pannes and hold submerged aquatic vegetation, such as widgeon grass (*Ruppia maritima*).

The marsh border is located at the upland edge of a salt marsh but can also be found in pockets of the marsh where elevation level is higher than that of the high marsh. The marsh border has the highest plant diversity in a salt marsh, with the following dominant species: marsh elder (*Iva frutescens*), sweet gale (*Myrica gale*), seaside goldenrod (*Solidago sempervirens*), and switchgrass (*Panicum virgatum*).

Frequency and duration of tidal flooding are key environmental factors that create and influence salt marsh vegetative patterns (Niering and Warren 1980, Mitsch and Gosselink 2000). In addition, salinity, substrate, fine-scale topography, availability of nutrients and oxygen, and human modifications influence vegetative patterns (Niering and Warren 1980). Nutrients that stimulate marsh plant growth are carried in with the tides, and organic matter that feeds fish and other organisms is carried out by the tides. Over time, organic matter accumulates on the marsh and forms peat. By building up more peat, salt marsh elevation can keep apace with rising sea level, unless the rate of sea-level rise becomes too great.

1.2 Justification

More than 50% of coastal and estuarine marshes in the United States have been lost, and the Northeast region is one of four "hotspots" with the most significant loss (Benoit and Askins 1999). In addition, by the 1930s, about 90% of salt marshes from Maine to Virginia were ditched for mosquito control (Clarke et al. 1984, Post and Greenlaw 1994). An estimated 30-50% of New Hampshire's original salt marsh habitat has been lost to development (New Hampshire Coastal Program (NHCP). Therefore, protecting and restoring remaining salt marsh habitat has become a high priority for New Hampshire.

Salt marsh habitat is an important conservation concern because it has many important values and functions, such as supporting biodiversity, scenic, and recreational values and serving as an upland buffer for storms (Mitsch and Gosselink 2000). Salt marshes provide habitat and food for small fish, crustaceans, and insects, as well as larger fish that are important to the New England fishing industry. Moreover, salt marshes provide breeding, foraging, and migratory stopover habitat for many species of birds (Mitsch and Gosselink 2000), including several species of special concern in New Hampshire, such as saltmarsh sharp-tailed sparrow, Nelson's sharp-tailed sparrow, and willet.

1.3 Protection and Regulatory Status

Salt marshes are regulated by NHDES. Activities that may involve filling, dredging, or destroying wetlands in any way are subject to strict guidelines, and approved permits must be obtained before work can commence (RSA 482-A).

1.4 Population and Habitat Distribution

Most of New Hampshire's salt marsh habitat is located along the open coast, with only 10% located in and around Great Bay (NHCP). Salt marshes are found in New Hampshire's coastal zone, which encompasses the following towns: Seabrook, Hampton, Hampton Falls, North Hampton, Rye, Portsmouth, New Castle, Newington, Greenland, Stratham, Exeter, Newfields, Newmarket, Durham, Madbury, Dover, and Rollinsford (NHCP).

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

Salt marsh habitat was mapped using National Wetlands Inventory (NWI) data (USFWS 2001). Specifically, those wetlands classified as emergent intertidal estuarine wetlands (code = E2EM) were extracted from the NWI data to represent salt marshes in New Hampshire. Salt marsh habitats were not restricted by size, vegetative structure, or other attributes. Therefore, habitat quality for different species varies among salt marsh polygons. Potential habitat maps for salt marsh species (e.g., salt marsh birds) can be created by querying for specific attributes (e.g., marshes larger than 20 ha).

1.7 Sources of Information

Information on salt marsh habitat ecology, research, management, and restoration was obtained from a literature review. National Wetland Inventory maps were used to identify salt marsh habitat in the state. The New Hampshire Coastal Program's website was used to gather information on salt marsh distribution and abundance in the state, management and restoration projects, and research and conservation issues in the state. Sperduto (2004) was used to crosswalk salt marsh habitat with the New Hampshire Natural Heritage Bureau natural communities and ecological systems (see State Ranks above).

1.8 Extent and Quality of Data

The extent and quality of data on the distribution of salt marsh habitat in New Hampshire are quite good. NHCP monitors habitat changes by regular sampling of soil, fish, vegetation, and birds at select sites that are natural or undisturbed, degraded or restricted, and restored or mitigated. Therefore, any changes in habitat quality or type (e.g., a tidally restricted salt marsh becoming brackish or dominated by invasive species) are well documented and handled by NHCP.

1.9 Distribution Research

Continuation of NHCP's long-term monitoring and surveying efforts of salt marsh habitat is needed so

that information on distribution and loss due to tidal restrictions or degradation is kept current.

Element 2: Species/Habitat Condition

2.1 Scale

The New Hampshire conservation units for salt marsh habitat are Great Bay and Portsmouth and Coast (including Rye, Hampton, and Seabrook).

2.2 Relative Health of Populations

Historically, the introduction of railroads and roads resulted in reduced or no tidal influence to marsh habitat. Currently, negative effects of these transportation systems are still impacting some of New Hampshire's salt marshes. Tidally restricted marshes are less productive than unrestricted marshes (Roman et al. 1984). Burdick et al. (1997) noted that observed trends in marsh degradation indicate that tidal restrictions negatively affect the entire salt marsh ecosystem. For instance, tidal restrictions result in a decrease in flooding frequency and salt and sediment exchange, as well as an increase in freshwater from rain and snowmelt (Burdick et al. 1997). These conditions result in the loss of salt marsh habitat, and typical salt marsh vegetation is replaced with invasive reeds and grasses, such as cattails and common reed (Sinicrope et al. 1990, Burdick et al. 1997, Brawley et al. 1998).

In New Hampshire, there are currently about 2509 ha (6,200 ac) of salt marsh habitat (NHCP). An estimated 30-50% of New Hampshire's original salt marsh habitat has been lost to development. Tidal restrictions and filling have caused most of this historic marsh loss and degradation (NHCP). Residential and commercial development along the entire length of the coast, and the presence of Route 1A, have disrupted and restricted the connection between ocean and the marshes (NHCP).

2.3 Population Management Status

There is no ongoing population management specifically for salt marsh birds in New Hampshire, but inventory work is under way. With historical records from ASNH and the ongoing research being conducted at UNH, potentially important sites for New Hampshire's salt marsh birds are being identified. Lack of data (e.g., habitat suitability and effects of restoration practices) is a significant hurdle in developing effective management guidelines. Currently, researchers at UNH are attempting to answer some of these questions surrounding habitat suitability and effects of restoration practices.

2.4 Relative Quality of Habitat Patches

Salt marsh habitat within New Hampshire's coastal zone can be identified in a geographical information system by using National Wetland Inventory data (NWI code = E2EM1P). Although these habitat patches are all considered salt marsh, they are vastly different in status (i.e., tidally restricted, undisturbed, or restored), size, shape, regime, vegetative structure, location on the landscape relative to human disturbance, elevation, presence of ditches, pools, and pannes, among many other characteristics. Their ability to provide key ecological attributes varies between sites and also depends on the target wildlife species or communities. For example, saltmarsh sharp-tailed sparrow, a salt marsh obligate, typically breeds in large, unrestricted, *Spartina*-dominated marshes with the presence of pannes, pools, and creeks for foraging. However, this is not always the case. Sparrows may occupy marshes that do not fit the above criteria, while marshes that appear to meet all the critical habitat attributes may have an absence of sparrows. Therefore, all New Hampshire's salt marshes potentially have key ecological attributes, but more research is needed to fully understand habitat quality in relation to rare or endangered salt marsh obligates.

2.5 Habitat Patch Protection Status

All salt marshes, regardless of ownership, are protected and regulated by the NHDES through a permitting process. Some marshes are protected further through conservation easements, such as Bay Road marsh in Newmarket, Squamscott River in Newfields, and Chapman's Landing in Stratham. In addition, areas of the Hampton marsh complex are protected through conservation easements held by ASNH, NHFG, and SPNHF.

2.6 Habitat Management Status

The Coastal Zone Management Act of 1972 created the federally consistent formal review process for any federal activities affecting New Hampshire's coastal zone. NHCP, part of the Department of Environmental Services, gained federal approval in 1982 and oversees all protection, mitigation, and restoration efforts surrounding salt marsh habitat in the state. With assistance from the Natural Resource Conservation Service (NRCS), and other partnerships and non-government organizations, NHCP identifies degraded salt marshes, prioritizes sites for restoration, and develops ways to measure the effectiveness of restoration techniques. NHCP is currently forming a comprehensive restoration program that will help coordinate, inventory, and monitor restoration projects in the state.

In a 1994 report, the NRCS identified 31 tidal restriction sites in New Hampshire. Of these, 16 have been rectified, 6 are in the planning stages of restoration, and the remaining restrictions are either infeasible or unnecessary to fix (NHCP). In New Hampshire, restriction removal, fill removal, and open marsh water management are techniques used for restoration. Between 1990 and 2000, removing tidal restrictions restored 236 ha (582 ac), 3 ha (8 ac) of marsh have been restored by fill removal at 2 sites, and the New Hampshire Coastal Program estimates 40 ha (98 ac) have been restored through open marsh water management.

2.7 Sources of Information

Information on salt marsh habitat ecology, research, management, and restoration was obtained from a literature review. The NHCP website was used to gather information on salt marsh condition, health, current management, and restoration efforts.

2.8 Extent and Quality of Data

The extent and quality of data on the condition and management efforts of salt marsh habitat in New Hampshire are quite good. NHCP monitors habitat changes by regular sampling of soil, fish, vegetation, and birds at select sites that are natural or undisturbed, degraded or restricted, and restored or mitigated. Therefore, any changes in habitat quality or type (e.g., a tidally restricted salt marsh becoming brackish or dominated by invasive species) are well documented and handled by NHCP.

2.9 Condition Assessment Research

Continuation of NHCP's long-term monitoring and surveying efforts of salt marsh habitat is needed. This information provides evidence of marsh health at specific sites and can be used to compare different sites. NHCP efforts focus on restricted and restored marshes, but many of New Hampshire's marshes are not monitored. Therefore, extending this effort to unmonitored marshes on an annual basis is recommended.

Element 3: Species and Habitat Threat Assessment

3.1.1 Development (Habitat Loss and Conversion)

(A) Exposure Pathway
Historically, human activities, such as dredging, filling, and the construction of roads, dikes, bridges, and impoundments, have reduced the amount of salt marsh habitat along the Atlantic coast (Roman et al. 1984). The coastal zone of New Hampshire is a popular location for residential and commercial development because of its flat landscape and proximity to the ocean.

(B) Evidence
More than 50% of coastal and estuarine marshes in the United States have been lost, with the Northeast region being one of the four "hotspots" for the most significant loss (Benoit and Askins 1999). In New England, 80% of the marshes have been lost to human development (Shriver et al. 2004). Habitat loss is a significant factor in the decline of wetland birds, especially species that depend on salt marshes for nesting, such as the saltmarsh sharp-tailed sparrow (Greenlaw and Rising 1994, Benoit and Askins 1999).

3.1.2 Development (Habitat Loss and Conversion)

(A) Exposure Pathway
Coastal development also results in the loss of marsh

border habitat and upland habitat surrounding the marsh, both of which act together as an important buffer zone (NHCP). Many species of birds and mammals use this buffer habitat for breeding, feeding, and other activities (NHCP).

(B) Evidence
The loss of upland buffer habitat and an increase in development surrounding a marsh system may negatively influence the behavior of salt marsh obligate wildlife species. For example, salt marsh nesting birds may nest greater distances from the edge due to the loss of the upland buffer and an increase in noise pollution and therefore be forced to occupy less space (NHCP).

Coastal development combined with an accelerated rate of sea-level rise and loss of upland buffer habitat threatens marsh growth. As sea level rises, marshes will not be able to keep pace with the rising ocean in places where the upland buffer has been lost to development. The result will be smaller and narrower fringe marshes bordering the ocean.

3.1.3 Development (Fragmentation)

(A) Exposure Pathway
Residential and commercial development has fragmented the landscape and created isolated patches of marsh habitat. Historically, the flat, open, and expansive qualities of salt marshes made them ideal locations for the construction of roads and railroads. Ultimately, construction of these transportation systems has left smaller and smaller patches of marsh that consist of more edge habitat and less interior habitat.

(B) Evidence
Fragmented habitats are usually associated with an increase in edge habitat and a decrease in available interior habitat. Area-sensitive species, such as saltmarsh sharp-tailed sparrows (Benoit and Askins 2002), could be negatively impacted by fragmentation and decreasing patch size. In Connecticut, saltmarsh sharp-tailed sparrow densities exhibited a significant positive relationship with marsh area (Benoit and Askins 2002). Moreover, an increase in the amount of edge in many different habitat types can be associated with higher densities of nest predators (Niehaus et al. 2003). Thus, salt marsh nesting birds may be impacted by increased nest predation in fragmented patches. Fragmentation also reduces the amount of suitable nesting habitat. With increasing edge and development pressures surrounding a marsh, many salt marsh nesting birds could lose quality nesting habitat and be forced to move further from the marsh edge or exist at lower densities.

3.1.4 Altered Hydrology (Tidal Restriction), Transportation Infrastructure

(A) Exposure Pathway
Transportation routes (roads and railroads) that have been built on salt marshes since the late 1800s sever the vital connection between the marsh and ocean (NHCP, Roman et al. 1984). Roads built on the marsh often have tide gates or inadequately sized culverts that reduce or eliminate tidal flooding of the marsh system.

(B) Evidence
Without tidal influence, typical salt marsh grasses of tidally restricted marshes are replaced with brackish species and invasive plants (Niering and Warren 1980, Sinicrope et al. 1990, Burdick et al. 1997, Brawley et al. 1998, Benoit and Askins 1999). Tidal restrictions also result in a decrease in salt and sediment exchange and an increase in fresh water from rain and snowmelt (Burdick et al. 1997). Further, tidally restricted marshes are less productive than unrestricted marshes (Roman et al. 1984). Burdick et al. (1997) found that tidal restrictions negatively affect the entire salt marsh ecosystem. Historical degradation of salt marsh habitat quality along the Atlantic coast has contributed to regional declines in the saltmarsh sharp-tailed sparrow population (Greenlaw and Rising 1994, Benoit and Askins 1999) and other salt marsh nesting birds.

3.2 Sources of Information

Information on salt marsh threats was obtained from a literature review and the New Hampshire Coastal Program.

3.3 Extent and Quality of Data

The above threats to salt marsh habitat are well documented and are the focus of many scientific studies in New England.

3.4 Threat Assessment Research

Because past human activities such as road construction continue to negatively affect salt marshes, habitat restoration is a high priority. Pre- and post-restoration research and monitoring of salt marsh structure and function are essential for accurate evaluation of restoration success. For example, open marsh water management for mosquito control may negatively affect the salt marsh ecosystem, but more research is needed (NHCP).

Research is needed to determine the effects of methylmercury on the salt marsh ecosystem in New Hampshire. Methylmercury has become an important regional ecological and human health concern. The Biodiversity Research Institute has started to investigate the effects of mercury on salt marsh birds in New England, but research is needed in New Hampshire. Salt marsh birds are already a regional conservation priority due to habitat loss and degradation, but mercury could pose an increasing threat to these and other salt marsh species. As scientific research assesses mercury's effects, conservation actions can better address the issue.

Element 4: Conservation Actions

4.1.1 Protecting remaining salt marsh habitat and surrounding upland buffer habitat, Habitat Protection

(A) Salt Marsh Loss, Upland Habitat Loss, Habitat Fragmentation, Increased Human and Noise Disturbance, Invasive Plant Species, Increased Deposition of Pollutants, Tidal Restriction, Dredge and Fill, Sea Level Rise

(B) Justification

1) Most of New England's historical salt marsh habitat has been lost to development and other human activities. Therefore, preserving the remaining habitat patches will ensure that no more salt marsh is lost or fragmented in New Hampshire. Protecting quality habitat and the upland buffer will reduce or lessen the threats listed in (A) in measurable ways and benefit the salt marsh community. For example, maintaining the upland buffer surrounding a marsh and protecting it from development will reduce or prevent human and noise disturbance at that site.
2) Many salt marsh nesting birds, such as willet, are area-sensitive and require large, contiguous patches of habitat on a landscape for population colonization and growth. Protecting existing patches will ensure that these and other populations will not decline or become locally extinct due to habitat loss and fragmentation. Protecting existing marshes and upland buffers will benefit New Hampshire's current salt marsh bird populations and allow them to stabilize, grow, or disperse into new protected areas.
3) Habitat protection across the landscape is necessary to maintain current population numbers because salt marshes are threatened by development everywhere.
4) Protection of existing salt marsh habitat structure, function, and value is achievable immediately. Habitat protection has the advantage of being a preventative approach, rather than a reconstructive or restorative approach. For example, sites currently used by salt marsh nesting sparrows likely would continue to be used if the habitat were protected.

(C) Conservation Performance Objective
The performance objective for salt marsh and upland buffer protection is to maintain a tidally influenced, *Spartina*-dominated system with low marsh, high marsh, pannes, pools, and a border of upland habitat. The objective for each conservation unit is to maintain known salt marsh structure, function, and value that can be measured through frequent monitoring. The ultimate goal is to maintain habitat quality within every conservation unit that potentially could support breeding populations of salt marsh obligate birds, which can be used as indicators of habitat health.

(D) Performance Monitoring
Performance monitoring should be conducted at as many salt marshes as possible, or at sites of high priority or concern, on a regular basis (depending on priority, available personnel, funding, and time). Monitoring includes regular sampling of soil salinity, tidal elevations, vegetation structure, and fish and bird communities.

(E) Ecological Response Objective
The desired ecological response to salt marsh protection is persistence of a tidally influenced, *Spartina*-dominated system that could support salt marsh fish populations and potentially support obligate bird populations. This response should be immediate at natural, undisturbed sites that are monitored and protected from further human disturbance and development. For salt marsh protection to be deemed successful, long-term monitoring and research should indicate that fish and bird use stabilizes or increases.

(F) Response Monitoring
Response monitoring should be conducted at as many salt marshes as possible, or at sites of high priority or conservation concern, on a regular basis (depending on priority, available personnel, funding, and time). The response indicator for successful marsh protection is a measured quality of marsh structure and function, in terms of soil salinity, vegetative structure, tidal elevations, and fish and bird communities.

(G) Implementation
NHCP oversees all protection and management of salt marsh habitat within New Hampshire and works with local partners and conservation commissions to ensure protection.

(H) Feasibility:
Although NHCP has successfully protected many hectares of salt marsh habitat in New Hampshire, the pressures of development within the coastal zone are significant. Any impact to wetlands must go through a permitting process before implementation. However, even legally permitted impacts can result in habitat loss. Therefore, reducing or eliminating future disturbance and development is crucial to protecting existing salt marsh systems and communities. The feasibility of intense long-term monitoring at natural sites is limited by personnel and funding.

4.1.2 Restoring degraded salt marshes back to Spartina-dominated systems, Restoration and Management

(A) Salt Marsh Loss, Upland Habitat Loss, Habitat Fragmentation, Invasive Plant Species, Tidal Restriction, Dredge and Fill, Mosquito Ditching

(B) Justification
1) Pre- and post-restoration environmental monitoring has shown that restoring degraded marshes by reintroducing tidal influence can be successful (see Warren et al. 2002, NHCP). Removing or reducing tidal restrictions decreases or eliminates invasive plant species and creates a functioning *Spartina*-dominated system over several years (Niering and Warren 1980, Roman et al. 1984, Warren et al. 2002).
2) Salt marsh restoration has produced a positive ecological response in degraded salt marsh ecosystems (Burdick et al. 1997, Warren et al. 2002). Although more research is needed, restoration is expected to benefit salt marsh obligate bird populations over the long-term. In a 20-year study of salt marsh restoration in Connecticut, abundance and nesting activity of salt marsh specialists were low following restoration, but were comparable to breeding populations of the same species in reference marshes after 15 years (Warren et al. 2002). Restoration may have a near-term negative effect on salt marsh nesting sparrows due to increased flooding, but over time it is possible for restoration to increase bird activity and reproductive success due to an increase in the amount of quality habitat.
3) Salt marsh restoration is critical across the landscape to conserve salt marsh habitat in New Hampshire. Without it, tidal restrictions would continue to degrade and alter these marshes into brackish or freshwater marshes and uplands dominated by common reed and other invasive species. Salt marsh habitat would continue to be lost in the state.
4) Warren et al. (2002) suggest restoration response times for certain ecological parameters to be between 5 and 21 years. Burdick et al. (1997) found significant positive changes to vegetative structure only a few years after restoration, and Warren et al. (2002) found typical salt marsh fish communities present at restoration sites 5 years after restoration. Limited research has been conducted on the timeframe of restoration success in terms of bird use. However, Warren et al. (2002) found salt marsh sharp-tailed sparrow activity at a restored site was similar to activity at reference sites 15 years after restoration.
5) There are many different techniques for restoring

salt marshes, including seeding and replanting *Spartina* grasses, reintroducing tidal flooding to restricted areas by constructing larger culverts under roads, installing self-regulating tide gates to permit water passage, and plugging ditches (see Broome et al. 1988, Sinicrope et al. 1990, Warren et al. 2002). These techniques can be tailored to obtain the desired ecological response depending on a site's specific needs. Ongoing monitoring of salt marsh functions at restored sites provides the necessary ecological information about the outcomes of restoration activities. These data can be used to guide restoration management goals and plans (i.e., adaptive management).

(C) Conservation Performance Objective
The salt marsh restoration performance objective is to create a tidally influenced, *Spartina*-dominated system with low marsh, high marsh, pannes, pools, and a border of upland habitat. The objective for an individual site is to establish marsh structure and function comparable to that of natural, undisturbed systems. Warren et al. (2002) suggests that full restoration of ecological functions, including salt marsh sparrow breeding activity, can occur within 2 decades. Therefore, the ultimate goal for the performance objective is to create habitat with salt marsh structure, function, and value relative to the conservation unit within 20 years of restoration.

(D) Performance Monitoring
Annual performance monitoring should be conducted at all restoration sites, including pre-restoration monitoring, if feasible. If pre-restoration monitoring is not possible due to time constraints and severity of marsh degradation, then monitoring of reference sites is acceptable. All monitoring and research activities should be conducted at reference sites and restoration sites to enable assessment of restoration success. Monitoring should be performed until at least 15-20 years after restoration to determine if desired effects are realized. Restoration is a long-term process and needs to be monitored over a long timeframe. Monitoring should include regular sampling of soil salinity, vegetation structure, tidal elevations, and fish and bird communities.

(E) Ecological Response Objective
The desired ecological response to salt marsh restoration is creating a tidally influenced, *Spartina*-dominated system that could support salt marsh fish populations and potentially support obligate bird populations. This response should be realized approximately 5-20 years after restoration (e.g., 5 years for fish colonization and 20 years for bird colonization) (Warren et al. 2002). For restoration to be deemed successful, long-term monitoring should indicate that soil salinity, vegetative structure, tidal elevations, and fish and bird use at restored sites are comparable to that of similar reference sites.

(F) Response Monitoring
Response monitoring should be conducted at all restoration sites on a regular basis (depending on priority, available personnel, funding, and time). The response indicator for successful marsh restoration is the quality of marsh structure and function measured in terms of soil salinity, vegetative structure, tidal elevations, and fish and bird communities.

(G) Implementation
NHCP oversees all protection, management, and restoration of salt marsh habitat within New Hampshire, often with partners such as Ducks Unlimited, U.S. Fish and Wildlife Service, University of New Hampshire, National Oceanic and Atmospheric Administration, and many local partners, such as town conservation commissions and businesses. Restoration sites are chosen based on degree of degradation, feasibility of proposed restoration activities, and available monetary resources for the project. Once technical support and funding are established for each project, a timeline is created for restoration activities and post-restoration monitoring of habitat functions.

(H) Feasibility
NHCP has successfully implemented salt marsh restoration projects throughout New Hampshire's coastal zone and is planning future restorations. In addition to planning, collaborating with partners, obtaining funding for each project, and carrying out the restoration, NHCP and its partners annually conduct biotic and abiotic sampling to monitor restoration success. The feasibility of intense long-term monitoring of restoration success is limited by personnel and funding.

4.2 Conservation Action Research

More research is needed in New Hampshire to determine the long-term effects of restoration on populations of salt marsh nesting birds, such as saltmarsh sharp-tailed sparrow, Nelson's sharp-tailed sparrow, seaside sparrow, and willet. Salt marsh obligate birds are of special concern in New Hampshire and the impact of restoration on these populations is not well documented. Because these birds may be faithful to breeding sites or territories (see Lowther et al. 2001, Benoit and Askins 2002) and their nests are sensitive to fluctuations in water level, restoration might cause high nest failure rates at a site for several years after restoration. The effects on the small and localized populations of these birds are unknown.

Element 5: References

5.1 Literature

Benoit, L. K., and R. A. Askins. 1999. Impact of the spread of Phragmites on the distribution of birds in Connecticut tidal marshes. Wetlands 19:194-208.

Benoit, L. K., and R. A. Askins. 2002. Relationship between habitat area and the distribution of tidal marsh birds. Wilson Bulletin 114:314-323.

Brawley, A. H., R. S. Warren, and R. A. Askins. 1998. Bird use of restoration and reference marshes within the Barn Island wildlife management area, Stonington, Connecticut, USA. Environmental Management 22:625-633.

Broome, S. W., E. D. Seneca, and W. W. Woodhouse, Jr. 1988. Tidal salt marsh restoration. Aquatic Botany 32:1-22.

Burdick, D. M., M. Dionne, R. M. Boumans, and F. T. Short. 1997. Ecological responses to tidal restorations of two northern New England salt marshes. Wetlands Ecology and Management 4:129-144.

Clarke, J. A., B. A. Harrington, T. Hruby, and F. E. Wasserman. 1984. The effect of ditching for in Rowley, Massachusetts. Journal of Field Ornithology 55:160-180.

Greenlaw, J. S., and J. D. Rising. 1994. Sharp-tailed Sparrow (Ammodramus caudacutus). Number 112 *in* A. Poole and F. Gill, editors. The birds of North America. The Academy of Natural Sciences, Philadelphia, Pennsylvania, USA.

Hunt, P. 2004(Draft). A regional perspective on New Hampshire's birds of conservation priority: objectives, threats, research needs, and conservation strategies. Audubon Society of New Hampshire.

Johnson, R. G., and S. A. Temple. 1990. Nest predation and brood parasitism of tallgrass prairie birds. Journal of Wildlife Management 54:106-111.

Lowther, P. E., H. D. Douglas, III, and C. L. Gratto-Trevor. 2001. Willet (*Catoptrophorus semipalmatus*). Number 579 in A. Poole and F. Gill, editors. The birds of North America. The Academy of Natural Sciences, Philadelphia, Pennsylvania, USA.

Mitsch, W. J., and J. G. Gosselink. 2000. Wetlands. Third edition. John Wiley & Sons, Inc., New York, New York, USA.

NHCP (New Hampshire Coastal Program). New Hampshire Department of Environmental Services, Concord, New Hampshire. NHCP home page: http://www.des.state.nh.us/Coastal/ Accessed 2004 November.

Niehaus, A. C., S. B. Heard, S. D. Hendrix, and S. L. Hillis. 2003. Measuring edge effects on nest predation in forest fragments: do finch and quail eggs tell different stories? American Midland Naturalist 149:335-343.

Niering, W. A., and R. S. Warren. 1980. Vegetation patterns and processes in New England salt marshes. BioScience 30:301-306.

Post, W., and J. S. Greenlaw. 1994. Seaside sparrow (Ammodramus maritimus). Number 127 *in* A. Poole and F. Gill, editors. The birds of North America. The Academy of Natural Sciences, Philadelphia, Pennsylvania, USA.

Roman, C. T., W. A. Niering, and R. S. Warren. 1984. Salt marsh vegetation change in response to tidal restriction. Environmental Management 8: 141-150.

Shriver, W. G., T. P. Hodgman, J. P. Gibbs, and P. D. Vickery. 2004. Landscape context influences salt marsh bird diversity and area requirements in New England. Biological Conservation 119:545-553.

Sinicrope, T. L., P. G. Hine, R. S. Warren, and W. A. Niering. 1990. Restoration of an impounded salt marsh in New England. Estuaries 13:25-30.

Sperduto, D. D. 2004. Wetland ecological systems of New Hampshire. New Hampshire Natural Heritage Bureau. Concord, New Hampshire, USA.

United States Fish & Wildlife Service. 2001. Ntional Wetlands Inventory. U.S. Department of Interior. St. Petersburg, Florida. http://wetlands.fws.gov/.

Warren, R. S., P. E. Fell, R. Rozsa, A. H. Brawley, A. C. Orsted, E. T. Olson, V. Swamy, and W.

A. Niering. 2002. Salt marsh restoration inConnecticut: 20 years of science and management. Restoration Ecology 10:497-513.

HABITAT PROFILE

Shrublands

Federal Listing: Not listed
State Listing: Not listed
Associated Species: Golden-Winged Warbler (Vermivora chrysoptera), American Woodcock (Scolopax minor), New England Cottontail (Sylvilagus transitionalis), Smooth Green Snake (Opheodrys vernalis), Black Racer (Coluber constrictor), Wood Turtle (Glyptemys insculpta).
Global Rank: N/A
State Rank: N/A
Author: James D. Oehler and Ellen Snyder, New Hampshire Fish and Game, Consulting Wildlife Biologist

Element 1: Distribution and Habitat

1.1 Habitat Description

Shrubland habitat (hereafter referred to as shrubland) refers to shrub-dominated areas with scattered forbs and grasses. These habitats are typically the result of some disturbance and include dry shrublands, utility rights-of-way, old agriculture fields, and reverting gravel pits.

1.2 Justification

Shrublands and other woody early-successional habitats are declining in New Hampshire and throughout the Northeast (Trani et al. 2001, Brooks 2003), as are the associated wildlife species (Hunter et al. 2001, Litvaitis 2001, Dettmers 2003, Wagner et al. 2003). For example, nearly half of the 33 shrubland birds covered by Breeding Bird Survey routes in the Northeast have significantly declined in the last 35 years (Dettmers 2003). Partners in Flight (PIF), a cooperative bird conservation organization seeking to maintain populations of North American land birds, has identified the Northeast as being particularly important for maintaining source populations of shrubland birds (Dettmers 2003a, Dettmers 2003b). Since 1960, the distribution and abundance of New England cottontail has declined substantially throughout New England (Johnston 1972, Jackson 1973, Litvaitis 1993) and are being considered for listing under the federal Endangered Species Act (USFWS 2004). Additionally, 139 species of reptiles, amphibians, birds, and mammals either prefer (17 species) or utilize (122 species) shrub and old-field habitats (Scanlon 1992).

1.3 Protection and Regulatory Status

Shrubland habitats in general have no special regulatory status. Shrublands inhabited by state endangered or threatened species are protected under RSA 212 if habitat modification would affect the species.
Few natural resource protection programs focus on shrubland habitats.

1.4 Population and Habitat Distribution

It is difficult to determine the distribution of shrublands in New Hampshire because of limitations of remote sensing data (see section 1.8 for details). United States Forest Service's (USFS) Forest Inventory and Analysis (FIA) data indicate that from 1973 to 2002, the amount seedling/sapling forest declined 63% from nearly 449,000 hectares to just over 167,000 hectares. Seven counties experienced a 70 to 100% decline. Grafton County experienced a 55% decline. Coos County, where much of New Hampshire's industrial forests are located, experienced only a 12% decline .

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

Not completed for this habitat.

1.7 Sources of Information

Sources of information include journal articles, USFS FIA data, New Hampshire Landcover Assessment, 1998 aerial photos, and discussions with previous data users.

1.8 Extent and Quality of Data

Existing data sources are inadequate to map shrubland habitat to assess abundance and distribution in New Hampshire. FIA data include a series of nearly 400,000 field points on stand age, size, composition, ownership, etc. This information is useful in assessing wildlife habitat, assessing the sustainability of ecosystem management practices, and in making forest-planning decisions (USFS 2005). FIA data is more relevant to young forests than to shrubland habitats.

FIA plots classified as "non-stocked" (stocking of less than 10% of live trees) would ideally provide the best information on shrublands in New Hampshire (Frieswyk and Widman 2000). However, due to the sporadic and incomplete nature of data collection for this classification, the "non-stocked" classification was deemed unreliable (Carol Alerich, USFS-FIA program, personal communication) . The next best indicator of the decline of shrubland habitats in New Hampshire is the trend in the amount of forestland dominated by seedlings and saplings (these stand size classes are typically lumped together in the FIA data). Data for seedling/sapling forest is not available for 1948 or 1963 (Carol Alerich, USFS-FIA program, personal communication).

Even if satellite imagery were more current, satellites are typically poor at detecting differences in vegetation structure (i.e., height and size of vegetation) (Bergen et al. 2002). Aerial photographs can be used, but would be time consuming and cost prohibitive if done for a large area (Dan Sundquist, SPNHF, personal communication).

1.9 Distribution Research

A better means of mapping shrubland habitats is needed to assess the abundance and distribution of New Hampshire's shrublands. Two options are radar and lidar sensors that can measure vegetation height and can directly estimate other variables related to vegetation structure (Bergen et al. 1997, Bergen and Dobson 1999).

Element 2: Species/Habitat Condition

2.1 Scale

Counties will be used as the conservation-planning unit for this habitat because that is the scale at which most information exists and because most technical and financial assistance (from the USDA NRCS, UNH Cooperative Extension, and others) is provided to private landowners by county.

2.2 Relative Health of Populations

Data on the distribution and health of shrublands are severely lacking (see section 1.8). From 1973 to 2002, the amount of area in seedling/sapling forest declined 63% from nearly 449,000 hectares to just over 167,000 hectares. Seven counties experienced a 70 – 100% decline. Grafton County experienced a 55% decline. Coos county, where much of New Hampshire's industrial forests are located, experienced only a 12% decline .

It is difficult to ascertain the historic extent of shrublands in New Hampshire. Native Americans in coastal and inland river valleys used fire to create and maintain agricultural fields, improve hunting grounds, and maintain travel corridors, among other purposes (Day 1953, Harris 1972, Cronon 1983, Whitney 1994). Settlements often occurred on sandy, glacial outwash deposits of major river valleys where food was plentiful (Whitney 1994). Pitch pine-scrub oak barrens occur in these areas (Howard et al. 2005). The result of Native American burning was a mosaic of habitat types in different states of succession, likely including native scrub oak shrublands and heathlands.

Fire regimes may have greatly influenced vegetation patterns (Patterson and Sassaman 1988), though some researchers determined that the use of fire was location-specific and not as extensive as some suggest (Clark and Royall 1996, Parshall and Foster 2002). Parshall and Foster (2002) found that fires were more common over the last 300 years than in the preceding 1,500 years with a great portion of these fires occur-

ring during the early settlement period.

Historic accounts summarized in Askins (1997) indicate that beaver (*Castor canadensis*) activity also created open areas. After an abandoned beaver dam degrades and becomes breeched, the previously ponded area succeeds to a meadow dominated by sedges, grasses, and forbs and without further disturbance will succeed to shrubland. Beaver activity may influence 20-40 percent of the total length of second- to fifth-order streams (Naiman et al. 1988). One study in the Adirondack Mountains of New York found that beaver dams created patches of disturbance up to 12 ha in size (Remillard et al. 1987). Interestingly, an analysis of the current status of wet flats in New Hampshire (the flat floodplain area adjacent to streams and rivers that would be impacted by beavers) shows that nearly 30% (267 out of 961) of the wet flats 7 – 12 ha in size are impacted by agriculture and likely no longer serve as shrubland habitat. Another 17% (165 out of 961) are impacted by development (CSRC 2001, TNC 2003).

Weather-related disturbances such as wind and ice storms may infrequently create early-successional habitats. Hurricanes capable of causing extensive blowdown occur every 150 years on average in southeastern New Hampshire, every 380 years in central New Hampshire, and less than once every 380 years in northern New Hampshire (Boose et al. 2001). The January 1998 ice storm was a major weather event in New Hampshire's history causing significant damage to the forests of central and northern New Hampshire.

The amount of early-successional habitat increased dramatically after European settlement. Much land was cleared for farmland in the eighteenth and nineteenth centuries (Cronon 1983, Whitney 1994). However, cleared lands were abandoned in the mid-1800s for more productive farms in the Midwestern United States and the industrial cities of the Northeast. Many tracts of land that were cleared for agriculture reverted to second-growth forests and species associated with early-successional habitats abounded (Irland 1982, DeGraaf and Miller 1996, Foster et al. 2002, Litvaitis et al. 2005). Most of the abandoned farmlands matured into closed-canopy forests by 1960, causing shrubland species to decline (Litvaitis 1993). Today, given the lack of fires and the reduction in areas potentially impacted by beavers, coupled with effect of habitat fragmentation caused by development, the future health of shrubland wildlife depends on active management.

2.3 Population Management Status

2.4 Relative Quality of Habitat Patches

It is difficult to assess the quality of habitat patches without a suitable habitat map. In general, habitat patch quality depends on a number of factors including vegetation structure (e.g., stem density), habitat patch size, and degree of habitat fragmentation in the surrounding landscape.

Vegetation Structure: Vegetation structure is a key component of shrubland habitats. Vegetation structure requirements can differ among wildlife species. For instance, New England cottontails require stem densities approaching 10,000 stems/hectare (Litvaitis and Tash 2005). American woodcock are found in areas with an overstory canopy cover of 53-64% in diurnal sites and a shrub canopy cover of 75-87% (Dunford and Owen 1973, Morgenweck 1977). The vegetation structure requirements are not clear for the other species covered under this profile.

Habitat Patch Size: Habitat patch size is also an important component to consider when evaluating habitat patch quality. Golden-winged warblers occupy patches that are at least 10 hectares in size (Confer 1992). Litvaitis (1993) found that New England cottontail occupied patches in southeastern New Hampshire ranging from 0.2 to > 15 ha, but very small patches were inherently volatile (Barbour and Litvaitis 1993, Villafuerte et al. 1997). Volatility of small patches is largely related to the relative abundance of generalist predators (e.g., coyotes, foxes, raccoons, skunks) within the surrounding landscape that, in turn, depends on the degree of habitat fragmentation expressed in the landscape (Barbour and Litvaitis 1993, Brown and Litvaitis 1995, Oehler and Litvaitis 1996).

Habitat Fragmentation: Southeastern New Hampshire is undergoing rapid development (Sundquist and Stevens 1999). Generalist predator populations in fragmented landscapes tend to increase because of the readily available food sources (e.g., trash, crops, pet food, etc.) (Oehler and Litvaitis 1996). As suit-

able habitat patches become increasingly smaller, wildlife species attempting to utilize those patches become increasingly vulnerable to predation (Brown and Litvaitis 1995). As such, shrubland patches in the southern part of the state should be at least 5 hectares in size if managing for New England cottontails and at least 10 hectares if managing for golden-winged warblers.

2.5 Habitat Patch Protection Status

Since habitat patches were not identifiable, no information on habitat patch protection status can be generated.

2.6 Habitat Management Status

Financial & Technical Assistance Programs

The USDA's Environmental Quality Incentive Program (EQIP) offers financial and technical help to agricultural producers to install or implement structural and management practices on eligible agricultural land (NRCS 2005b). An EQIP Technical Committee in each state sets eligible habitat improvement practices. There are nearly 70 eligible practices in New Hampshire. These include such things and nutrient management and the installation of manure storage facilities to restoration of declining habitats. Eligible EQIP practices that would benefit shrubland habitat include brush management, hedgerow planting, prescribed grazing, restoration and management of declining habitats, and tree/shrub establishment, among others (New Hampshire NRCS 2005a). Statistics are currently unavailable to determine how many hectares have been treated with each of these practices. In 2005, New Hampshire received nearly $8 million for EQIP.

The USDA's Wildlife Habitat Incentives Program (WHIP) encourages the creation of high quality wildlife habitat on private land through technical and financial assistance (NRCS 2005c). Like EQIP, a WHIP Technical Committee in each state sets eligible habitat improvement practices. Like many states in the Northeast, New Hampshire's list of eligible practices include such things as brush management, early-successional habitat management/development, prescribed burning, tree/shrub planting, upland wildlife habitat management, and other practices applicable to shrubland habitats (New Hampshire NRCS 2005b). Statistics are currently unavailable to determine how many hectares have been treated with each of these practices. In 2005, New Hampshire received over $1,000,000 for WHIP.

Since 1990, the USFWS' Partners Program has provided technical and financial assistance to landowners, state agencies, organizations, and individuals to restore fish and wildlife habitat such as coastal wetlands, riparian habitats, and grasslands (USFWS 2001). Since its inception, the Partners Program has restored over 40.5 hectares of upland habitat in New Hampshire (USFWS 2001). It is unknown how many hectares specifically pertain to shrubland habitats.

NHFG administers the Small Grants Program, which was established to fund small-scale habitat restoration and enhancement projects on privately owned lands. Up to $50,000 per year is committed to the Small Grants Program. The funds are obtained via a $2.50 habitat fee required of all who purchase a New Hampshire hunting license. A number of Small Grant practices apply to shrubland habitats. These include release of apple trees, release of fruiting shrubs, mowing to maintain grasslands and shrublands, regeneration or restoration of alder or aspen/birch, and brush clearing/sapling removal to maintain old fields and shrublands. Since 2000, nearly 2,500 apple trees have been released, 14 hectares of fruiting shrubs have been released, 400 ha of grasslands or shrublands have been mowed, 20 ha have had alder or aspen/birch regenerated, and 438 ha of old fields have been maintained, (NHFG unpublished data).

UNH Cooperative Extension specialists and county-based educators in the Forestry and Wildlife Program also provide technical assistance to landowners on wildlife habitat management issues.

Management on State Lands

The NHFG owns in fee-simple or under conservation easement just over 334 ha of fields (NHFG unpublished data). Of these, 173 ha are maintained in active agriculture (either hay or cropland). The remainder is maintained by mowing occurring every 1-3 years after the bird nesting season. All of the fields under NHFG management should be evaluated to determine which ones would be more suited for shrubland habitat management rather than grassland management.

DRED owns in fee-simple or under conserva-

tion easement approximately 543 ha of fields and shrubland openings (DRED unpublished data). Forty hectares are maintained in active agriculture (either hay or cropland), 137 ha are maintained via mowing by State Parks or NHFG personnel, and the remainder is not maintained on a regular basis. The NHFG State Lands Biologist will be working with DRED to evaluate the fields under DRED management to determine which ones would be more suited for shrubland habitat management and to develop a management strategy.

Management on Other Lands
All other shrubland habitats occur on federal lands (e.g., WMNF, Umbagog National Wildlife Refuge, Great Bay National Wildlife Refuge, Pondicherry National Wildlife Refuge, and others), private land, and to a much lesser extent land of private land trusts, municipalities, and other conservation organizations/agencies. It is not known to what extent shrubland habitats are maintained on these lands.

2.7 Sources of Information

Sources of information for element 2 include journal articles, websites, GIS data, and white papers.

2.8 Extent and Quality of Data

It is difficult to assess the distribution and condition of shrublands without an adequate habitat map. The habitat requirements of some shrubland dependent wildlife are lacking.

2.9 Condition Assessment Research

- Determine specific habitat needs of shrubland dependent wildlife (e.g., vegetation structure and habitat patch size).
- Develop an adequate early-successional habitat map to identify and prioritize habitat management opportunities.

Element 3: Species and Habitat Threat Assessment

3.1.1 Altered Natural Disturbance (Natural Succession)

(A) Exposure Pathway
Shrubland-dependent vertebrate wildlife species require dense understory cover; their occurrence is influenced more by the height and density of vegetation than by specific plant communities (Litvaitis 2003). New England cottontail, woodcock, ruffed grouse, eastern towhee, and other shrubland species shift in space and time in response to natural succession, disturbance, and human land uses (Litvaitis 2005). As more open land is converted to development there is less overall space for shrubland-dependent species to shift into when natural forest succession or lack of active management makes their current habitat patch unsuitable.

(B) Evidence
Although over 80% of New Hampshire is reforested, second growth forests lack the structural diversity present in virgin forests. Forest maturation, coupled with suppression of natural disturbance (e.g., fire) has reduced the amount of early successional conditions (Litvaitis 2003). Concurrently, shrublands are being developed for residential and commercial purposes. Thus, early successional habitat is at or below historical levels (Brooks 2003). Human created shrublands (e.g., old fields, reverting gravel pits, rights-of-way) have increased in importance to shrubland-dependent wildlife. These human created shrublands tend to be ephemeral and require natural or human disturbance to retain their characteristics (Brooks 2003).

3.1.2 Development (Fragmentation, Habitat Loss and Conversion)

(A) Exposure Pathway
Direct loss of shrubland habitat occurs through the conversion of these lands for residential, industrial, and commercial purposes. Development patterns lead to fragmentation of remaining undeveloped habitats, creating smaller patches that may not sustain wildlife populations and promoting generalist predators that prey on shrub-dependent wildlife (Barbour and Litvaitis 1993, Litvaitis 2005).

(B) Evidence
In eastern North America over the last 60 years, open habitats (grasslands, savanna, barrens, and shrublands) have declined by 98%, with shrubland communities comprising 24% of this decline (Tefft 2005). New Hampshire's population grew by 17.2% from 1990 to 2004--the fastest growing state in the Northeast for the past four decades. New Hampshire has lost more than 17,000 acres of open space to development each year in the past five years (Society for the Protection of New Hampshire Forests, unpublished report).

The amount of shrubland habitat of functional quality for wildlife may now be falling below historic levels as current landscape conditions are strikingly different than in pre-settlement times (Brooks 2003). Habitat loss and fragmentation of remaining habitat is causing shrubland species to decline (Litvaitis 2005), especially New England cottontail, American woodcock, eastern towhee, golden-winged warbler, black racer, and smooth green snake since their populations are embedded in a rapidly developing landscape (Society for the Protection of New Hampshire Forests, unpublished report). Increases in generalist predators may reduce or even eliminate small populations of prey species like New England cottontails and some songbirds.

3.1.3 Recreation (Off Road Vehicles)

(A) Exposure Pathway
Two and four wheeled all-terrain vehicles (ATVs) can have direct and indirect impacts on shrubland habitat and associated wildlife. Although by state law ATVs are not allowed on private land without permission or public roads, there is overwhelming anecdotal evidence of ATVs crossing lands without permission. Direct impacts include trampling vegetation by riding through and over shrubs. Indirect effects include the introduction of invasive species (carried inadvertently on the vehicle), excessive noise disturbance, and compaction and rutting of soil. These direct and indirect effects can degrade habitat quality for shrub dependent wildlife.

(B) Evidence
ATVs are registered through NHFG, which reported that ATV registrations doubled from 1998 to 2001 (from 9,452 to 18,001 ATVs). This increase follows a national trend with a concomitant increase in concerns about negative impacts to soils, water, wildlife, and habitats. In April 2003, the USFS Chief Dale Bosworth identified unmanaged off-road vehicle use as one of the four greatest threats to the National Forests, along with fire, the spread of invasive species, and habitat fragmentation. Bosworth particularly noted the unplanned ATV tracks crisscrossing many forests. In New Hampshire, conflicts have arisen around ATV use at Pisgah State Park, Nash Stream, and on other public lands. Private landowners, including tree farmers, are raising concerns about detrimental effects by ATV riders on their lands. A report by the Montana Chapter of The Wildlife Society documents the direct and indirect effects of recreation, including off-highway vehicles, on wildlife and their habitats (Joslin and Youmanns 1999).

3.2 Sources of Information

Sources of information on threats to shrub-dominated early successional habitat included peer-reviewed scientific papers, GIS-analysis in reports by New Hampshire organizations, agricultural statistics from the USDA website, and gray literature.

3.3 Extent and Quality of Data

The decline in shrubland and other early successional habitats and their associated wildlife species is well documented. The effects of development that lead to fragmentation and the increase in generalist predators (e.g., coyote, fox, raccoon) are well documented. The impacts of ATV's on shrublands needs further study.

3.4 Threat Assessment Research

Studies are needed to determine the impacts of ATVs on wildlife and their habitats in New Hampshire.

Element 4: Conservation Actions

4.1.1 Habitat Conservation, Habitat Protection Direct Threats: Development

(B) Justification
The loss of open space in New Hampshire is a major threat to shrubland habitats. Permanently protecting shrublands that harbor species of concern (e.g., New England cottontail) through fee simple acquisitions

or conservation easements may be required to protect and manage species. Land conservation measures will provide an opportunity to manage ephemeral shrublands. Given the pace of development and loss of open space in New Hampshire, this conservation action should receive priority. Once lands are permanently protected the decision cannot be reversed, however management decisions to benefit priority wildlife species can be adapted to changing information and site conditions.

(C) Conservation Performance Objective
The conservation objective is to permanently protect, through fee simple acquisition or conservation easements, shrub-dominated early successional habitat that support populations of declining species including New England cottontail, American woodcock, and eastern towhee.

(D) Performance Monitoring
The measurable component is the acres of shrubland that support priority wildlife species that are permanently protected.

(E) Ecological Response Objective
The ecological objective is to ensure that populations of New England cottontails and other priority wildlife successfully reproduce in these permanently protected shrublands.

(F) Response Monitoring
Populations of New England cottontails and other key species in the protected shrublands should be monitored to determine their reproductive success and to determine if additional shrublands need permanent protection to sustain the populations statewide.

(G) Implementation
This conservation action requires the development of an adequate statewide habitat map to determine which shrublands are most significant for New England cottontail and other wildlife and that would benefit from permanent protection. This should include an assessment of which shrublands are best protected through fee simple acquisition and which shrublands can be adequately protected through conservation easements. The latter approach requires a conservation easement that incorporates the management strategies for maintaining shrubland conditions such as mowing, cutting, prescribed fire, or grazing. These actions may be more easily incorporated into conservation easements for lands owned by conservation organizations rather than individual private landowners.

(H) Feasibility
The ephemeral nature of shrubland habitats makes it more difficult to identify priorities for permanent protection. The best approach may be to identify known areas of importance to New England cottontail, American woodcock, and other priority species and focus on conserving these core areas. Land conservation partners (e.g., land trusts) can be engaged to contact landowners with priority shrublands to assess their interest in selling their land or placing a conservation easement on their land. The Farmland Protection Program and North American Wetlands Conservation Act (NAWCA) may be more applicable for grassland conservation. The New Hampshire Land and Community Heritage Investment Program is a critical resource (if new funds become available). Permanent land conservation is typically more expensive than other conservation measures (such as encouraging shrubland management among private landowners).

4.1.2 Vegetation Management, Restoration, and Management

Direct Threat: Altered Natural Disturbance (Natural Succession)

(B) Justification
Since shrubland habitats are relatively short lived, periodic management is needed to maintain the dense habitat structure. Relatively stable shrublands require monitoring and selective removal of small trees that invade the area (e.g., every 5 years). Reclamation of old fields, pastures, or gravel pits that have succeeded to second growth forest will initially require aggressive clearing. Once shrublands become well established, they may require only periodic mowing or cutting, every 5 to 10 years or more (Tefft 2005).

Creating small patches of shrub-dominated early-successional habitats in New Hampshire's highly developed landscapes may not prove effective since predation pressure is often intense in small patches and surrounding land uses may create migration barriers.

Therefore, positioning managed habitats near existing patches of shrubland, wetland, or a beaver flowage would create larger patches of suitable habitat. The establishment and maintenance of some moderate (>10 acres) to large-size (>25 acres) patches of early-successional habitat can serve as core habitats within human-dominated landscapes (Litvaitis 2005).

Utility rights-of-way (e.g., power line corridors), offer another opportunity to create a larger mosaic of shrub-dominated early successional habitat. Recent research in southern New York has shown that power line corridors can be very productive habitat for a number of songbirds that nest in shrubby habitats. However, these linear habitats may not be suitable for other species affiliated with shrublands. New England cottontails, for example, are not found along corridors, possibly because raptors perched on utility poles are very efficient predators. Therefore, positioning several acres of managed early-successional habitat near a power line corridor could improve the suitability of corridors for cottontails and other species that may be vulnerable to predation. Placing managed habitats near utility corridors may also increase the ability of animals to move across a landscape by using the utility corridor as a dispersal route (Litvaitis 2005).

(C) Conservation Performance Objective
The conservation objective is to identify core areas of shrubland habitats in the state and apply vegetation management to maintain these habitats in a shrub-dominated early successional condition.

(D) Performance Monitoring
The measurable component is the number and acreage of core areas managed as shrub-dominated early successional habitat.

(E) Ecological Response Objective
The ecological objective is to increase the amount of functional shrub-dominated early successional habitat that supports reproducing populations of New England cottontails, woodcock, and other habitat associates.

(F) Response Monitoring
A suggested monitoring approach is to monitor the populations of key species (e.g., New England cottontail, American woodcock, eastern towhee) within the core shrubland habitats.

(G) Implementation
The core shrub-dominated early successional areas in the State need to be identified. If in public ownership, then land managers can manage the habitat. If core areas are on private lands, then an outreach program is needed to interest landowners in managing shrubland habitats. The NHFG Small Grants Program is important in reimbursing landowners for this type of management since there is typically no economic return from shrubland management. Relevant Farm Bill conservation programs should also take into consideration priority species and focus areas for shrubland habitat management. UNH Cooperative Extension and the NH Coverts Program have an extensive network of landowners interested in wildlife and could be valuable partners in identifying and maintaining core shrubland habitats as well as connectivity between habitat patches.

(H) Feasibility
NHFG can work with its state and federal partners to identify the most important shrub-dominated early successional habitats on state and federally owned lands. These shrubland habitats may be near extensive grassland habitats and could be managed collectively. Private landowners may be unwilling or unable (because of cost) to manage large shrubland areas so cost-share and grant programs are extremely important to achieving this conservation objective. The WHIP program and NHFG small grants program could support landowner involvement in managing shrubland habitats.

ATV Rider Education and Enforcement
Refer to the general recreation strategy.

4.2 Conservation Action Research

An important step in maintaining shrub-dominated early successional habitat is to identify the known core areas of this habitat type on public land. If public lands lack sufficient shrubland habitat to sustain the associated wildlife species of concern than analysis of private lands is needed to identify additional potential core areas. This includes an analysis of which lands may require permanent protection through fee simple or conservation easements assuming landowners are interested.

Element 5: References

5.1 Literature

Barbour, M.S., and J.A. Litvaitis. 1993. Niche dimensions of New England cottontails in relation to habitat patch size. Oecologia 95:321-327.

Bergen, K.M., D.G. Brown, M.C. Dobson, and E. Gustafson. 2002. Integrating Radar Remote Sensing of Forested Habitat Structure: A Pilot Project for Biodiversity Informatics. Pages 149-154 in *Proceedings, National Science Foundation National Conference on Digital Government Research*, Los Angeles, California.

Bergen, K.M. and M.C. Dobson. 1999. Integration of remotely sensed radar imagery in modeling and mapping of forest biomass and net primary production. Ecological Modelling 122: 257-274.

Bergen, K.M., M.C. Dobson, L.E. Pierce. 1997. Effects of within-season dielectric variations on terrain classification using SIR-C/X-SAR. Proceedings of the International Geoscience Remote Sensing Symposium, Singapore, China.

Brooks, R.T. 2003. Abundance, distribution, trends, and ownership patterns of early-successional forests in the northeastern United States. Forest Ecology & Management 185:65-74.

Brown, A.L., and J.A. Litvaitis. 1995. Habitat features associated with predation of New England cottontails: what scale is appropriate? Canadian Journal of Zoology 73:1005-1011.

Complex Systems Research Center. 2002. Landcover Assessment - 2001. University of New Hampshire, Durham. http://www.granit.sr.unh.edu/data/datacat/pages/nhlc01.pdf. Accessed 8 February 2002.

Confer, J.C. 1992. Golden-winged warbler, *Vermivora chrysoptera*. Pp. 369-383 in K.J. Schneider and D.M. Pence, editors. Migratory nongame birds of management concern in the Northeast. U.S. Fish & Wildlife Service, Newton Corner, Massachusetts, USA.

Cronan, W. 1983. Changes in the land: Indians, colonists, and ecology of New England. Hill and Wang, New York, New York.

Day, G. 1953. The Indian as ecological factor in the northeastern forests. Ecology 34:329-346.

DeGraaf, R.M., and R.I. Miller. 1996. The importance of disturbance and land-use history in New England: implications for forested landscapes and wildlife conservation. Pages 3-25 *in* R.M. DeGraaf and R.I. Miller, editors. Conservation of faunal diversity in forested landscapes. Chapman and Hall, London.

Dettmers, R. 2003a. Status and conservation of shrubland birds in the northeastern US. Forest Ecology & Management 185:81-93.

Dettmers, R. 2003b. DRAFT: Blueprint for the design and delivery of bird conservation in the Atlantic northern forest. U.S. Fish & Wildlife Service. 289pp.

Dunford, R.D., and R.B. Owen, Jr. 1973. Summer behavior of immature radio-equipped woodcock in central Maine. Journal of Wildlife Management 37: 462-469.

Foster, D.R., G. Motzkin, D. Bernardos, and J. Cardoza. 2002. Wildlife dynamics in the changing New England landscape. Journal of Biogeography 29:1337-1358

Howard, L.F., J.A. Litvaitis, T.D. Lee, and M.J. Ducey. 2005. Reconciling the Effects of Historic Land Use and Disturbance on Conservation of Biodiversity in Managed Forests in the Northeastern United States: part 1—pine barrens. National Commission on Science for Sustainable Forestry. Washington, DC.

Hunter, W.C., D.A. Buehler, R.A. Canterbury, J.L. Confer, and P.A. Hamel. 2001. Conservation of disturbance-dependent birds in eastern North America. Wildlife Society Bulletin 29:440-455.

Irland, L.C. 1982. Wildlands and woodlots – a story of New England's forests. University Press of New England, Hanover, New Hampshire, USA.

Jackson, S.N. 1973. Distribution of cottontail rabbits (*Sylvilagus* spp.) in northern New England. M.S. Thesis, University of Connecticut, Storrs.

Johnston, J.E. 1972. Identification and distribution of cottontail rabbits in southern New England. M.S. Thesis, University of Connecticut, Storrs.

Joslin, G., and H. Youmans, coordinators. 1999. Effects of recreation on Rocky Mountain wildlife: a review for Montana. Committee on Effects of Recreation on Wildlife, Montana Chapter of The Wildlife Society.

Kingsley, N.P. 1976. The forest resources of New Hampshire. U.S. Forest Service Resource Bulletin NE-43, Northeast Forest Experimental Station, Upper Darby, PA. 71 pp.

Latham, R.E. 2003. Shrubland longevity and rare plant species in the northeastern United States. Forest Ecology and Management 185:21-39.

Litvaitis, J.A., M.S. Barbour, A.L. Brown, A.I. Kovach, J.D. Oehler, B.L. Probert, D.F. Smith, J.P. Tash, R. Villafuerte, and M.K. Litvaitis. 2005*a*. Testing multiple hypotheses to identify the causes of the range-wide decline of New England cottontails. In review for forthcoming book, Biology of lagomorphs - evolution, ecology and conservation. P. Alves and K. Hackländer, editors.

Litvaitis, J.A. 2001. Importance of early-successional habitats to mammals in eastern forests. Wildlife Society Bulletin 29:466-473.

Litvaitis, J.A. 1993. Response of early successional vertebrates to historic changes in land use. Conservation Biology 7:866-873.

Ludlum, D. 1976. The Country Journal: New England weather book. Houghton Mifflin: Boston, Massachusetts, USA.

Miles, P.D. Dec-23-2004. Forest inventory mapmaker web-application version 1.7. U.S. Department of Agriculture, Forest Service, North Central Research Station, St. Paul, MN. [Available only on internet: www.ncrs2.fs.fed.us/4801/fiadb/index.htm]

Morganweck, R.O. 1977. Diurnal high use areas of hatching-year female American woodcock. Pp. 155-160 *in* D.M. Keppie and R.B. Owen, Jr. editors. Proceedings of Sixth Woodcock Symposium, New Brunswick Departent of Natural Resources, Fredericton, New Brunswick.

Oehler, J.D., and J.A. Litvaitis. 1996. The role of spatial scale in understanding responses by medium-sized carnivores to forest fragmentation. Canadian Journal of Zoology 74: 2070-2079.

Patterson, W.A. III, and K.E. Sassaman. 1988. Indian fires in the prehistory of New England. Pages 107-135 *in* G.P. Nichols, editor. Holocene human ecology in northeastern North America. Plenum Publishing Corporation, New York, New York.

Scanlon, J.J. 1992. Managing forests to enhance wildlife diversity in Massachusetts. Northeast Wildlife Vol. 42.

Sundquist, D., and M. Stevens. 1999. New Hampshire's changing landscape: population growth, land conversion and resource fragmentation in the Granite State. The Society for Protection of New Hampshire Forests, Concord, New Hampshire, USA.

Tefft, B.C. 2005 (in prep.) Shrublands and old fields. *In* A guide to managing grasslands, shrublands, and young forest habitats in the northeast. Oehler, J.D. and D.F. Covell, eds. Northeast Upland Habitat Technical Committee and Massachusetts Division of Fisheries & Wildlife.

The Nature Conservancy. 2003. Ecological landunit data layer. Conservation Science Support Program, Eastern Resource Office of The Nature Conservancy, Boston, Massachusetts.

Trani, M.K., R.T. Brooks, T.L. Schnmidt, V.A. Rudis, and C.M. Gabbard. 2001. Patterns and trends or early-successsional forests in the eastern United States. Wildlife Society Bulletin 29:413-424.

United State Fish & Wildlife Service. 2004. Endangered and threatened wildlife and plants; 90-day finding on a petition to list the New England cottontail as threatened or endangered. Federal Register 69: 39395-39400. http://www.epa.gov/fedrgstr/EPA-SPECIES/2004/June/Day-30/e14610.htm.

United States Forest Service. 2005. Program structure for forest inventory and monitoring: FIA fact sheet series. United States Department of Agriculture. 2pp. http://fia.fs.fed.us/library/fact-sheets/overview/Pgm_Structure_FS.pdf.

Villafuerte R., J.A. Litvaitis, and D.F. Smith. 1997. Physiological responses by lagomorphs to resource limitations imposed by habitat fragmentation: implications to condition-sensitive predation. Canadian Journal of Zoology 75:148-151.

Wagner, D.L., M.W. Nelson, and D.F. Schweitzer. 2003. Shrubland lepidoptera of southern New England and southeastern New York: ecology, conservation, and management. Forest Ecology & Management 185:95-112.

Whitney, G. 1994. From coastal wilderness to fruited plain: a history of environmental change in temperate North America from 1500 to present. Cambridge University Press, Cambridge, Massachusetts.

Zielinski, G.A. 1998. Extreme Climatic Events in New England History. In New England's changing climate, weather, and air quality. Climate Change Research Center, University of New Hampshire. http://www.neci.sr.unh.edu/neccwaq.html#5

HABITAT PROFILE

Talus Slopes and Rocky Ridges

Associated Species: Melissa arctic (Oeneis melissa), Timber Rattlesnake (Crotalus horridus), Peregrine Falcon (Falco peregrinus), and Bobcat (Lynx rufus).
Global Rank: Not ranked
State Rank: (affected natural communities)
TALUS SLOPES: Rich Appalachian oak rocky woods (S1), Subalpine cold-air talus barren (S1), Red oak - hickory wooded talus (S1S2), Red oak - ironwood - Pennsylvania sedge woodland (S2), Rich red oak rocky woods (S2S3), Semi-rich Appalachian oak - sugar maple forest (S2S3), Temperate lichen talus barren (S2S3), Montane lichen talus barren (S3), Spruce - birch - mountain maple wooded talus (S3), Montane landslide (S3S4), Red oak - black birch wooded talus (S3S4)
ROCKY RIDGES: Circumneutral rocky ridge (S1), Chestnut oak forest/woodland (S1S2), Montane heath woodland (S2), Jack pine rocky ridge woodland (S1), Red pine rocky ridge (S2), Red oak - ironwood - Pennsylvania sedge woodland (S2), Appalachian oak - pine rocky ridge (S3), Red oak - pine rocky ridge (S3S4), Red spruce - heath - cinquefoil rocky ridge (S3S4)
Authors: Benjamin D. Kimball and Steven G. Fuller, Natural Heritage Inventory and New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

This profile covers two related but distinct habitats: talus slopes and rocky ridges. Talus slopes range from open, lichen covered talus "barrens" to closed-canopy forested talus communities (Sperduto and Nichols 2004). Rocky ridges generally occur on outcrops and shallow-to-bedrock ridge and summit settings (Sperduto and Nichols 2004). While it is opportune to lump them together for the purposes of habitat modeling, each is treated separately in certain text portions of this profile.

Talus Slopes

Both forested and unforested talus slopes commonly occur below steep mountain slopes and cliffs, usually as a result of mass wasting of the cliff above. The boulders and other component rock material can be stabilized or loose. Some plant species and natural communities are associated with the conditions of talus slopes (Kruckberg 2002). Four talus slope natural community systems occur in New Hampshire: montane acidic talus, temperate acidic talus, rich north-temperate talus/rocky woods, and rich Appalachian oak rocky woods (Sperduto 2004). These systems are distinguished from each other primarily by climate, elevation, and level of enrichment (nutrient availability).

Montane acidic talus slopes are found at mid to high elevations in the White Mountains and are characterized by spruce, fir, and various other northern species. This system tends to have an open woodland character, with frequent canopy gaps and lichen-dominated talus barren openings. Soil development is variable on these slopes, and moisture conditions range from dry to mesic. Larger examples have giant talus blocks at their base with late-melting ice that produces a cold, moist microclimate supporting alpine plants well below treeline. This system mostly occurs above 670 m (2,200 ft) in elevation, but occasionally down to about 450 m (1,500 ft). This system includes a few low-elevation "talus gorges" such as Ice Gulch and Devil's Hopyard. Montane acidic talus slopes are often found below montane cliff systems, and surrounded by either northern hardwood or high-elevation spruce–fir forests.

Temperate acidic talus slopes are found at low

elevations (below 550 m [1,800 ft] elevation) in central and southern New Hampshire characterized by oaks (*Quercus* spp.), black birch (*Betula lenta*), and other temperate species. This system tends to have an open woodland character, with frequent canopy gaps and occasional lichen-dominated talus barren openings. Soil development is variable on these slopes, and moisture conditions range from dry to mesic. Most examples are smaller than montane acidic talus systems. A few temperate acidic talus slopes in the state have giant talus blocks with late-melting ice that produces a relatively cold, moist microclimate compared to the rest of the talus slope. These areas support patches of montane species such as red spruce (*Picea rubens*) and American mountain ash (*Sorbus americana*) within the larger temperate mosaic. This system transitions to forested talus or forested till areas characterized by hemlock–hardwood–pine forest or oak–pine forest systems. Temperate cliff systems, and sometimes, Appalachian oak rocky ridges, are often associated upslope.

Rich north-temperate talus/rocky woods system is found on enriched talus and other rocky slopes in central New Hampshire from about 150–365 m (500 - 1,200 ft) in elevation, and occasionally up to about 600 m (2,000 ft) in the low elevation valleys in the White Mountain region. The larger talus slopes often have patches of temperate lichen talus barren, and occasionally patches of rich mesic or semi-rich mesic sugar maple forest communities in mesic, colluvial areas at the base of the talus slopes. A few examples at intermediate elevations in the White Mountains (around 450 m [1,500 ft]) include patches of spruce-birch-mountain maple wooded talus, which is otherwise indicative of montane acidic talus systems. Tree canopy dominants usually include sugar maple (*Acer saccharum*) and red oak (*Quercus rubra*), with lesser amounts of basswood (*Tilia americana*), white ash (*Fraxinus americana*), ironwood (*Carpinus caroliniana*), black birch (*Betula lenta*), red maple (*Acer rubrum*), and occasionally yellow birch (*Betula allegheniensis*) and paper birch (*Betula papyrifera*). Softwoods are sparse or absent. This system often transitions to montane rocky ridge and montane cliff systems upslope and northern hardwood–conifer forest or hemlock–hardwood–pine forest systems downslope.

Rich Appalachian oak rocky woods system is the southern equivalent of rich north-temperate talus/rocky woods system (see above). It occurs on rocky to shallow till hillsides mostly below 150 m (500 ft) within 48 km [30 mi] of the coast or Massachusetts border. It is indicated by a host of southern plants that do not occur further north or at higher elevations. There are 2 primary natural communities, rich Appalachian oak rocky woods, and red oak-ironwood-Pennsylvania sedge woodland. Temperate lichen talus barrens are small and rare in this system, as are patches of rich mesic forest. This system typically transitions to more nutrient-poor, rocky conditions on the ridge tops classified as Appalachian oak rocky ridge system, but occasionally they occupy the ridge top settings as well where the red oak-ironwood-Pennsylvania sedge woodland community dominates. The hillsides on which this system occurs includes talus, other unconsolidated, loose rocky slopes, and relatively shallow till soils with occasional outcrops.

Rocky Ridges

Rocky ridges occur on outcrops and shallow-to-bedrock ridge and summit settings below those that are classified as alpine habitat (Sperduto and Nichols 2004). There are two major rocky ridge natural community systems in New Hampshire: montane rocky ridge system and Appalachian oak rocky ridge system. The primary differences between these 2 systems are climate and elevation, and because of this, they have distinctly different geographic distributions in New Hampshire (D. D. Sperduto, NHNHB, personal communication).

Montane rocky ridges occur on outcrops and shallow-to-bedrock ridges and summits at mid-elevations in New Hampshire. They are dominated by some combination of red spruce (*Picea rubens*), red pine (*Pinus resinosa*), and red oak. Outcrops include cliff slabs, which are steep bedrock exposures of < 65° slope. This system includes nearly all the rocky ridges in the White Mountain region and other rocky exposure between 400-900 m (1300–3000 ft) in elevation elsewhere in the state. These rocky ridges, summits, and slabs have a woodland to sparse woodland canopy structure (ranging from completely open patches to thin forest cover > 65%), much open bedrock exposure, and one or more of the three primary diagnostic communities that overlap in their elevation ranges. Small cliffs are found in some examples of this system. Downslope, this system sometimes transitions to montane cliff, montane acidic talus,

or rich north-temperate talus/rocky slope systems. Upslope (when it exists), this system becomes subalpine heath–krummholz/rocky bald, northern hardwood–conifer, or high-elevation spruce–fir–northern hardwood forest systems.

Appalachian oak rocky ridges occur on outcrops and shallow-to-bedrock ridges and summits below 356 m [1,200 ft]) in southern New Hampshire. They are dominated by southern oaks and pines with little if any red spruce, red pine, and other northern plants diagnostic of montane rocky ridge and slab systems. Outcrops include small cliff slabs, which are steep bedrock exposures of < 65° slope. This system includes nearly all the rocky ridges in southern New Hampshire and most other ledges below 300m (1,000 ft) in elevation. These ridges, summits, and slabs typically have a woodland to sparse woodland canopy (ranging from completely open patches to thin forest cover >65%) and much open bedrock exposure. Red oak is typically present, but the presence of other oaks is the key diagnostic feature of this system (in combination with the absence of red spruce and red pine and other northern plants in any abundance). This system typically transitions to oak–pine forest systems, though rich Appalachian oak rocky woods are occasionally found below it on mid- to lower-slope positions.

1.2 Justification

Talus slope and rocky ridge habitat is uncommon throughout the Northeast, occurring mostly in isolated patches near cliffs and on the tops of low mountains and hills. Due to their scenic views, rocky ridges are recreational destinations, and thus the potential for recreational impacts to the habitat is high. As in alpine habitat, soil depth is shallow and therefore the vegetation is highly susceptible to trampling (D. D. Sperduto, NHNHB, personal communication). Multiple instances of damage and threats to rare plant populations and exemplary natural community occurrences in rocky ridge settings have been documented (NHNHB 2005). Rock outcrops in intensively managed forests have been shown to serve as important biodiversity refugia for some bryophyte species (Pykala 2004), and therefore presumably for related invertebrates and other wildlife species that use this habitat.

Due to the inaccessible nature of talus slopes, human impacts exist primarily on the rocky ridge portion of this habitat, though some bootleg trails and other impacts are found on talus. For example, rock-climbing activity, in particular, has been found to decrease plant diversity and gastropod species richness, density, and diversity on the talus at the base of cliffs with climbing routes (McMillan and Larson 2002, McMillan et. al. 2003). Talus slopes have a distinct habitat compared to cliffs (Kubesova and Chytry 2005) and therefore deserve separate treatment in conservation plans. Talus slopes and rocky ridges provide crucial habitat for several rare wildlife species in New Hampshire, including timber rattlesnake and bobcat.

1.3 Protection and Regulatory Status

Very little of New Hampshire's talus slope and rocky ridge habitat is protected by laws, rules, or regulations. A notable exception, however, is within the boundaries of the WMNF where many of New Hampshire's larger examples or groupings of talus slopes and rocky ridges occur and where several forms of protection apply. In the 2004 revised management plan (draft) for the WMNF, special protection is afforded specifically to "the rarest exemplary natural communities," including all exemplary cliff and talus slope communities (US Forest Service 2004). The WMNF is part of the National Wilderness Preservation System (16 U.S.C. 1131-1136, 78 Stat. 890). Some of these habitat areas occur within federally owned areas designated by Congress as "Wilderness Areas." There are currently 4 Wilderness Areas in the WMNF (Great Gulf, Presidential-Dry River, Pemigewasset, and Sandwich) containing talus slope and rocky ridge habitat. Management practices and recreational impacts are tightly restricted in these areas.

1.4 Population and Habitat Distribution

In New Hampshire, known and predicted (within the limitations of Geographic Information Systems [GIS] modeling) talus slope and rocky ridge habitat occupies 0.47% (11,269 ha [27,826 ac]) of the state. There is no particular locus of concentration, with isolated polygons and clusters of polygons occurring throughout the state. However, this habitat by definition does occur more frequently in the mountains and regions with steep hilly slopes, such as the White Mountains, hilly ridges in the central and western

parts of the state, and discreet mountain areas such as Pawtuckaway State Park and the Ossipee Mountain Range.

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

The definition of talus slope and rocky ridge habitat used in this analysis was a combination of areas occurring on outcrops and shallow-to-bedrock ridge and summit settings, and slopes with large, often lichen covered rocks with little or no soil accumulation. Talus slope and rocky ridge habitat areas were identified by modeling shallow-to-bedrock polygons from soils data layers as well as the NHNHB data depicting exemplary natural communities and systems for this habitat type. At its upper elevation limits, around 1,160-1,220 m (3,800-4,000 ft), this habitat transitions to alpine habitat. Smaller occurrences at this elevation may be considered inclusions within high-elevation spruce–fir forest.

1.7 Sources of Information

Current distribution, historic distribution, and status information of talus slope and rocky ridge habitat is primarily found in records of rare plant and exemplary natural community and system locations in the NHNHB database (Biotics). Habitat maps were generated using State Soil Geographic (STATSGO) soil layers and NHNHB exemplary talus slope and rocky ridge natural community and system occurrences. Other data sources consulted include state and federal agency web sites, information from the NHNHB database, consultations with experts, and textbooks and peer-reviewed literature.

1.8 Extent and Quality of Data

Lack of soils data for portions of the WMNF, Belknap and Merrimack Counties, and eastern Hillsboro County present a significant challenge in predicting talus slope and rocky ridge habitat occurrences in New Hampshire. Several known examples of this habitat that are not included in the model as a result of this limitation include the summit of Mount Kearsarge in Warner, Ragged Mountain in Danbury, and summits in the Belknap Range in Gilford and Alton.

The vegetation and biota of New Hampshire's talus slopes and rocky ridges has received relatively little research attention in comparison to alpine habitats. Very little is known about fauna and their distribution in these habitats.

1.9 Distribution Research

Habitat mapping could be improved by further refining the habitat definition and separating talus slopes from rocky ridges and treating the two as distinct and unique habitat types. This could happen as new and updated GIS layers (e.g., new county soils layers and new exemplary natural community/system polygons) become available. In addition, NHNHB continues to add and refine exemplary natural community and system polygons for this habitat, and these updates should be included in future iterations of the model. Lastly, the elevation boundary between alpine habitat and talus slope and rocky ridge habitat could be further investigated and improved upon in the model. This could result in areas such as the boulder fields in several ravines in the Presidential Range to be predicted polygons for this habitat type (these are too low for alpine and too large to be considered an inclusion in the surrounding forest).

Field verification of predicted polygons for this habitat type would help refine attribute parameters of the model. As noted in the metadata for this habitat's coverage, limitations of the soils data layer lend to errors of omission or commission, and field truthing will need to take place to better ascertain levels of error. This is especially recommended in the southeastern part of the state, where, for example, the town of Windham seems to contain an abnormally large concentration of predicted polygons for this habitat.

Inventory studies are needed to better understand the makeup and distributions of plant and animal populations on talus slopes and rocky ridges in New Hampshire. Research should include inventories of rare wildlife in these habitats.

Element 2: Species/Habitat Condition

2.1 Scale

To facilitate conservation planning, talus slope and rocky ridge habitat polygons (both known and predicted) derived from the mapping process were clustered by major ridgelines, mountain ranges, and, occasionally, general geographic proximity regardless of intervening landform. Clustering in this fashion resulted in 70 conservation planning units being defined. Known sites missed by the model are not yet accounted for.

2.2 Relative Health of Populations

The largest known talus slope in the state (below Cannon Cliff) was not mapped. The largest known rocky ridge occurrence, Grantham Mountain, is 409 ha (1,011 ac). The largest predicted habitat polygon, at Smarts Mountain, is almost 809 ha (2,000 ac). The average size for both known and potential talus slope and rocky ridge polygons is about 28 ha (70 ac) each.

2.3 Population Management Status

N/A

2.4 Relative Quality of Habitat Patches

For known exemplary occurrences as mapped and recorded in the NHNHB database, relative quality of this habitat is high. For known sites, habitat patches mapped as >40 ha (100 ac) and assigned an Element Occurrence Rank of "A" in the NHNHB database, are as follows: red pine rocky ridge at Green Hills in Conway, red spruce–heath–cinquefoil rocky ridge at Grantham Mountain, red pine rocky ridge at Owls Head in Benton, and red oak–pine rocky ridge at Rattlesnake Mountain in Rumney. The largest mapped, A-ranked talus habitat is a spruce–birch–mountain maple wooded talus community in Zealand Notch. While some recreational threats and impacts have been noted at certain sites, many remain in good condition. Habitat quality at predicted sites is unknown.

2.5 Habitat Patch Protection Status

Of the 11,345 ha (28,035 ac) mapped for this habitat, 57% (6,457 ha [15,957 ac]) occur on conservation lands as mapped by the Geographically Referenced Analysis and Information Transfer (GRANIT) System. Of these protected sites, 293 ha (723 ac [0.03% of the total]) are protected by conservation easements while the majority (6,165 ha [15, 234 ac]; 54% of the total mapped acres) are fee ownership parcels, 2,332 ha (5,763 ac) of which are in the WMNF (21% of the total).

2.6 Habitat Management Status

The 4 Wilderness Areas in the WMNF containing talus slope and rocky ridge habitat (Pemigewasset, Presidential-Dry River, Sandwich Range, and Great Gulf Wilderness Areas) are managed according to the guidelines and standards delineated in the Land and Resource Management Plan for the WMNF, such that natural processes are allowed to continue with minimal impediment, effects and impacts of human use will be minimized, primitive recreation opportunities will be provided, appreciation of the qualities of wilderness landscapes will be fostered, and utilization for educational and scientific purpose will be continued (USFS 2004). National scenic trails bisecting talus slope and rocky ridge habitat will be administered in accordance with the Wilderness Act (1981) and are under the management authority of the Cooperative Management System (1984 MOU between the USFS and the Appalachian Trail Conference), composed of the Appalachian Mountain Club, Dartmouth Outing Club (DOC), NHDES, and WMNF. In addition, an MOU between NHFG, USFWS, and the USFS was established in 1996 delegating authority to develop, maintain, and manage all of the fish, wildlife, and rare plant resources and their habitats within the WMNF to NHFG. See also Cliffs habitat profile.

2.7 Sources of Information

Information regarding the management and protection of talus slope and rocky ridge habitat was obtained from the 2004 Proposed Land and Resource Management Plan for the WMNF, Appalachian National Scenic Trail comprehensive management plans, as well documents delineating the Wilderness Act. Habitat patch identification and quality were determined utilizing the STATSGO database for New Hampshire (Natural Resources Conservation Service 1994), and NHNHB natural community and natural

community system polygon delineations (NHNHB 2005). A full literature review of the habitat was conducted, and field researchers familiar with the habitat were consulted.

2.8 Extent and Quality of Data

See Species/Habitat Condition Technical Assessment. See also sections 1.8 and 1.9.

2.9 Condition Ranking

See Species/Habitat Condition Technical Assessment

2.10 Condition Assessment Research

Possible measurable parameters for evaluating relative condition of talus slope and rocky ridge habitat, including extent of recreational impacts and rare natural communities, could include the following: extent of trampling, disappearance of or decline in known rare species occurrences at sites, succession to forest without advent of fire, extent of visitation at sites, and number of trails at sites.

Element 3: Habitat Threat Assessment

3.1.1 Recreation

(A) Exposure Pathway
Recreational use of rocky ridge habitat is high (much less so for talus slopes). Structures, designated trails, undesignated trails, climbing routes, popular ski areas, and viewpoints co-occur with the some of the most sensitive rocky ridge communities, such as those at Mount Cardigan in Orange, Mount Pawtuckaway in Nottingham, and Humphreys Ledge in Bartlett. The disturbance incurred at such sites from trampling in summer and snow compaction in winter (both from foot traffic and snowmobiles) may result in vegetative stress, mortality, and erosion, thereby reducing recolonization within these sensitive communities.

(B) Evidence
Rocky ridges in New Hampshire are highly recreated, enduring high levels of foot traffic and motorized vehicle use (NHNHB 2005). Human disturbance, primarily trampling and off-road vehicle use, is the greatest threat to rocky ridge habitat (USFS 2004, D. D. Sperduto, NHNHB, personal communication). Magnitude of response is strongly correlated with trampling intensity (Cole 1995, US Forest Service 2004). Like alpine communities, rocky ridge communities and their soils have been shown to have low tolerances for trampling (Sperduto and Cogbill 1999, D. D. Sperduto, NHNHB, personal communication). Substantial reductions in both vegetation cover and height, as well as soil erosion, results from trampling (Cole 1995, Cole and Monz 2002). Despite varying tolerances of trampling resistance and resiliency among natural communities within this habitat, they all have a threshold beyond which impacts become irreversible (D. D. Sperduto, NHNHB, personal communication).

3.1.2 Climate Change

(A) Exposure Pathway
The composition of the earth's atmosphere is changing, altering temperature, precipitation, air quality, and extreme weather frequency. All of these factors, along with fire and other natural disturbance, play roles in the persistence of the open character of some of New Hampshire's rocky ridge habitats. As such, climate change could significantly affect the phenology and distribution of this habitat in the state.

(B) Evidence:
Climate change has been extensively demonstrated regionally and locally (Climate Change Research Center 1998, Harvey 2003), and could significantly alter the phenology and distribution of vegetation on rocky ridges (Kimball and Weihrauch 2000). In New Hampshire, temperatures have increased by 0.7°F, 2-3 times the regional average (NERA 2001, Harvey 2003). Walther et al. (2002) has documented poleward and upward shifts of species ranges including: treeline advancement towards higher altitudes, elevation shift of alpine plants, as well as northward range shifts of 39 butterfly species, each of which are linked to global warming (Grabherr et al. 1994, Pauli et al. 1996, Harvey 2003). Changing climatic regimes will ultimately alter species distributions and composition, disrupting community structure as well as overall function (Walther et al. 2002).

3.1.3 Acid Deposition

(A) Exposure Pathway
Acid deposition may cause the following reactions in

alpine communities: changes in community structure, changes in spatial distribution of ecosystems, changes in soil properties, and changes in soil fauna (Rusek 1993). While talus slope and rocky ridge habitat, occurring at slightly lower or lower elevations, may not experience this threat to the same degree, the similarities between the habitats would suggest cause for concern.

(B) Evidence
Exposure to acid deposition is high at high elevation and in areas with frequent direct exposure to clouds. Many rocky ridge and talus slope occurrences meet these criteria. Extensive studies have demonstrated the detrimental consequences of acid deposition in alpine communities. Data provided by such research have attributed decreases soil pH, the increased range of acidophilic species, the disappearance of calciphilic species, and changes plant community distribution to acid deposition (Rusek 1993). While similar studies have not been conducted specifically in talus slope and rocky ridge habitat, the two habitat types share many of the same characteristics (e.g., thin soils, frequently open canopy structure, ridge top settings, etc.) and therefore the same concern is likely warranted for this habitat.

3.1.4 Altered Natural Disturbance (Fire Suppression)

(A) Exposure Pathway
Fire may play an important role in the persistence of this habitat at some sites. Many of the component species are adapted to the open, exposed conditions, and would suffer under a more shaded canopy. Suppression of wildfires could negatively impact the ability of some species to reproduce and alter the open woodland character of the natural communities and systems, resulting in different species compositions and succession to a more forested structure.

(B) Evidence
Open rocky ridge habitats persist for a variety of reasons, including exposure, wind disturbance, soil depth, drought, and periodic fire (Whitney and Moeller 1982, Ruffner and Abrams 1998, Sperduto and Nichols 1999). Fire in particular may play an important role in the continued existence of this habitat and its component species at some sites (Sperduto and Nichols 1999, Sperduto and Nichols 2004). Fires may play an important role in maintaining the relatively depauperate soils, open lighting, and xeric conditions of these sites (P. Bowman, NHNHB, personal communication). Control and suppression of wildfires may affect the ability of some rocky ridge species to germinate seed (e.g. jack pine [*Pinus banksiana*]) and cause community succession of the surrounding forest (Baldwin 1979, USFS 1990). It should be noted that in the early 1900s, New Hampshire experienced tremendous human-induced fires because of the logging industry and settlement activities (Baldwin 1974, Belcher 1980, Leonard 1885). It is unclear how much of a role those fires played in the existence of today's subalpine exposures, and, ironically, there may be some examples of sites where a more natural fire regime would lead to smaller habitat extents than at present (Nichols 2002).

3.1.5 Energy and Communication Infrastructure

See Threats, Energy and Communication Infrastructure)

3.2 Sources of Information

Information regarding talus slope and rocky ridge threats was compiled from expert review and consultation, management plans, technical field reports, and peer reviewed scientific journals.

3.3 Extent and Quality of Data

Threats affecting talus slope and rocky ridge habitat are poorly documented throughout the scientific literature. However, extensive research has been conducted in alpine zones, which share some similar habitat characteristics. Such research has been concentrated on recreation impacts, global warming, and increasing atmospheric pollution.

3.4 Threat Assessment Research

Further research should be focused on range shifts of talus slope and rocky ridge flora and fauna, history and significance of fire on rocky ridges, and pollution-induced wildlife stress/mortality. Measuring the effects of recreational impacts to the habitat (hiker trampling as well as all-terrain vehicle and snowmobile use) is a high priority. Investigation into the importance of fire is also a high priority.

Element 4: Conservation Actions

(See also: Cliffs habitat profile)

4.1.1 Advise Trail Managers on Mitigation for Habitat Impacts, Regulation, and Policy

(see also Strategies, Recreational Management)

(A) Recreation

(B) Justification

- Restricting trail use, placement, and width in sensitive areas will reduce the area of exposure.
- Trail advisories will be designated for high-use trails through delineated sensitive areas.
- Advisories will be provided immediately upon entry into trail management agreements (see below, Implementation).
- Trail use and design will be modified based on habitat response indicators.

(C) Conservation Performance Objective
Eliminate the co-occurrence of adverse trail impacts with delineated S1-ranked natural communities and rare plant populations in talus slope and rocky ridge habitat. Performance will be indicated by entry into trail management agreements, modification of trails, and adoption of trail advisories.

(D) Performance Monitoring
Advisories will include trail use and design modification reporting protocols.

(E) Ecological Response Objective
Restore S1-ranked natural communities and protect rare plant and animal populations in delineated areas. Advisories will include restoration, protection, and monitoring recommendations.

(F) Response Monitoring
Cover of rocky ridge vegetation and soils will be measured in delineated areas prior to implementation of advisories and in subsequent years. Responses will be used to revise advisories.

(G) Implementation
NHFG will delineate sensitive areas and provide trail advisories to all managing agencies to mitigate trail impacts to wildlife and wildlife habitats. NHFG will become a recognized participant of the Appalachian Trail Conference (ATC) Cooperative Management System. Participants include AMC, DOC, NHDES, and WMNF formalized through a series of cooperative agreements at both the state-level and trail section-by-trail section level (New Hampshire is one of the only states that do not have a wildlife agency as a partner). The NHFG will be involved in the development, review, and approval of the Appalachian Trail Local Management Plan. The NHFG will enter a Memorandum of Agreement with the Department of Resources and Economic Development to maintain and manage trails in accordance with the health of wildlife and wildlife habitats. The NHFG will review the 1996 Memorandum of Understanding between the Department, USFWS, and the USFS.

4.1.2 Advise the International Association of Fish and Wildlife Agencies Regional Coordination Team on Climate Change and Acid Deposition Impacts, Regulation and Policy

(see Strategies, Regional Coordination)

4.1.3 Engage in Inter-Agency Risk Assessments for Climate Change and Acid Deposition, Regulation and Policy

(see Strategies, Inter-Agency Regulation and Policy)

4.1.4 Identify High Risk Areas, Conservation Planning

(see Strategies, Conservation Planning)

4.1.5 Monitor Indicator Species for Climate Change and Acid Deposition, Monitoring

(see Strategies, Monitoring)

4.2 Conservation Action Research

Baseline surveys need to be conducted to better identify diagnostic species for sensitive talus slope and rocky ridge habitat areas and indicators of climate change and acid deposition. A permanent monitoring scheme needs developed and implemented in order to assess habitat changes across space and time.

Element 5: References

Baldwin, H. 1974. The flora of Mt. Monadnock,

New Hampshire. Rhodora 76:205-228.

Baldwin, H. 1979. The distribution of *Pinus banksiana* Lamb. in New England and New York. Rhodora 81:549-565.

Belcher, C.F. 1980. Logging Railroads of the White Mountains. Appalachian Mountain Club, Boston, Massachusetts, USA.

Climate Change Research Center. 1998. New England's changing climate, weather and air quality. Institute for the Study of Earth, Oceans, and Space, Durham, New Hampshire, USA.

Cole, D.N. 1995. Res. Note INT-RN-425. Ogden, Utah United States Department of Agriculture, Forest Service, Intermountain Research Station, USA.

Cole, D.N. and C.A. Monz. 2002. Trampling disturbance of high-elevation, Wind River Mountains, Wyoming, USA. Arctic, Antarctic, and Alpine Research. 34:365-376.

Cox, J., and D.W. Larson. 1993. Environmental relations of the bryophytic and vascular components of a talus slope plant community. Journal of Vegetation Science. 4:553-560.

Grabherr, G., M. Gottfried, and H. Pauli. 1994. Climate effects on mountain plants. Nature. 369: 448.

Harvey, R.J. 2003. Using the Northeastern Alpine Zone as a bio-monitor of climate change. Paul Smith's College. Paul Smiths, New York, USA.

Kimball, K.D. and D.M. Weihrauch. 2000. Alpine vegetation communities and the alpine-treeline ecotone boundary in New England as biomonitors for climate change. USDA Forest Service Proceedings. 3:93-101.

Kite, J.S., K.M. Andrews, S.C. Kite, and T. Wilson. 2004. Dynamics of cold-air flow from talus at the Ice Mountain Ecological Refugium, West Virginia, USA. Geological Society of America Abstracts with Programs 36:283.

Kruckberg, A.R. 2002. Geology and plant life. Seattle: University of Washington Press. Seattle, Washington, USA.

Kubesova, S., and M. Chytry. 2005. Diversity of bryophytes on treeless cliffs and talus slopes in a forested central European landscape. Journal of Bryology 27:35-46.

Leonard, L.W. 1855. History of Dublin, New Hampshire. Boston, Massachusetts, USA.

McMillan, M.A., and D.W. Larson. 2002. The effects of rock climbing on the vegetation of the Niagara Escarpment in Southern Ontario, Canada. Conservation Biology 16:389-398.

McMillan, M.A., J.C. Nekola, and D.W. Larson. 2003. Effects of rock climbing on the land snail community of the Niagara Escarpment in Southern Ontario, Canada. Conservation Biology 17: 616-621.

New England Regional Assessment (NERA). 2001. Preparing for a changing climate: the potential consequences of climate variability and change. New England Overview, U.S. Global Change Research Program, University of New Hampshire, Durham, New Hampshire, USA.

Nichols, W.F. 2002. Rare plant and exemplary natural community inventory of Mt. Monadnock State Park, Gay State Forest, and adjacent Town of Jaffrey Lands. New Hampshire Natural Heritage Bureau, Concord, New Hampshire, USA.

New Hampshire Natural Heritage Bureau. 2005. Database of rare species and exemplary natural community occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

Pauli, H., M. Gottfried, and G. Grabherr. 1996. Effects of climate change on mountain ecosystems-upward shifting of alpine plants. World Resource Review 8:382-390.

Pykala, J. 2004. Effects of new forestry practices on rare epiphytic macrolichens. Conservation Biology 18:831.

Ruffner, C.M., and M.D. Abrams. 1998. Relating land-use history and climate to the dendrocology of a 326-year old *Quercus prinus* talus slope forest. Canadian Journal of Forest Research 28:347-358.

Rusek, J. 1993. Air-pollution-mediated changes in alpine ecosystems and ecotones. Ecological Applications 3:409-416.

Sperduto, D.D. and C.V. Cogbill. 1999. Alpine and subalpine vegetation of the White Mountains, New Hampshire. New Hampshire Natural Heritage Inventory, Concord, New Hampshire, USA.

Sperduto, D.D. and W.F. Nichols. 1999. Fern-leaved false-foxglove (*Aureolaria pedicularia* var. *intercedens*) at the New Boston Air Station, New Hampshire. New Hampshire Natural Heritage Inventory. Concord, New Hampshire, USA.

Sperduto, D.D. and W.F. Nichols. 2004. Natural

communities of New Hampshire. New Hampshire Natural Heritage Bureau. Concord, New Hampshire, USA.

Sperduto, D.D. 2004. Upland natural community systems of New Hampshire. New Hampshire Natural Heritage Bureau. Concord, New Hampshire, USA.

US Forest Service. 1990. Silvics of North America Volume 1, Conifers. Agriculture Handbook 654. USDA Forest Service, Washington, DC. USA.

US Forest Service. 2004. Proposed land and resource management plan for the White Mountain National Forest. USDA Forest Service, Eastern Region, USA.

Walther, G.R., E. Post, P. Convey, A. Menzel, C. Parmesan, T.J. Beebee, J.M. Fromentin, O. Hoegh-Guldberg, and F. Bairlein. 2002. Ecological responses to recent climate change. Nature 416: 389-395.

Whitney, G.G., and R.E. Moeller. 1982. An analysis of the vegetation of Mt. Cardigan, New Hampshire: a rocky, subalpine New England summit. Bulletin of the Torrey Botanical Club 109:177-188.

HABITAT PROFILE

Vernal Pools

Associated Species: Marbled Salamander, Jefferson Salamander, Blue-Spotted Salamander, Spotted Turtle, Blanding's Turtle, Ribbon Snake
Global Rank: Not ranked
State Rank: Vernal woodland pool (S3), vernal floodplain pool (S2)
Author: Kimberly J. Babbitt and Jessica S. Veysey, University of New Hampshire

Element 1: Distribution and Habitat

1.1 Habitat Description

Vernal pools are depressional wetlands characterized by generally small size, physical isolation, and alternating periods of flooding and drying. Precipitation and groundwater levels determine hydroperiod, though some are fed by spillover from nearby water bodies or intermittent streams. Vernal pools with a hydroperiod shorter than two months (in spring or summer) may be more properly characterized as ephemeral, as they are not inundated long enough for vernal pool species to complete their life cycle (Colburn 2004). Pools inundated less than four months following spring ice-out might not support a full array of vernal-pool dependent amphibians (Paton and Couch 2002, Babbitt et al. 2003).

The regular drying of vernal pools prevents fish from becoming established. Larvae of vernal pool amphibians lack (or have weakly developed) anti-predator mechanisms to cope with fish predation (Wellborn et al. 1996, Skelly 1997). Technically, vernal pools are hydrologically isolated from other water bodies; however, sites that form periodic connections with other bodies, or that do not dry every year can support vernal pool species if fish populations do not become established.

Vernal pools often have little vegetation. However, pools with a long hydroperiod often have a variety of wetland plants such as *Sphagnum*, sedges, rushes, ferns, shrubs, and trees. Common shrubs and trees in vernal pool depressions include buttonbush (*Cephalanthus occidentalis*), highbush blueberry (*Vaccinium corymbosum*), winterberry (*Ilex verticillata*), red maple (*Acer rubrum*), speckled alder (*Alnus rugosa*), and eastern hemlock (*Tsuga canadensis*) (Colburn 2004, Sperduto and Nichols 2004).

1.2 Justification

Concern for vernal pool conservation is that they are small and easily overlooked (because they are seasonally dry), thus more likely to be filled during development. Because they are temporary, they historically received weaker regulatory oversight than larger permanent wetlands. Increasing population growth in the state and associated development will result in loss of vernal pools and disruption of dispersal capabilities (via increased roads and road traffic) of species that rely on them. Significant loss of vernal pool habitat can result in local extirpation of obligate vernal pool species such as the fairy shrimp (*Eubranchipus* spp.), wood frog (*Rana sylvatica),* spotted salamander (*Ambystoma maculatum*), blue-spotted salamander (*Ambystoma laterale*), Jefferson salamander (*Ambystoma jeffersonianum*), and the state endangered marbled salamander (*Ambystoma opacum*). In addition, other species of concern such as the Blanding's turtle (*Emydoidea blandingii*) and spotted turtle (*Clemmys guttata*) feed in vernal pools and use them as staging areas during migration (Joyal et al. 2001, Jenkens and Babbitt 2003).

1.3 Protection and Regulatory Status

Vernal pools do not have any special regulatory protection at the state level. Local wetland regulations and zoning vary considerably. Some towns (e.g.,

Litchfield) have initiated upland buffer protection around vernal pools. Because vernal pools are generally small and regulatory review of wetland impacts often focuses on size of impacts, vernal pools could be overlooked (M. Marchand, NHFG, personal communication). The NHDES Wetlands Bureau does not require construction setbacks from non-tidal freshwater wetlands (except under RSA 485-A).

- State Fill and Dredge in Wetlands; NHDES, RSA 482-A: Requires applicant to obtain a permit to fill or dredge jurisdictional wetland habitats. Although vernal pools should be identified as jurisdictional wetlands, they will not necessarily be identified as breeding habitat for obligate vernal pool amphibians and invertebrates.
- Nongame Species Management Act (1988) (RSA 212-B): The NHFG Nongame and Endangered Species Program has responsibility and authority to conduct research, management, and education related to those species not hunted, fished, or trapped.

1.4 Population and Habitat Distribution

Vernal pools are widespread throughout New Hampshire and the Northeast, but generally are less abundant in mountainous regions. Because vernal pools are under-reported on National Wetland Inventory (NWI) maps, the location and abundance of vernal pools in New Hampshire are not known. Further, historical records of vernal pool distribution and abundance are lacking. Vernal pools have been identified in areas of New Hampshire for various purposes including research (e.g., Turtle 2000, Jenkens and Babbitt 2003, Mattfeldt 2004, Hermann et al. 2005, Tarr et al. In Press), natural resource inventories, and citizens documenting vernal pools using the Identification and Documentation of Vernal Pools in New Hampshire manual (Tappan and Marchand 2004). However, these data have not been compiled into one database.

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

1.7 Sources of Information

Sources of information include a literature review, the NHDES website, and NHFG.

1.8 Extent and Quality of Data

Vernal pool habitat is well documented in the scientific literature. Specific knowledge about the distribution and abundance of vernal pools in different areas of the state is lacking and is needed.

1.9 Distribution Research

There is a critical need to map vernal pools in New Hampshire and create a database (including GIS data layers) to store data for documented vernal pools. Information on vernal pool spatial distribution, density, hydroperiod, and breeding suitability for vernal pool obligates should also be collected.

Element 2: Species/Habitat Condition

There is a general lack of data relevant to section 2. Knowledge about the distribution of vernal pools in the state is lacking and is needed. No assessment of quality of vernal pool habitats has been conducted.

The relative health of vernal pools is closely tied to the quality of surrounding upland habitat. Hydroperiod and land use strongly influence the suitability of vernal pools for pool-dependent wildlife (Semlitsch 2000, Snodgrass et al. 2000, Paton and Couch 2002, Babbitt et al. 2003, Mattfeldt 2004, Hermann et al. 2005, Babbitt in press). It would be instructive to develop a bioassessment program for vernal pools that is stratified by relevant spatial scale (e.g., country, bioregion) and land use (e.g. urban, suburban, forested, agriculture, protected). Measures of health or quality could include measures of amphibian use (e.g., species richness of vernal-pool dependent species, amphibian egg mass counts), species richness/abundance of aquatic insect taxa, standard water quality measures (e.g., pH, conductivity, nitrogen, phosphorus, BOD, temperature, DOC), and contaminants. Presence of fish or invasive species should be documented. Wetland hydroperiod should be measured, and the bioassessment program must be

developed with a critical examination of land use and land use change attributes.

Element 3 Habitat Threat Assessment

3.1.1 Development (Habitat Loss and Conversion)

(A) Exposure Pathway
Development may affect breeding habitat (loss and degradation of vernal pools), upland habitat (loss and degradation of forests), and dispersal corridors (by fragmenting landscapes), and may even directly kill vernal pool wildlife (vehicle traffic, land clearing activity, etc). Runoff from roads and other impervious surfaces can pollute and degrade nearby wetland habitat. Opportunistic predators (e.g., raccoons) and invasive plant and animal species are more common near human development. Myriad stressors associated with development collectively reduce local population sizes of amphibians, reduce gene flow between populations, and may ultimately extirpate local populations.

(B) Evidence
The evidence provided below is focused on amphibians. Vernal pools often occur in discrete patches within a matrix of terrestrial habitat, and amphibians that breed in these habitats may exist as metapopulations (e.g., Gill 1978, Sjögren 1991, Sinsch 1992, Marsh and Trenham 2001). The long-term persistence of populations depends on the exchange of individuals through dispersal and the colonization probability of vernal pools from terrestrial adult populations (Hanski and Gilpin 1991, Sjögren, 1991, Dodd 1997, Semlitsch and Bodie 1998, Skelly et al. 1999). Most amphibians use terrestrial habitat to obtain food and shelter from predation, desiccation, or freezing (Madison 1997, Lamoureaux and Madison 1999, Knutson et al. 1999). Therefore, the suitability of terrestrial habitat surrounding a vernal pool is likely to have a significant influence the composition and abundance of amphibians that breed in or otherwise utilize a vernal pool.

Even strict wetland regulations and oversight may not protect vernal pool habitat suitability if upland habitat is not also protected. Maintenance of appropriate terrestrial habitat, through buffers (e.g., Semlitsch 1998, Calhoun and deMaynadier 2001, Calhoun and Klemens 2002, Semlitsch and Bodie 2003) or other means will offer some protection, although more research is needed determine both the utility and consequences of guiding development or logging practices via this mechanism. Further, because some species range widely (e.g., Blanding's turtle), a landscape-level approach to conservation and planning will be required to ensure long term persistence of the full range of species associated with vernal pools.

In the last few decades, commercial and residential development in New Hampshire have increased dramatically, in conjunction with accelerated human population growth and immigration (Sundquist and Stevens 1999). Similar urbanization has eliminated the marbled salamander from large portions of its former range on Long Island and mainland New York (Klemens 1993). Petranka (1998) noted that thousands of local populations of marbled salamanders have already been eliminated due to habitat loss. Windmiller (1996) noted that increasing urbanization likely reduces mole salamander abundance and excludes salamanders from otherwise suitable habitat. Gibbs (1998a) suggested that ambystomatids are predisposed to local extinction caused by habitat fragmentation.

3.1.2 Transportation Infrastructure (Mortality, Fragmentation, Dispersal Barriers)

(A) Exposure Pathway
Vehicle traffic can kill vernal pool-dependent species by hitting and crushing them as they cross roads. This can have a significant impact on some species, particularly rare turtles, and in severe cases could result in local extirpation. Roads may act as partial barriers to overland dispersal or migration, perhaps resulting in decreased gene flow between populations and decreased colonization of unpopulated vernal pools. This could disrupt metapopulation dynamics and long-term viability of some species.

Roads also create edge habitat. Along these edges, soil and air moisture may be reduced, leading to increased salamander desiccation. Roads may act as conduits for predators that prey on amphibians or turtle eggs (e.g., skunks and raccoons), and dispersal avenues for invasive plants and animals. Runoff from roads can also reduce habitat quality of vernal pools via pollution, increased salt levels, sedimentation, and erosion in pools and adjacent habitats.

(B) Evidence
Roads significantly threaten turtles, causing skewed sex and age ratios (Marchand and Litvaitis 2004, Gibbs and Steen 2005). Computer modeling by Gibbs and Shriver (2002) predicted that relatively low road densities (e.g., 1 km/km2 with > 100 vehicles/lane/day) could result in severe negative impacts on semi-terrestrial turtles. Roads are a significant source of direct mortality for migrating amphibians (Fahrig et al. 1995, Ashley and Robinson 1996, Mazerolle 2004, Forman 2003), and salamander abundance in roadside habitats may be reduced (deMaynadier and Hunter 2000). Gibbs (1998) found that forest-road edges are less permeable to ambystomatid salamanders than are forest interior and forest-open land edges. Recent research conducted in southern New Hampshire suggests that roads have a negative impact on wood frogs (Rana sylvatica) and spotted salamanders (Ambystoma maculatum), two species of amphibians that breed in vernal pools (Mattfeldt 2004). Amphibians can experience delayed development or mortality from runoff contamination from roads, including road salt (Trombulak and Frissell 2000, Turtle 2000). Negative effects of roads have been well documented for a variety of animal and plant species, and likely apply generally to vernal-pool dependent species (Vos and Chardon 1998, Forman and Deblinger 2000, Carr and Fahrig 2001, Forman 2003, Mazerolle 2004).

3.1.3 Development (Habitat Loss and Conversion)

(A) Exposure Pathway
Vernal pools are filled to provide non-wet areas for residential and commercial development, recreation, agriculture, and road development. Vernal pool filling results in immediate loss of habitat and, for certain species, population extirpation. Wetland filling also increases the distance that dispersing amphibians must travel to reach suitable breeding habitat, resulting in decreased gene flow between local populations and decreased colonization of unpopulated breeding pools. This could disrupt metapopulation dynamics and long-term viability of the species.

(B) Evidence
Wetland loss in the United States from historic draining and filling is well documented (e.g., Dahl 1990, 2000); see Marsh and Shrub Wetlands profile for details. Lack of reliable data for vernal pools creates difficulty in accurately determining historic losses. An important aspect of wetland loss is not simply the continued loss of habitat, but the continued undervaluing of vernal pool habitat as well. Size has traditionally been used an important criterion for assessing wetland value. Further, recent Supreme Court ruling (SWANCC 2001) decreases protection for wetlands that are "isolated" from waters of the United States, under the federal regulation of dredge and fill as per Section 404 of the Clean Water Act. Although the consequences of this decision are still being debated, it likely results in no federal protection under Section 404 for most or all vernal pools. Thus, it falls to the state or local governments to ensure that vernal pools are protected (see section 1.3). New Hampshire has the fasted growing population in New England (Sundquist and Stevens 1999) and consequently faces significant development impacts. Without increased protection priority for vernal pools, it is certain that vernal pool habitat will decrease in the future.

Amphibians, particularly ambystomatid salamanders, generally breed in the same wetland every year (Semlitsch et al. 1993, Semlitsch 1998). It is not well known how these species respond when a breeding wetland is no longer available (i.e., filled). Some ambystomatid salamanders will return to breeding wetlands even after those wetlands have been filled, whereas others have been able to disperse to nearby created wetlands (Pechmann et al. 2001). Created mitigation wetlands usually are unsuccessful at replicating the functiona or wildlife habitat of the wetlands they are intended to replace (Brown 1999).

3.1.4 Unsustainable Harvest (Forestry Operations and Management)

(A) Exposure Pathway
Forest management practices such as clear cutting and partial cutting.

(B) Evidence
Forest management practices (e.g., clear cutting, partial cutting) may reduce forest canopy cover over or near vernal pools. This often results in warmer ambient temperatures (in soil, water, and air), increased wind, and increased insolation. Higher temperatures and wind can lead to increased desiccation and mor-

tality of dispersing or breeding amphibians. Higher temperatures may increase metabolism, increasing energetic demands and leading to starvation if food is scarce. Greater irradiation of breeding wetlands may increase water temperatures, wetland hydroperiod, and exposure to UV radiation.

Forest cutting might disrupt dispersal corridors, force species into suboptimal habitat, and increase exposure to predation or competition. Logging roads can be barriers to wildlife movement, or alternatively, create areas that attract breeding amphibians but that dry too quickly or are subject to vehicular traffic. Runoff from logging roads can transport silt and other pollutants to breeding wetlands, interfering with breeding, embryonic development, and juvenile survival. Reforestation of commercial forests solely with evergreen species [e.g., red spruce (*Picea rubens*)] is not optimal for species that prefer deciduous/mixed upland areas.

3.2 Sources of Information

Information was obtained from a literature search.

3.3 Extent and Quality of Data

The quality of existing data is relatively good in term of our general understanding of factors that are likely to impact vernal pools and associated fauna. However, we lack information on the abundance and distribution of vernal pools in the landscape in New Hampshire. Further, to be able to make informed decisions about vernal pool protection, we need better data on the terrestrial habitat requirements of obligate (and facultative) users of vernal pools.

3.4 Threat Assessment Research

An accurate map of vernal pools is needed for the state. Because not all vernal pools show up on NWI maps, this is not a trivial task. Wetland filling, as a threat, is driven by developmental pressure and how the state of New Hampshire chooses to regulate wetland filling. NHDES maintains records of legal filling activities and could use a comparative aerial photography approach (i.e., before-after) to document recent (e.g., last 10 years) illegal impacts to vernal pools. Monitoring of vernal pool habitat quality (e.g., water quality, hydroperiod) must be conducted concurrently with research that examines land use attributes (e.g., land use type, roads, impervious surface, etc.) on vernal pool habitat quality and ability to support species dependent on vernal pools.

Element 4: Conservation Actions

This list is not intended to be exhaustive (particularly 4.1.2 – 4.1.13), but rather to provide a list of conservation actions that should have the greatest conservation impact or that are needed to enhance threat assessment activities.

4.1.1 Rewrite Municipal Zoning Codes, Habitat Protection/Regulation and Policy

(A) Development, roads, wetland fill, pollution (toxins, fertilizers, increased soil and water acidity), disease, invasive species, fish stocking, collection, global warming.

(B) Justification
Rewriting local zoning codes to favor open-space and mixed-use development is expected to be the most effective means of reducing the negative effects of development and thereby protecting vernal pool habitat and pool-dependent wildlife. Rewriting local zoning codes should have the following effects, compared to development under conventional zoning codes:

- Development can be clustered more densely, allowing permanent preservation of and connection between larger tracts of undeveloped land, and reduced fragmentation of the landscape.
- Transportation infrastructure can be reduced, since buildings are closer together; and residential, commercial, and industrial buildings are intermixed. Consequently, effects of roads and development (see sections 3.1.1 and 3.1.2) on vernal pools and their wildlife can also be reduced.
- The design process is more flexible so that development can be planned around, instead of through or near, vernal pools, wildlife migration routes, and other valuable natural resources.

This action can be applied at the state or municipal level. This action is most critical in those areas experiencing the greatest population growth (i.e., southern and southeastern New Hampshire). Revised zoning

codes can be implemented quickly if supported by the public. Model zoning codes already exist and can be adapted to local situations. Moreover, state law (i.e., NH RSA 674, RSA 675, RSA 477) already permits municipalities to amend zoning codes such that they allow or promote open-space and mixed use development. Zoning codes can be revised as needed to respond to new information.

(C) Conservation Performance Objective
The objective of rewriting zoning codes is to promote and facilitate open-space/mixed use development, instead of traditional (low-density, large-lot, separated land use) development. Zoning codes should be revised as soon as feasible, and the effect on open-space/mixed use development should be documented within a year of implementation.

(D) Performance Monitoring
Performance will be assessed using the following three parameters:

1. Number of towns that have adopted revised zoning codes (that favor open-space/mixed use development)
2. Numbers of each type of building permit (open-space/mixed use versus conventional)
3. Acreage claimed by each type of development (for all developments, this includes land that is part of the developable parcel but not developed, such as permanently-preserved open space in open-space developments)

These parameters should be measured on a regular basis at the municipal level and will be reported to the agency that is charged with monitoring this conservation action. The municipal scale is most practical since municipal boards will possess this information because of municipal zoning (planning) board activities and the development permitting process. If performance is deemed unsatisfactory, the entity charged with administering this conservation action should consider methods to promote this action, including educating municipal zoning boards and the public.

(E) Ecological Response Objective
The desired ecological results of revising zoning codes are to maintain large mosaics of relatively undisturbed forest and wetland habitats. This habitat-based approach should allow local wildlife populations to persist.

(F) Response Monitoring:
Several ecological responses could be monitored, depending on research or management goals. The following list provides a few examples:

- Survey the distribution and abundance of target vernal pool wildlife (salamanders, turtles)
- Monitor breeding habitat (habitat structure, water chemistry, pollution, etc)
- Monitor populations for growth, mortality, fecundity, migration, and occurrence of disease or deformities
- GIS data layers for vernal pools and target wildlife species should be developed using aerial photographs and/or remote sensing data. Separate data layers could be developed for other measured habitat or population variables
- Develop indicators for breeding habitats (hydroperiod, landscape position, etc), upland landscapes (forest area, forest to edge ratio, and landscape connectivity), and human development (road density, impervious surfaces, etc.)
- Add a zoning code status layer to the GIS map. Then periodically update field and aerial/remote sensing data to compare indicators (above) over time to evaluate the effects of zoning changes (or compared with models).
- If response indicators show that vernal pool habitat or critical upland habitat continues to degraded or fragmented, or vernal pool wildlife are decreasing, then this conservation action should be readdressed.

(G) Implementation
Educate the public, municipal zoning boards, and real estate agents about the benefits of open-space/mixed-use development. Develop a model open-space/mixed use zoning code for each municipality and have it endorsed by the municipal zoning board, town meeting, or otherwise have it approved as outlined in NH RSA 91, RSA 477, RSA 674, and RSA 675). A state agency, consulting group, or non-profit group should coordinate a statewide effort, although towns may also want to delegate responsibilities to volunteers, zoning board or conservation commissioners, or consultants. Efforts should first focus on communities where critical species are known to exist. For example, Winchester is the only municipality where a pure Jefferson salamander has been documented and should

therefore receive special attention.

Incorporate data from habitat surveys, rare species surveys, and GIS datalayers (see section 4.1.1 F) into proposed zoning codes and to revise codes as new information becomes available. Calculate ecological response indicators to assess the success of the conservation action.

4.1.2 Maintain the natural hydroperiod of individual vernal pools. Regulations should not allow for dredging, excavation, drainage, or filling in or adjacent to vernal pools. (Habitat Protection/ Regulation and Policy)

Any changes to wetland hydroperiod can alter habitat suitability, including rendering the pool unsuitable for supporting many vernal pool-dependent species. Vernal pools in which hydroperiods are shortened may not be inundated for a sufficient length of time to allow development of larval amphibians to metamorphosis. Vernal pools that are converted to permanent sites will not support the same assemblage of species if fish populations become established.

4.1.3 Change wetland dredge and fill and set back regulations so that vernal pools are given equal value to other wetland types. When vernal pools are impacted or completely filled in, compensatory mitigation should be required. Use wetlands functions and values assessments when evaluating permit applications, rather than focusing on size of wetland impact (Habitat Protection/Regulation and Policy).

The continued approach of placing higher value on larger wetlands will result in relatively higher loss of vernal pool habitat compared to other wetlands because a large majority of vernal pools are small. There is ample evidence that size is a poor criterion on which to measure wetland value (Gibbs 1993, Semlitsch and Bodie 1998, Snodgrass et al. 2000, Paton and Couch 2002, Babbitt in press).

4.1.4 Establish a mechanism to use mitigation funds for wetland loss to support efforts to conduct applied research on impacts of development and on vernal pools. (Regulation and Policy/Habitat Protection)

As measures are taken to encourage "smart growth" and establish Best Management Practices (BMPs) for vernal pools, it is important to examine whether these approaches are effective. Long-term research would be required, so commitment on the part of developers at the start of development projects would be necessary. Although this conservation action would require significant time and effort, it is an effective and direct way of obtaining critically needed information about how best to manage land in a developed landscape. Given trends in population growth and development, the suburban landscape is the area in which impacts to vernal pools and the species that depend on them is likely to offer both the greatest challenges and the greatest opportunities for conservation.

4.1.5 Establish a GIS data layer for vernal pools. (Habitat Protection)

An accurate map of vernal pools is needed to efficiently and effectively conserve vernal pools, track impacts, assess protection efforts, assess threats, and to document and seek mitigation for legal and illegal filling.

4.1.6 Create a database to store the location and condition of documented vernal pools (Habitat Protection, Regulation and Policy, Education and Outreach)

NHFG published a guide 'Identification and Documentation of Vernal Pools in New Hampshire' (Tappan and Marchand 2004). Landowners, citizens, towns, consultants, and non-profits have used this manual to document vernal pools in New Hampshire and submitted documentation to NHFG. In addition, many vernal pools have been documented and studied as part of research conducted by schools and universities, especially the University of New Hampshire (e.g., Turtle 2000, Jenkens and Babbitt 2003, Mattfeldt 2004, Hermann et al. 2005, Tarr et al. In Press). All documented vernal pools should be acquired and stored in a central database. This information could be used during development site reviews, prioritizing land for protection, creating species habitat models, or identifying locations for research.

4.1.7 Determine location of vernal pool-rich areas of the landscape and permanently protect the land. (Habitat Protection)

The most permanent source of protection for vernal pools and vernal-pool dependent species is through land protection that includes wetlands and critical uplands. Land protection though fee simple purchase or easements should be considered.

4.1.8 Support establishment of BMPs for vernal pools. (Habitat Protection/Regulation and Policy)

Vernal pool BMPs have recently been developed for residential and commercials development (Calhoun and Klemens 2002) and forestry (Calhoun and deMaynadier 2001). These BMPs are laudable and provide a good first step. However, research to test the efficacy of these BMPs is lacking. It is unclear whether these BMPs, which largely establish terrestrial buffer zones, will result in long-term protection of widely ranging species. Support of BMPs for vernal pools, together with research to examine their utility and need for refinement, should be established.

4.1.9 Support development design standards that keep roads distant from vernal pools and that limit use of road salt in areas where vernal pools are adjacent to roads. (Habitat Protection)

See section 3.1.2 for justification. To the extent possible, roads should not be constructed to run near a vernal pool, through a cluster of vernal pools, or between vernal pools and forested uplands. Alternatives to standard road salt applications should be used on roads adjacent to vernal pools.

4.1.10 Establish standards for the development of criteria for assessing and determining critical locations for tunnel crossings. (Habitat Protection)

The use of tunnels to safely direct wildlife under or over roads has proven effective in many circumstances, including for vernal pool species. Care must be taken to design structures that animals will use (i.e., no behavioral avoidance) and are not likely to experience increased predation (i.e., from predators cuing in on migrating organisms). Tunnel crossings are particularly important in areas where rare, endangered, threatened, or species of special concern still occur (e.g., marbled salamander, Jefferson salamander, Blanding's turtle, spotted turtle). For more details see Jefferson salamander profile.

4.1.11 As part of broader initiative relative to invasive species management, document trends in increasing invasive species in vernal pools. (Habitat Management)

Invasive species are not considered a significant threat to vernal pools now, but should be watched to ensure that this threat does not increase in the future.

4.1.12 Recognize that the spatial relationship among pools of varying hydroperiod, including permanent sites, has a significant influence on local biodiversity. (Habitat Protection)

Efforts should be undertaken to develop watershed-scale conservation management plans. Because we lack historic data on vernal pool abundance, we do not know what we have lost. However, maintaining a similar ratio of wetlands in differing hydroperiod/habitat types, as well as maintaining uplands surrounding these wetlands in a fashion that will support wetland-dependent species, will ensure that the relative densities of vernal pools are not decreased significantly relative to other habitat types. For example, species such as the Blanding's turtle require both permanent pools and vernal pools.

4.1.13 Develop a bioassessment program for vernal pools.

A suitable approach for assessing vernal pool quality is lacking. Because it is not likely that development will abate or that all vernal pools will be protected, it will become increasingly important to assess the value of vernal pools to decrease our chances of "protecting the wrong pools." A bioassessment program should be stratified by relevant spatial scale (e.g., country, bioregion) and land use (e.g. urban, suburban, forested, agriculture, protected). Measures of health or quality could include measures of amphibian use (e.g., richness of vernal-pool dependent species, amphibian egg mass counts) species richness/abundance of aquatic

insect taxa, standard water quality measures (e.g., pH, conductivity, nitrogen, phosphorus, BOD, temperature, DOC), and contaminant levels. Presence of fish or invasive species should be documented. Wetland hydroperiod should be measured, and the bioassessment program must be developed with a critical examination of land use and land use change attributes that can be obtained through remote sensing (e.g., Tiner 2004).

4.2 Conservation Action Research

In addition to the need for documentation and mapping of vernal pools, it is essential to assess what protection and management activities in the terrestrial landscape will ensure that vernal pools retain habitat quality and continue to support wildlife. Information needs include species-specific requirements, and the quality, amount, and type of habitat required for long-term maintenance of populations. More research on dispersal mechanisms and upland habitat is needed to protect some pool-dependent species.

Element 5: References

Ashley, E.P., and J.T. Robinson. 1996. Road mortality of amphibians, reptiles and other wildlife on the Long Point Causeway, Lake Erie, Ontario. Canadian Field-Naturalist 110: 403-412.

Babbitt, K.J., M.J. Baber, and T.L. Tarr. 2003. Patterns of larval amphibian distribution along a wetlands hydroperiod gradient. Canadian Journal of Zoology 81:1539-1552.

Babbitt, K.J. in press. The relative importance of wetland size and hydroperiod for amphibians in the northeast. Wetland Ecology and Management.

Calhoun, A.J.K., and P. deMaynadier. 2001. Forest habitat management guidelines for vernal pool wildlife in Maine. Maine Department of Inland Fisheries and Wildlife. Augusta, Maine.

Calhoun, A.J.K., and M.W. Klemens. 2002. Best management practices: conserving pond-breeding amphibians in residential and commercial developments in the northeastern United States. MCA Technical Paper No. 5. Metropolitan Conservation Alliance, Wildlife Conservation Society. Bronx, New York.

Carr, L.W., and L. Fahrig. 2001. Effects of road traffic on two amphibian species of differing vagility. Conservation Biology 15:1071-1078.

Colburn, E.A. 2004. Vernal pools: natural history and conservation. McNaughton & Gunn, Inc. Saline, Michigan.

Dahl, T.E. 1990. Wetlands losses in the United States 1780s to 1980s. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C., USA.

Dahl, T.E. 2000. Status and trends of wetlands in the conterminous United States 1986 to 1997 U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C., USA.

deMaynadier, P.G., and M.L. Hunter, Jr. 1995. The relationship between forest management and amphibian ecology: a review of the North American literature. Environmental Reviews 3:230-261.

deMaynadier, P.G., and M.L. Hunter. 2000. Road effects on amphibian movements in a forested landscape. Natural Areas Journal 20:56-65.

Dodd, C.K., Jr. 1997. Imperiled amphibians: a historical perspective. Pages 165 – 200 in G. W. Benz and D. E. Collins, editors. Aquatic Fauna in peril: the southeastern perspective. Special Publication I Southeast Aquatic Research Institute. Lenz Design and Communications, Decatur, Georgia, USA.

Fahrig, L., J.H. Pedlar, S.E. Pope, P.D. Taylor, and J.F. Wegner. 1995. Effect of road traffic on amphibian density. Biological Conservation 73:177-182.

Forman, R.T.T. 2003. Road ecology: s*cience and solutions.* Island Press. Washington, D.C.

Forman, R.T.T., and R.D. Deblinger. 2000. The ecological road-effect zone of a Massachusetts (U.S.A.) suburban highway. Conservation Biology 14:36-46.

Gibbs, J.P. 1993. Importance of small wetlands for the persistence of local populations of wetland-associated animals. Wetlands 13:25-31.

Gibbs, J.P. 1998. Amphibian movements in response to forest edges, roads, and streambeds in southern New England. Journal of Wildlife Management 62: 584-589.

Gibbs, J.P., and D.A. Steen. 2005. Trends in sex ratios of turtles in the United States: implications of road mortality. Conservation Biology 19:552-556.

Gibbs, J.P., and G. Shriver. 2002. Estimating the Effects of Road Mortality on Turtle Populations. Conservation Biology 16:1647-1651.

Gill, D.E. 1978. The metapopulation ecology of the red-spotted newt, *Notopthalmus viridescens* (Rafin-

esque). Ecological Monographs 48:145-166.

Guerry A.D. and Hunter M.L., Jr. 2002. Amphibian distributions in a landscape of forests and agriculture: an examination of landscape composition and configuration. Conservation Biology 16:745-754.

Hanski, I. 1994. Patch-occupancy dynamics in fragmented landscapes. Trends in Ecology and Evolution 9:131-135.

Hanski, I., and M.E. Gilpin. 1991. Metapopulation dynamics: brief history and conceptual domain. Biological Journal of the Linnean Society 42:3-16.

Hecnar, S.J,. and R.T. M'Closky. 1996. Regional dynamics and the status of amphibians. Ecology 77: 2091-2097.

Hermann, H.L., K.J. Babbitt, M.J. Baber, and R.G. Congalton. 2005. Effects of wetland and surrounding landscape characteristics on amphibian assemblages. Biological Conservation. 123:139-149.

Jenkens, R., and K.J. Babbitt. 2003. Developing a conservation strategy to protect land habitat functions for New Hampshire's reptiles and amphibians using the Blanding's turtle (*Emydoidea blandingii*) as a flagship species. Final report submitted to the New Hampshire Fish & Game Department, Concord, New Hampshire, USA.

Joyal, L.A., M. McCollough, and M.L. Hunter, Jr. 2001. Landscape ecology approaches to wetland species conservation: a case study of two turtle species in southern Maine. Conservation Biology 15: 1755-1762.

Knutson, M.G., J.R. Sauer, D.A. Olsen, M.J. Mossman, L.M. Hemesath, and M.J. Lannoo. 1999. Effects of landscape composition and wetland fragmentation on Frog and Toad abundance and species richness in Iowa and Wisconsin, USA. Conservation Biology 13: 1437-1446.

Laan, R. and B. Verboom. 1990. Effects of pool size and isolation on amphibian communities. Biological Conservation 54:251-262.

Lamoureux, V.S., and D.M. Madison. 1999. Overwintering habitats of radio-implanted green frogs, *Rana clamitans*. Journal of Herpetology 33:430-435.

Lehtinen, R.M., S.M. Galatowitsch, and J.R. Tester. 1999. Consequences of habitat loss and fragmentation for wetland amphibian assemblages. Wetlands 19:1–12.

Madison, D.M. 1997. The emigration of radio-implanted spotted salamanders, Ambystoma maculatum. Journal of Herpetology 31:542–551.

Marchand, M.N., and J.A. Litvaitis. 2004. Effects of habitat features and landscape composition on the population structure of a common aquatic turtle in a region undergoing rapid development. Conservation Biology 18:758-767.

Marsh, D.M. and P.B. Pearman. 1997. Effects of habitat fragmentation on the abundance of two species of Leptodactylid frogs in an Andean montane forest. Conservation Biology 11:1323-1328.

Marsh, D.M., and P.C. Trenham. 2001. Metapopulation dynamics and amphibian conservation. Conservation Biology 15:40-49.

Mattfeldt, S. 2004. Effects of wetland isolation and surrounding landscape characteristics on vernal pool-dependent amphibians. M.S. Thesis. University of New Hampshire, Durham, New Hampshire.

Mazerolle, M.J. 2004. Amphibian road mortality in response to nightly variations in traffic intensity. Herpetologica 60: 45-53.

Paton, P.W.C., and W.B. Couch, III. 2002. Using phenology of pond-breeding amphibians to develop conservation strategies. Conservation Biology 16: 194-204.

Pope S.E., L. Fahrig, and H.G. Merriam. 2000. Landscape complementation and metapopulation effects on leopard frog populations. Ecology 81: 2498-2508.

Semlitsch, R.D. 1998. Biological delineation of terrestrial buffer zones for pond breeding salamanders. Conservation Biology 12:1113-1119.

Semlitsch, R.D. 2000. Principles for management of aquatic-breeding amphibians. Journal of Wildlife Management 64:615-631.

Semlitsch, R.D., and J.R. Bodie. 1998. Are small, isolated wetlands expendable? Conservation Biology 12:1129-1133.

Semlitsch, R.D., and J.R. Bodie. 2003. Biological criteria for buffer zones around wetlands and riparian habitats for amphibians and reptiles. Conservation Biology 17:1219-1228.

Sinsch, U. 1992. Structure and dynamic of a natterjack toad metapopulation (*Bufo calamita*). Oecologia 90:489–499.

Sjögren, P. 1991. Extinction and isolation gradients in metapopulations: the case of the pool frog (*Rana lessonae*). Biological Journal of the Linnean Society 42:135-147.

Skelly, D.K. 1997. Pond permanence and predation are powerful forces shaping the structure of tadpole assemblages. American Scientist 85:36-45.

Skelly, D.K., E.E. Werner, and S. Cortwright. 1999. Long-term distributional dynamics of a Michigan amphibian assemblage. Ecology 80:2326-2337.

Snodgrass, J.W., M.J. Komoroski, A.L Bryan, Jr., and J. Burger. 2000. Relationships among isolated wetland size, hydroperiod, and amphibian species richness: implications for wetland regulations. Conservation Biology 14:414-419.

Sperduto, D.D., and W.F. Nichols. 2004. Natural communities of New Hampshire. New Hampshire Natural Heritage Bureau and The Nature Conservancy. Concord, New Hampshire, USA.

Sundquist, D., and M. Stevens. 1999. New Hampshire's Changing Landscape. Population growth, land use conversion, and resource fragmentation in the Granite State. The Society for the protection of New Hampshire Forests and The Nature Conservancy, Concord, New Hampshire, USA.

Tappan, A., and M. Marchand (editors). 2004. dentification and Documentation of Vernal Pools in New Hampshire. New Hampshire Fish and Game Department Nongame and Endangered Wildlife Program, Concord, New Hampshire, USA.

Tarr, T.L., M.J. Baber, and K.J. Babbitt. in press. Changes in the distribution and abundance of invertebrates across the hydrologic gradient. Wetland Ecology and Management.

Tiner, R.W. 2004. Remotely-sensed indictors for monitoring the general condition of "natural habitats" in watersheds: an application for Delaware's Nanticoke River watershed. Ecological Indicators 4:227-243.

Travis, J. 1994. Calibrating our expectations in studying amphibian populations. Herpetological Review 50:104-108.

Trombulak, S.C. and C.A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14:18-30.

Turtle, S.L. 2000. Embryonic survival of the spotted salamander (*Ambystoma maculatum*) in roadside and woodland vernal pools in southeastern New Hampshire. Journal of Herpetology. 34:60-67.

Vos, C.C. and J.P. Chardon. 1998. Effects of habitat fragmentation and road density on the distribution pattern of the moor frog *Rana arvalis*. Journal of Applied Ecology 35:44-56.

Wellborn, G.A., D.K. Skelly, and E.E. Werner. 1996. Mechanisms creating community structure along a freshwater habitat gradient. Annual Review of Ecology and Systematics 27:337-363.

Windmiller, B.S. 1996. The pond, the forest, and the city: spotted salamander ecology and conservation in a human-dominated landscape. Dissertation, Tufts University, Medford, Massachusetts.

HABITAT PROFILE

Lowland Spruce-Fir Forest

Associated Species: spruce grouse, Northern Goshawk, three-toed woodpecker, bay-breasted warbler, purple finch, rusty blackbird, hoary bat, Canadian lynx, American marten, northern bog lemming
Global Rank: Not ranked
State Rank: Not ranked
Author: Carol R. Foss
Affiliation: New Hampshire Audubon

Element 1: Distribution and Habitat

1.1 Habitat description

This system is a mosaic of lowland spruce - fir forest and red spruce swamp communities that occur on mineral soils. In northern New Hampshire, these range from well or moderately well drained upland forests to poorly or very poorly drained swamps. Somewhat poorly drained soils are intermediate and very common. The average condition for red spruce swamps is acidic and poorly drained, with shallow, well decomposed organic soils (10 – 40 cm) over sandy to silty mineral soil. When soils are very poorly drained, these systems tend toward black spruce peat swamps. In steeper areas at moderate elevation, such as the White Mountains, swampland may be dominated by red spruce. These areas may border areas of narrow spruce fir, hardwood forest, or high elevation spruce fir. Lowland spruce fir is more minerotrophic than black spruce peat swamps, but less so than northern white cedar or near-boreal hardwood-conifer minerotrophic swamp systems. Diagnostic natural communities:

- Red spruce swamp (S3)
- Lowland spruce - fir forest (S3)
- Montane black spruce - red spruce forest (S1)

Associated natural community systems: Black spruce peat swamp systems occur on adjacent very poorly drained peat soils. In more minerotrophic settings this system can be adjacent and transition into northern white cedar or near-boreal hardwood-conifer minerotrophic swamp systems. Upslope, lowland spruce – fir forest/swamps typically transition to northern hardwood – conifer systems.

1.2 Justification

Lowland spruce-fir forest covers approximately 10% of New Hampshire. This forest type supports 101 vertebrate species in the state, including 9 amphibians, 2 reptiles, 53 birds, and 37 mammals. Of the bird species, 15 are essentially restricted to or heavily dependent on spruce-fir forest, and 7 require mature age classes. Threatened and endangered wildlife species occurring in this forest type include Canadian Lynx, eastern small-footed bat, marten, osprey, Peregrine falcon, Bald Eagle, and three-toed woodpecker. Extensive heavy cutting in recent decades has substantially reduced the distribution of mature spruce-fir forest in New Hampshire. Recent forest inventory data (Miles 2005) suggest that 71% of live spruce and fir trees are in the 2-inch diameter class and less than 1.5% are in diameter classes of 10 inches and above. Soil and other environmental conditions over extensive acreage in northern New Hampshire create the potential to support either spruce-fir or northern hardwood-conifer forest. Past harvesting in some of these areas have resulted in conversion of former spruce-fir sites to northern hardwood-conifer forest.

2.3 Protection and Regulatory Status

Much of New Hampshire's lowland spruce-fir occurs on private industrial land; approximately 30% of this forest type occurs on conservation lands. Areas of

public ownership include the White Mountain National Forest, Nash Stream Forest, Lake Umbagog National Wildlife Refuge, Pondicherry Refuge, and Randolph Community Forest.

Forestry on state lands is covered by RSAs 216, 217, and 218. RSA 227 stipulates requirements for residual basal area in riparian areas. The manuals "Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire" (Cullen 1996) and "Good Forestry in the Granite State" (FSSWT 1996) provide recommended management practices for sustainable forestry in New Hampshire.

2.4 Distribution

Lowland Spruce-Fir forest occurs primarily in northern New Hampshire, with approximately 45% by area in Coos County and approximately 20% in Grafton County.

2.5 Town Distribution Map

See attached.

1.6 Habitat Mapping

To develop a map of lowland spruce-fir forest in New Hampshire a model was developed for each ecoregion subsection of the state based on the 2001 New Hampshire Land Cover Assessment, elevation, landform, and soils (Keys and Carpenter 1995, Sperduto and Zankel 2005). The model was developed by experts from TNC and NHNHB.

First, 2001 New Hampshire Land Cover Assessment grid value 422 (spruce-fir) was selected and combined with elevations from 1,000 to 2,500 feet extracted from the USGS National Elevation Dataset. Only spruce-fir occurring in that elevation range was included (CSRC 2001, USGS 2003). Ecological Land Units (ELU), created by TNC's Conservation Science Support, were then added to capture additional areas likely to have geo-physical conditions favorable to lowland spruce-fir, or remove areas likely to have geophysical conditions unfavorable to lowland spruce-fir (TNC 2003). Specifically, acidic granitic dry flats, acidic sedimentary/metasedimentary dry flats, acidic shale dry flats, mafic/intermediate granitic dry flats, moderately calcareous sedimentary/metasedimentary dry flats, and wet flats were included. Water bodies were used to erase wet flats in the ELU layer that were actually open water.

To further refine the model, soil types associated with lowland spruce-fir were identified by NHNHB scientists and selected from digitized county soil data, where available (NRCS 2002). The soils data added areas that, while not captured as spruce-fir in the New Hampshire Land Cover Assessment, had requisite features for spruce-fir habitat.

NHFG had previously completed a model to map high-elevation spruce fir in New Hampshire, based on a Vermont Institute of Natural Science (VINS: Lambert et al. 2005) elevation threshold, which depicts the lower elevation limit of Bicknell's Thrush habitat, Hale's (in press) Bicknell's Thrush probability surface, and New Hampshire Natural Heritage Bureau (NHB) exemplary high-elevation spruce-fir natural communities. This layer was used to erase features in the lowland spruce-fir layer to ensure that there was no overlap between the two. However, overlap is unlikely because of the different elevation ranges that were used. NHFG then applied a filter to determine the majority forest type between neighboring polygons in TNC's model, and smoothed the boundaries to generalize the transition between matrix forest types.

Model results were reviewed by experts from TNC, NHFG, and NHNHB, who agreed that the broad patterns depicted by the model align with reasonable expectations. No ground truthing was conducted. This is a first version of the model, and further refinements may be developed in the future.

1.7 Sources of Information

The lowland spruce-fir map was developed based on expert input from scientists from NHNHB and the New Hampshire Chapter of TNC. The results were reviewed by additional scientists from NHFG and ASNH. A variety of GIS data was used to generate the map including USGS elevation data, landform data from TNC's eastern regional office, landcover data from the New Hampshire Landcover Assessment, among others, and soils as outlined by NHNHB scientists based on extensive fieldwork in lowland spruce-fir areas.

1.8 Extent and Quality of Data

The habitat map is considered a first version but is thought to provide a useful depiction of broad landscape patterns. Additional refinements will likely be necessary based on ground truthing of the existing map. Soils information gathered during extensive NHNHB fieldwork in spruce-fir areas was used instead of those outlined by the NRCS. NRCS provided a table of soil series that were believed to be strongly correlated with lowland spruce-fir and other forest types (Homer 2005). Soil series were provided by ecoregional subsection and elevation ranges. There was considerable overlap between series outlined for lowland spruce-fir and some of the other forest types. Thus, additional review and refinement are necessary prior to incorporating the NRCS listed soils into a lowland spruce-fir model. This was not possible for this initial version.

1.9 Distribution Research

Fieldwork is needed to evaluate correlations between soil series and forest type as outlined in Homer (2005). County soil surveys outline soils suitable for forestry from an economic perspective. However, little has been done to evaluate soils from an ecological perspective (e.g., if left unmanaged, an area with a particular soil would eventually succeed to lowland spruce-fir forest). Fieldwork is also needed to ground truth the lowland spruce-fir map to assist with refining it.

Element 2: Species/Habitat Condition

2.1 Scale: County

2.2 Relative Health of Populations

An approximately 3% decrease in forest area occurred between 1992 and 1993 and 2001 in the two-county area where approximately 95% of New Hampshire's potential Lowland Spruce-Fir forest occurs. An additional approximately 1% decrease is projected to occur between 2001 and 2025 (Calculated from data in SPNHF 2005).

2.4 Relative Quality of Habitat Patches: Analysis pending.

2.5 Habitat Patch Protection Status

Approximately 30% of potential Lowland Spruce-Fir forest in the two-county area where approximately 80% of this forest type occurs is in conservation ownership (calculated from TNC data).

2.6 Habitat Management Status

Certified Tree Farms cover approximately 55% of the two-county area in which approximately 80% of New Hampshire's potential Lowland Spruce-Fir forest area occurs (calculated from data in Thorne and Sundquist 2001 and TNC data).

2.7 Sources of Information

See 1.7

2.8 Extent and Quality of Data

See 1.8 regarding extent and quality of data associated with the TNC matrix forest map. Tree farm data from Thorne and Sundquist 2001 are based on a New Hampshire Tree Farm program database issued in August 2000. Data regarding changes in forest area from SPNHF 2005 include information from the New Hampshire Land Cover Assessment, 2001 and results of predictive modeling.

2.9 Condition Assessment Research

Research is needed:

- to determine the age class distribution of this forest type on the landscape;
- to determine locations and sizes of remaining mature patches and identify stands that will reach maturity in the near term;
- to determine the extent of this forest type that occurs in large un-fragmented blocks;
- to determine presence and breeding status of spruce-fir dependent species in remaining mature patches;
- to ground-truth Capen et al.'s remote-sensing based habitat models for priority spruce-fir bird species

Element 3: Species and Habitat Threat Assessment

3.1.1. Unsustainable Harvest (Forestry Operations and Management)

(A) Exposure Pathway: Extensive, heavy cutting in recent decades has substantially reduced the distribution of mature spruce-fir forest in New Hampshire. Soil and other environmental conditions over extensive acreage in northern New Hampshire create the potential to support either spruce-fir or northern hardwood-conifer forest. See also 3.1.2.

(B) Direct Evidence: Recent forest inventory data (Miles 2005) suggest that 71% of live spruce and fir trees are in the 2-inch diameter class and less than 1.5% of these trees are in diameter classes of 10 inches and above. Historical harvesting practices in some areas have resulted in conversion of former spruce-fir sites to northern hardwood-conifer forest.

3.1.2. Non-Point Source Pollution

(A) Exposure Pathway: Use of DDT and related pesticides to control forest pests during the mid twentieth century resulted in dramatic population declines of raptors and other wildlife species (Cade et al. 1971, Ogden 1977, Bednarz et al. 1990). More recent pest management strategies have included shorter rotations and pre-salvage harvesting, which may create extensive even-aged stands that are increasingly vulnerable to future outbreaks.

(B) Direct Evidence: The Osprey population in northern New Hampshire included only 3 to 4 known nesting pairs by 1977 (Smith 1979). After DDT was banned in 1976, this population gradually increased to 21 pairs by 1989 (Evans in Foss 1994). Recent forest inventory data (Miles 2005) suggest that 71% of live spruce and fir trees are in the 2-inch diameter class and less than 1.5% of these trees are in diameter classes of 10 inches and above.

3.1.4. Altered Natural Disturbance

(A) Exposure Pathway: Short rotations on managed spruce-fir forests prevent much of the forest from reaching sufficient age for bark beetles and, more recently, spruce budworm, to create natural stand mortality and to provide prey for species that depend heavily on these resources (e.g., three-toed woodpecker, Bay-breasted Warbler, Cape May Warbler).

(B) Direct Evidence: Recent forest inventory data (Miles 2005) suggest that 71% of live spruce and fir trees are in the 2-inch diameter class and less than 1.5% of these trees are in diameter classes of 10 inches and above.

3.2 Sources of Information

Threat information was derived from a work session with forestry professionals and stakeholders, available data, published literature, and personal experience.
3.3 Extent and Quality of Data: Threat pathways are well documented. Spatially explicit data regarding areas affected by threats are inadequate or lacking.

3.4 Threat Assessment Research

Comprehensive analysis of the current age-class distribution of lowland spruce fir forest across the landscape, including patch sizes, is needed.

Identification of areas that historically supported lowland spruce-fir forest but have been converted to northern hardwood-conifer forest as a result of past management practices is needed.

Element 4: Conservation Actions

4.1.1. Protect un-fragmented blocks and other key wildlife habitats.

See Strategies: Land Protection

4.1.2. Develop a comprehensive land protection support program.

See Strategies: Land Protection

4.1.3. Advocate adoption of sustainable forestry.

See Strategies: Education and Outreach

4.1.4. Restore and maintain late successional habitats.

See Strategies: Habitat management

4.1.5. Establish IRAT for Forestry

See Strategies: Interagency Regulation and Policy

4.2 Conservation Action Research

Identify existing unprotected patches of late successional lowland spruce-fir forest. Determine patch sizes of late successional lowland spruce-fir forest needed to support species dependent on that habitat type.

Element 5: References

5.1 Literature

Complex Systems Research Center. 2001. New Hampshire land cover assessment – 2001. 30m raster data. Available from GRANIT, University of New Hampshire.

Homer, J. 2005. Soil types corresponding to the NH Natural Heritage Bureau forest systems classification. U.S. Department of Agriculture, Natural Resource Conservation Service, Lancaster, NH, U.S.A., Unpublished Report to New Hampshire Fish and Game Department.

Keys, J.E. and C.A. Carpenter. 1995. Ecological units of the eastern United States: first approximation. U.S. Department of Agriculture, Forest Service.

Lambert, J. D., K. P. McFarland, C. C. Rimmer, S. D. Faccio, and J. L. Atwood. 2005. A practical model of Bicknell's Thrush distribution in the northeastern United States. Wilson Bulletin 117:1-11.

Natural Resources Conservation Service. Date varies, in progress with last revision in 2002. Soil Units of Rockingham, Sullivan, Cheshire, and Strafford Counties. Automated by and available from GRANIT, University of New Hampshire.

Sperduto, D, and M. Zankel. 2005. Distribution of matrix forest systems in New Hampshire by subsection, elevation, slope, and aspect. NH Department of Resources and Economic Development, Division of Forests and Lands, Natural Heritage Bureau, and The Nature Conservancy, Concord, NH, U.S.A. Unpublished Report to New Hampshire Fish and Game Department.

The Nature Conservancy, Conservation Science Support. 2003. Ecological Land Units. 30m raster data. Available from TNC, Eastern Resource Office, Boston, MA.

United States Geological Survey. Date varies, complete by 2003. National Elevation Dataset. 30m raster data. Projected by Complex Systems Research Center in January 2005, available from GRANIT, University of New Hampshire.Twith most of New Hampshire's potential lowland spruce-fir forest area.

HABITAT PROFILE

Northern Hardwood - Conifer Forest

Associated Species: Ruffed grouse, American woodcock, wood thrush, veery, Canada warbler, cerulean warbler, eastern pipistrelle, eastern red bat, hoary bat, northern long-eared bat, silver-haired bat, gray wolf. Global Rank: Not ranked
State Rank: Not ranked
Author: Carol R. Foss
Affiliation: Audubon Society of New Hampshire

Element 1: Distribution and Habitat

1.1 Habitat description

New Hampshire's northern hardwood forests are characterized by Fagus grandifolia (American beech), Acer saccharum (sugar maple), and Betula alleghaniensis (yellow birch). In latitude and elevation, these northern hardwood forests are positioned between the high-elevation spruce - fir forest and hemlock – hardwood – pine forest systems. Northern hardwood forests are generally found between 1,400 and 2,500 ft. in elevation in northern New Hampshire and along the western highlands (Sunapee Uplands subsection), although the tolerance of individual species varies. Some occurrences can be found down to about 1,000 ft. elevation.

The upslope transition to spruce - fir forest is marked by the appearance of Picea rubens (red spruce), Abies balsamea (balsam fir), the increased importance of yellow birch, and the disappearance of sugar maple and beech; the downslope transition to the hemlock – hardwood – pine forest system is marked by the appearance of more Tsuga canadensis (hemlock) along with Quercus rubra (red oak), Pinus strobus (white pine), and occasionally Ostrya virginiana (ironwood) and decreased dominance of yellow birch and sugar maple.

This system is a matrix of sugar maple, beech, and yellow birch forest and mixes with patches of several other communities. Hemlock - beech - northern hardwood forests occur at lower elevations (800 to 2,000 ft.) and are differentiated from the matrix community by a substantial presence of hemlock. It occurs in valley bottoms and lower mountain slopes of the White Mountains, and middle to higher elevations of hills and low mountains of the Sunapee Uplands subsection of western New Hampshire. Hemlock – spruce – northern hardwood forests are also found at elevations below 2,000 ft. This is a conifer to mixed community type with considerable hemlock and spruce mixing with variable amounts of birches, other northern hardwoods, balsam fir, and sometimes white pine. It occurs primarily on river terraces, stream ravines, and compact till settings in the mountains where it transitions to more pure northern hardwoods on better soils (e.g., fine tills). Semi-rich mesic sugar maple forests are a common but relatively small part of the mosaic formed by this system where there is slightly enriched till or fine river terrace sediments. Both beech forest and hemlock forest types are occasional in this and the hemlock – hardwood – pine forest systems, but generally form relatively small patches. Northern hardwood - spruce - fir forests mark the transition to high-elevation spruce-fir forest, but in most cases are considered part of the northern hardwood – conifer forest system because the hardwood trees that disappear in high-elevation spruce - fir (due to climate and/or soil conditions) are still present. Some spruce – fir or mixed forests that have been cut or heavily disturbed may currently support a hardwood or mixed forest canopy, and may or may not succeed to greater spruce – fir prominence.

Herbs such as Aralia nudicaulis (wild sarsaparilla) and Trientalis borealis (starflower) are common to both transitional and northern hardwood forests. Species of the northern hardwood forests generally not found in transitional forests include Dryopteris campyloptera (mountain wood fern), Lonicera canadensis (Ca-

nadian honeysuckle), Polystichum braunii (Braun's holly fern), and other northern herbs also found in the spruce - fir forest. Species that tend to be more abundant in northern hardwoods including Oxalis acetosella (northern wood sorrel), Huperzia lucidula (shining clubmoss), Clintonia borealis (blue-bead lily), and Streptopus spp. (twisted stalks).

Diagnostic natural communities:

- Sugar maple - beech - yellow birch forest (S5) – matrix forest type
- Hemlock – spruce – northern hardwood forest (S3S4)
- Hemlock - beech - northern hardwood forest (S4)
- Semi-rich mesic sugar maple forest (S3S4)
- Northern hardwood - spruce - fir forest (S4)

Peripheral or occasional natural communities:

- Beech forest (S4)
- Hemlock forest (S4)

Associated natural community systems: Northern hardwood – conifer forest systems transition upslope to high-elevation spruce - fir forest systems. Downslope they transition to either 1) hemlock – hardwood – pine forest systems, especially in low elevation valleys of White Mountains and further south; or 2) lowland spruce – fir forest/swamp systems in the North Country and some valley bottoms in the White Mountains.

1.2 Justification

Northern hardwood-conifer forest covers approximately 20% of New Hampshire. Available data indicate that approximately 19% of the state's potential Northern Hardwood-Conifer forest is on permanently protected lands. This forest type supports 137 vertebrate species in the state, including 42 mammals, 73 birds, 8 reptiles, and 14 amphibians. Threatened and endangered wildlife species occurring in this forest type include osprey, Cooper's hawk, Peregrine falcon, and Bald Eagle. Development pressure is heavy within some parts of the range of Hemlock-Hardwood-Pine forest in New Hampshire, particularly in the Lakes Region and the perimeter of the WMNF. A full range of age classes well distributed on the landscape is important to support the diversity of wildlife species that depend on this forest type.

1.3 Protection and Regulatory Status

Much of New Hampshire's northern hardwood-conifer forest is under private management for production of pulp, veneer, and lumber. Approximately 40% of this forest type occurs on conservation lands. Public ownerships include the WMNF, Lake Umbagog National Wildlife Refuge, various state lands, and town forests and conservation lands. Several non-governmental conservation organizations also hold northern hardwood-conifer forest lands in fee or easement. Forestry on state lands is covered by RSAs 216, 217, and 218. RSA 227 stipulates requirements for residual basal area in riparian areas. The manuals "Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire" (Cullen 1996) and "Good Forestry in the Granite State" (FSSWT 1996) provide recommended management practices for sustainable forestry in New Hampshire.

1.4 Distribution

Northern Hardwood-Conifer forest occurs primarily in northern New Hampshire, with approximately 45% by area in Coos County and approximately 30% in Grafton County. Carroll and Sullivan counties support 5 to 10%, and Belknap, Cheshire, and Hillsborough counties support less than 5%.

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

To develop a map of northern hardwood-conifer forest in New Hampshire a model was developed for each ecoregion subsection of the state based on the 2001 New Hampshire Land Cover Assessment, elevation, and landform (Keys and Carpenter 1995, Sperduto and Zankel 2005). The model was developed by experts from TNC and NHNHB.

First, relevant 2001 New Hampshire Land Cover Assessment grid values were selected and combined with elevations from 500 to 1,400 feet extracted from the USGS National Elevation Dataset (CSRC 2001,

USGS 2003). Appropriate elevation ranges were determined for each of New Hampshire's 9 ecoregional subsections in which northern hardwood-conifer was expected to occur. Ecological Land Units, created by TNC's Conservation Science Support, were then added to capture additional areas likely to have geophysical conditions favorable to northern hardwood-conifer, or remove areas likely to have geo-physical conditions unfavorable to northern hardwood-conifer (TNC 2003). Specifically, south-facing sideslopes and south-facing coves were removed from some land cover/elevation groups, and some land cover/elevation groups were restricted to only north-facing sideslopes and north-facing coves.

NHFG had previously completed a model to map high-elevation spruce fir in New Hampshire, based on a Vermont Institute of Natural Science (VINS: Lambert et al. 2005) elevation threshold, which depicts the lower elevation limit of Bicknell's Thrush habitat, Hale's (in press) Bicknell's Thrush probability surface, and NHNHB exemplary high-elevation spruce-fir natural communities. Some areas fell between the lowest elevation of this high-elevation spruce fir model, and the upper elevation of the northern hardwood conifer model. Areas in this gap that met the other requirements for northern hardwood conifer were assigned to the northern hardwood conifer matrix type. Soils were not used in this model. NHFG then applied a filter to determine the majority forest type between neighboring polygons in the TNC model and smoothed the boundaries to generalize the transition between matrix forest types.

The lowland spruce-fir model layer was used to erase some areas of overlap from the northern hardwood-conifer layer, so that the lowland spruce fir model was considered to take precedence over the northern hardwood-conifer model. Criteria for the lowland spruce-fir model were based on more information than the northern hardwood-conifer model, and without the lowland spruce-fir precedence lowland spruce-fir appeared to be underpredicted.

Model results were reviewed by experts from TNC, NHFG, and NHB, who agreed that the broad patterns depicted by the model align with reasonable expectations. No ground truthing was conducted. This version of the model is considered a first version, and further refinements may be developed in the future.

1.7 Sources of Information

The Northern hardwood-conifer map was developed based on expert input from scientists from NHNHB and the New Hampshire Chapter of TNC. The results were reviewed by additional scientists from NHFG and ASNH. A variety of GIS data were used to generate the map, including USGS elevation data, landform data from TNC's eastern regional office, land cover data from the New Hampshire Landcover Assessment, among others.

1.8 Extent and Quality of Data

The habitat map is considered a first version but is thought to provide a useful depiction of broad landscape patterns. Additional refinements will likely be necessary based on ground truthing of the existing map. NRCS provided a table of soil series that were believed to be strongly correlated with northern hardwood-conifer forest (Homer 2005). Soils series were provided by ecoregional subsection and elevation ranges. There was considerable overlap between series outlined for northern hardwood-conifer and some of the other forest types. Thus, additional review and refinement are necessary prior to incorporating soils into a northern hardwood-conifer model. This was not possible for this initial version.

1.9 Distribution Research

Additional fieldwork is needed to evaluate correlations between soil series and forest type as outlined in Homer (2005). County soil surveys outline soils suitable for forestry from an economic perspective. However, little has been done to evaluate soils from an ecological perspective (e.g., if left unmanaged, an area with a particular soil would eventually succeed to northern hardwood-conifer forest).

a) Fieldwork is also needed to ground truth the northern hardwood-conifer map to assist with refining it.

b) Spatially explicit information on age-class distribution for this forest type is needed.

Element 2: Species/Habitat Condition

2.1 Scale

County

2.2 Relative Health of Populations

Relative Health of Populations: An approximately 3% decrease in forest area occurred between 1992 and 1993 and 2001 in the two-county area where approximately 80% of New Hampshire's potential Northern Hardwood-Conifer forest occurs. An additional approximately 1% decrease is projected to occur between 2001 and 2025 (Calculated from data in SPNHF 2005).

2.4 Relative Quality of Habitat Patches

Analysis pending.

2.5 Habitat Patch Protection Status

Approximately 40% of potential Northern Hardwood-Conifer forest in the two-county area where approximately 80% of this forest type occurs is in conservation ownership (calculated from TNC and SPNHF data).

2.6 Habitat Management Status

Certified Tree Farms cover approximately 55% of the two-county area in which approximately 80% of New Hampshire's potential Northern Hardwood-Conifer forest area occurs (calculated from TNC data and data in Thorne and Sundquist 2001).

2.7 Sources of Information

See 1.7

2.8 Extent and Quality of Data

See 1.8 regarding extent and quality of data associated with the TNC matrix forest map. Tree farm data from Thorne and Sundquist 2001 are based on a New Hampshire Tree Farm program database issued in August 2000. Data regarding changes in forest area from SPNHF 2005 include information from the New Hampshire Land Cover Assessment, 2001 and results of predictive modeling.

2.9 Condition Assessment Research

- Research is needed to determine the extent of this forest type that occurs in large unfragmented blocks.
- Research is needed to determine the age class distribution of this forest type on the landscape.

Element 3: Species and Habitat Threat Assessment

3.1.1 Acid Deposition

(A) Exposure Pathway: Combustion in vehicle engines, power plants, and other industrial processes generates nitrogen oxides and sulfur oxides, which enter the atmosphere and are transformed into acids. These chemicals can travel for hundreds of miles in the upper atmosphere before returning to earth as acid precipitation or dry deposition. In New Hampshire, vehicles generate 51% of nitrogen oxide emissions, while power plants generate 90% of sulfur oxide emissions and 39% of nitrogen emissions (NHDES 1989). However, much of the acidic deposition in the state comes from heavily industrialized areas in the mid-western and south-western United States (New Hampshire Comparative Risk Project 1997).

(B) Direct Evidence: Northern New Hampshire, where most of the State's Northern Hardwood-Conifer forest is located, lies within an area of particularly low pH precipitation and high nitrate and excess sulfate deposition (Freedman 1995). Long-term data from the Hubbard Brook Experimental Forest document a long history of severe acid deposition (Likens et al. 1984).

3.2 Sources of Information

Threat information was derived from a work session with forestry professionals and stakeholders, available data, published literature, and personal experience.

3.3 Extent and Quality of Data

Threats to Northern Hardwood – Conifer forest

resulting directly or indirectly from acid deposition, land conversion, and development are well-documented.

3.4 Threat Assessment Research

Long-term research regarding levels and effects of acid deposition is being addressed by the Hubbard Brook Experimental Forest.

Research to evaluate relative development pressure and vulnerability of different geographic areas within the range of Northern Hardwood – Conifer Forest would help to prioritize areas for protection and for application of land-use planning tools.
Element 4: Conservation Actions

4.1.1. Incorporate Habitat Conservation into Local Land Use Planning
See Strategies: Local Regulation and Policy

4.1.2. Advise Conservation Commissions and Open Space Committees
See Strategies: Local Regulation and Policy, Education and Outreach

4.1.3. Promote Role of the Regional Planning Commissions in Landscape-Scale Conservation
See Strategies: Local Regulation and Policy

4.1.4. Protect unfragmented blocks and other key wildlife habitats.
See Strategies: Land Protection

4.1.5. Develop a comprehensive land protection support program.
See Strategies: Land Protection

4.1.6. Advocate adoption of sustainable forestry.
See Strategies: Education and Outreach

4.1.7. Establish IRAT for pollutants to address acid deposition.
See Strategies: Interagency Regulation and Policy

4.2 Conservation Action Research

Research is needed to provide a scientific basis for new tools to help municipalities maintain large forest blocks and significant wildlife habitat in the face of development. Such research could examine:

- Road noise effects on forest bird distribution and breeding status
- Behavior and land use of mesocarnivores in relation to development and road densities
- Bear use of mast stands as a function of proximity to development
- Effects of residential lot sizes on habitat suitability and landscape permeability for selected wildlife species

and similar topics.

Element 5: References

5.1 Literature

Keys, J.E. and C.A. Carpenter. 1995. Ecological units of the eastern United States: first approximation. U.S. Department of Agriculture, Forest Service.

Lambert, J. D., K. P. McFarland, C. C. Rimmer, S. D. Faccio, and J. L. Atwood. 2005. A practical model of Bicknell's Thrush distribution in the northeastern United States. Wilson Bulletin 117:1-11.

Sperduto, D, and M. Zankel. 2005. Distribution of matrix forest systems in New Hampshire by subsection, elevation, slope, and aspect. NH Department of Resources and Economic Development, Division of Forests and Lands, Natural Heritage Bureau, and The Nature Conservancy, Concord, NH, U.S.A. Unpublished Report to New Hampshire Fish and Game Department.

5.2 Data sources

Complex Systems Research Center. 2001. New Hampshire land cover assessment – 2001. 30m raster data. Available from GRANIT, University of New Hampshire.

Homer, J. 2005. Soil types corresponding to the NH Natural Heritage Bureau forest systems classification. U.S. Department of Agriculture, Natural Resource Conservation Service, Lancaster, NH, U.S.A., Unpublished Report to New Hampshire Fish and Game Department.

Miles, P.D. May 11, 2005. Forest inventory mapmaker web-application version 1.7, St. Paul, MN: U.S.

Departmetn of Agriculture, Forest Service, North Central Research Station [www.ncrs2.fs.fed.us/4801/fiab/index.htm]

Natural Resources Conservation Service. Date varies, in progress with last revision in 2002. Soil Units of Rockingham, Sullivan, Cheshire, and Strafford Counties. Automated by and available from GRANIT, University of New Hampshire.

New Hampshire Natural Heritage Bureau. January 2005. Exemplary Natural Community Data. Scale varies, vector data. Available with permission from the NH Natural Heritage Bureau.

Sperduto, D, and M. Zankel. 2005. Distribution of matrix forest systems in New Hampshire by subsection, elevation, slope, and aspect. NH Department of Resources and Economic Development, Division of Forests and Lands, Natural Heritage Bureau, and The Nature Conservancy, Concord, NH, U.S.A. Unpublished Report to New Hampshire Fish and Game Department.

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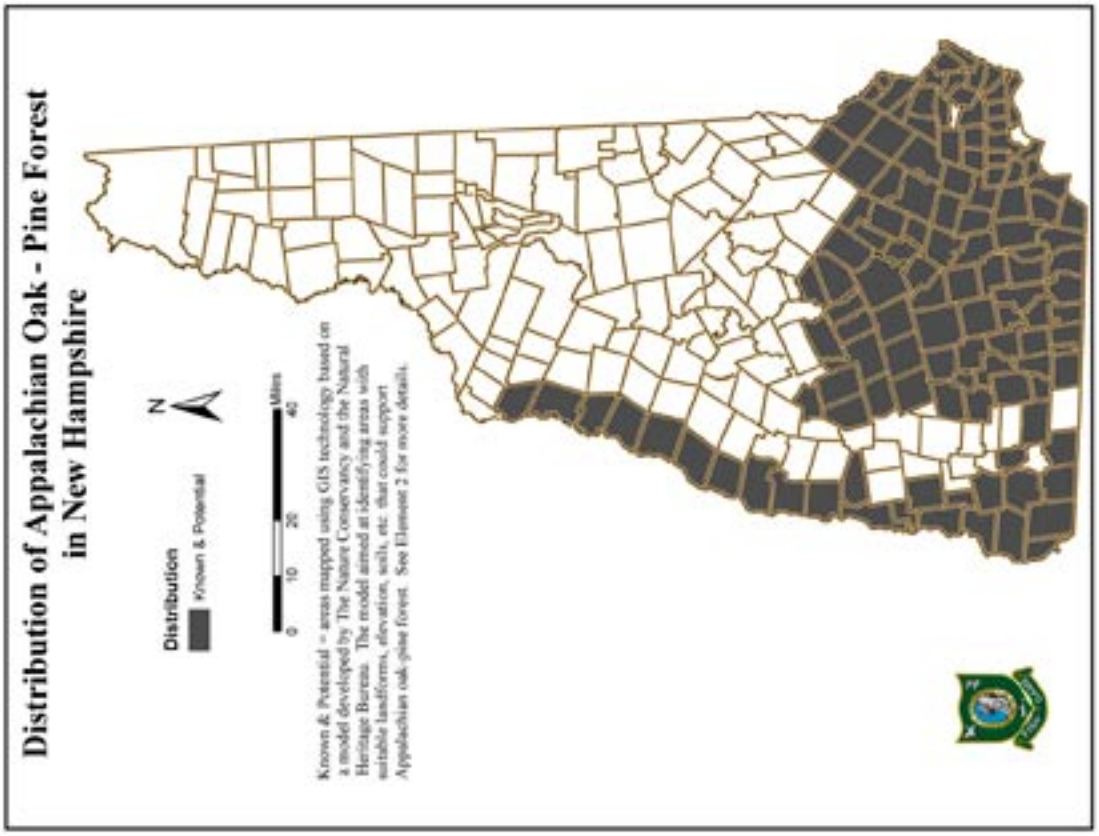
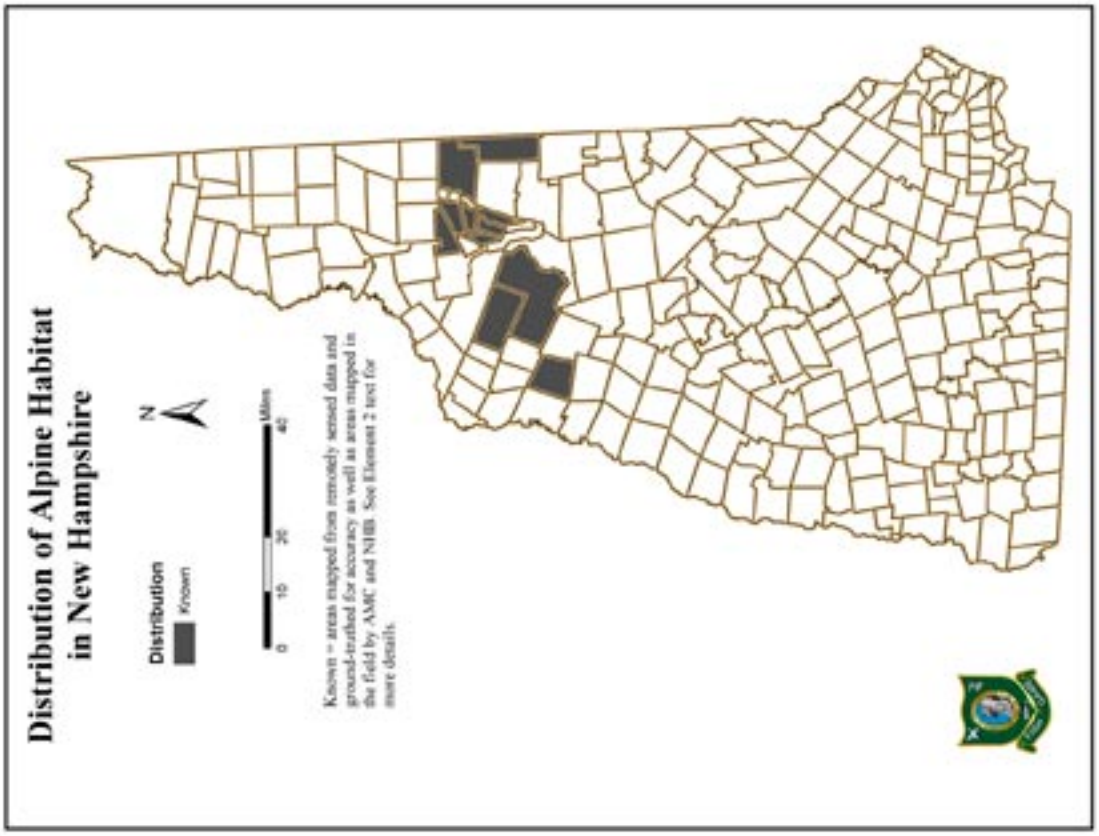
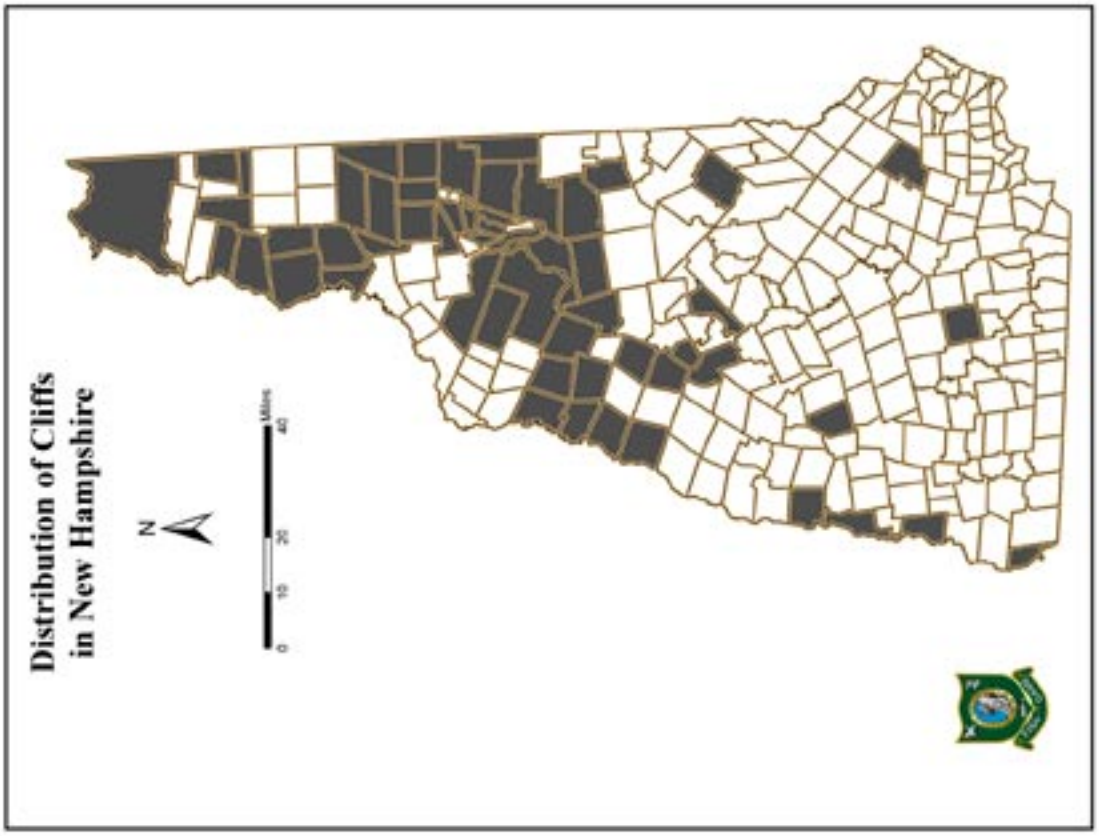
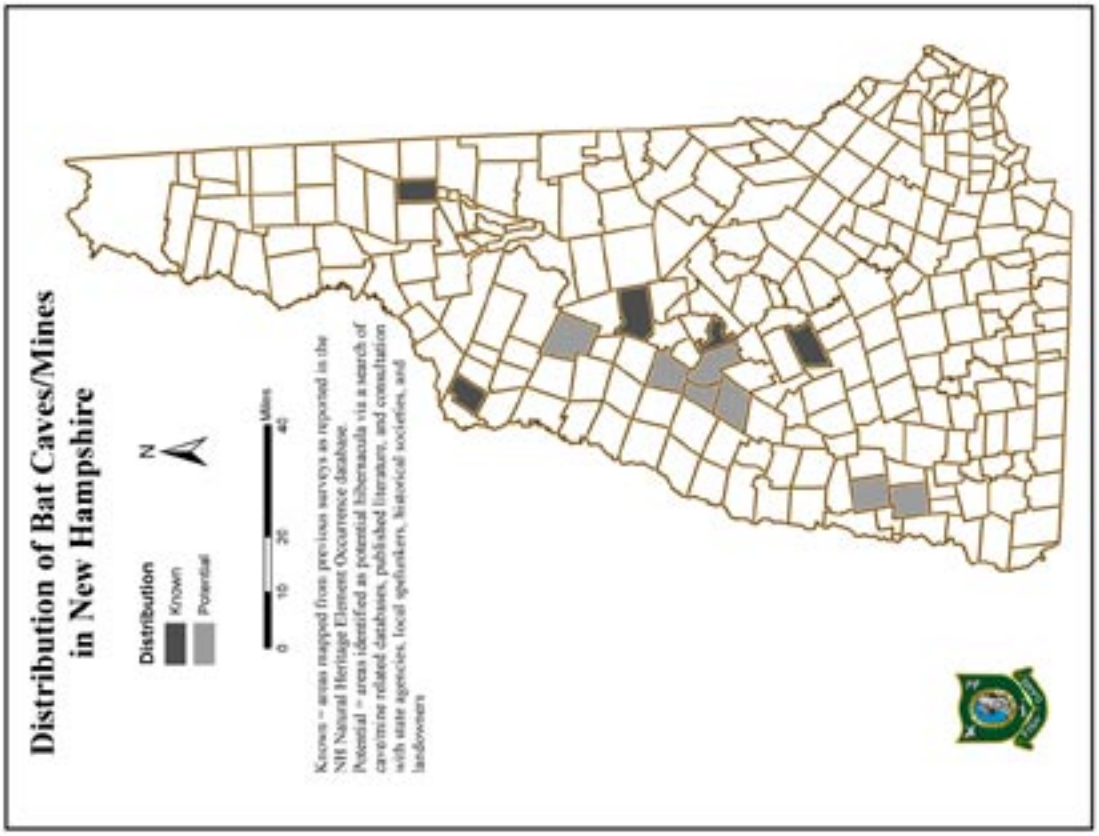
United States Geological Survey. Date varies, complete by 2003. National Elevation Dataset. 30m raster data. Projected by Complex Systems Research Center in January 2005, available from GRANIT, University of New Hampshire.

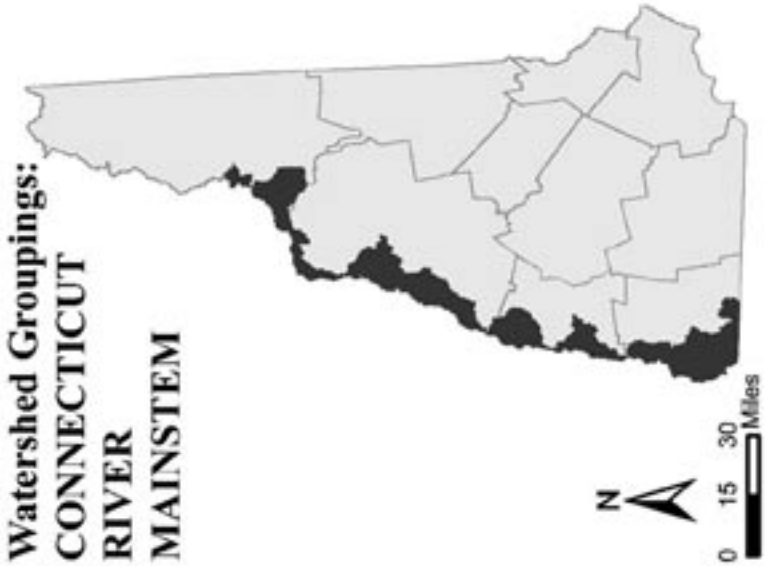
Mammal Maps

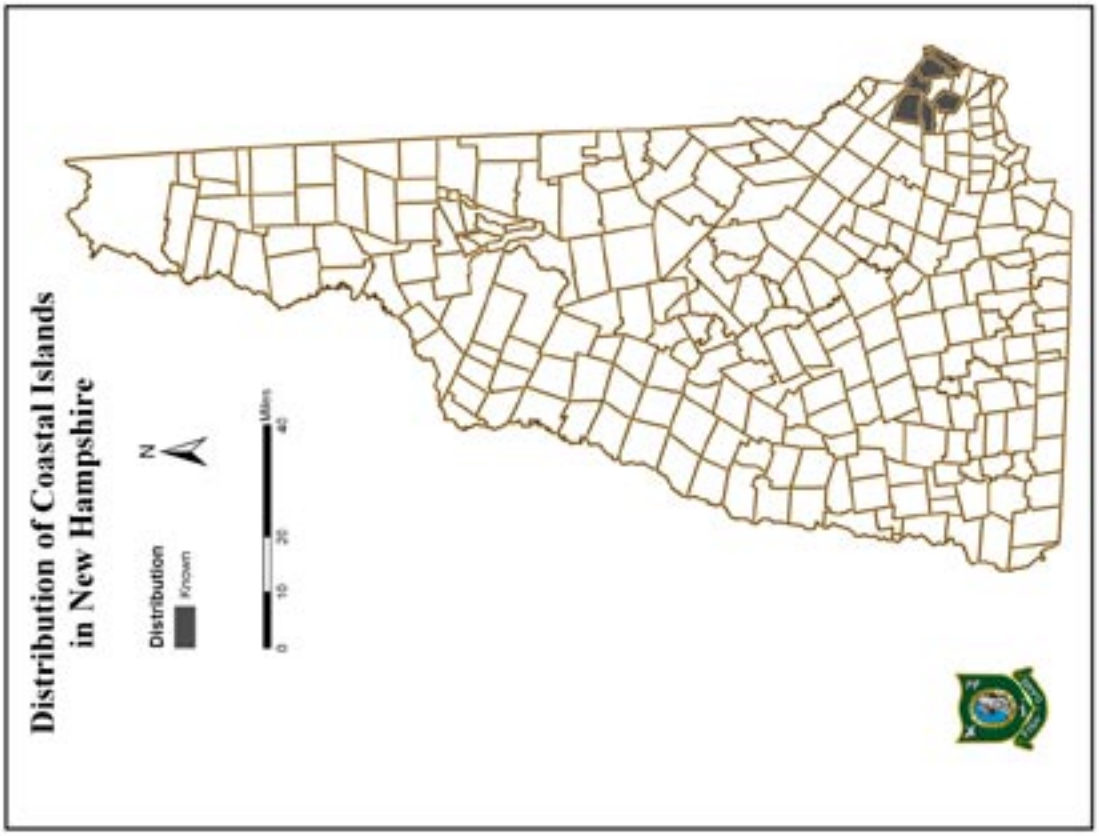

Distribution of Appalachian Oak - Pine Forest in New Hampshire
Distribution
Known & Potential
N
0 10 20 40 Miles
Known & Potential = areas mapped using GIS technology based on a model developed by The Nature Conservancy and the Natural Heritage Bureau. The model aimed at identifying areas with suitable landforms, elevation, soils, etc. that could support Appalachian oak-pine forest. See Element 2 for more details.

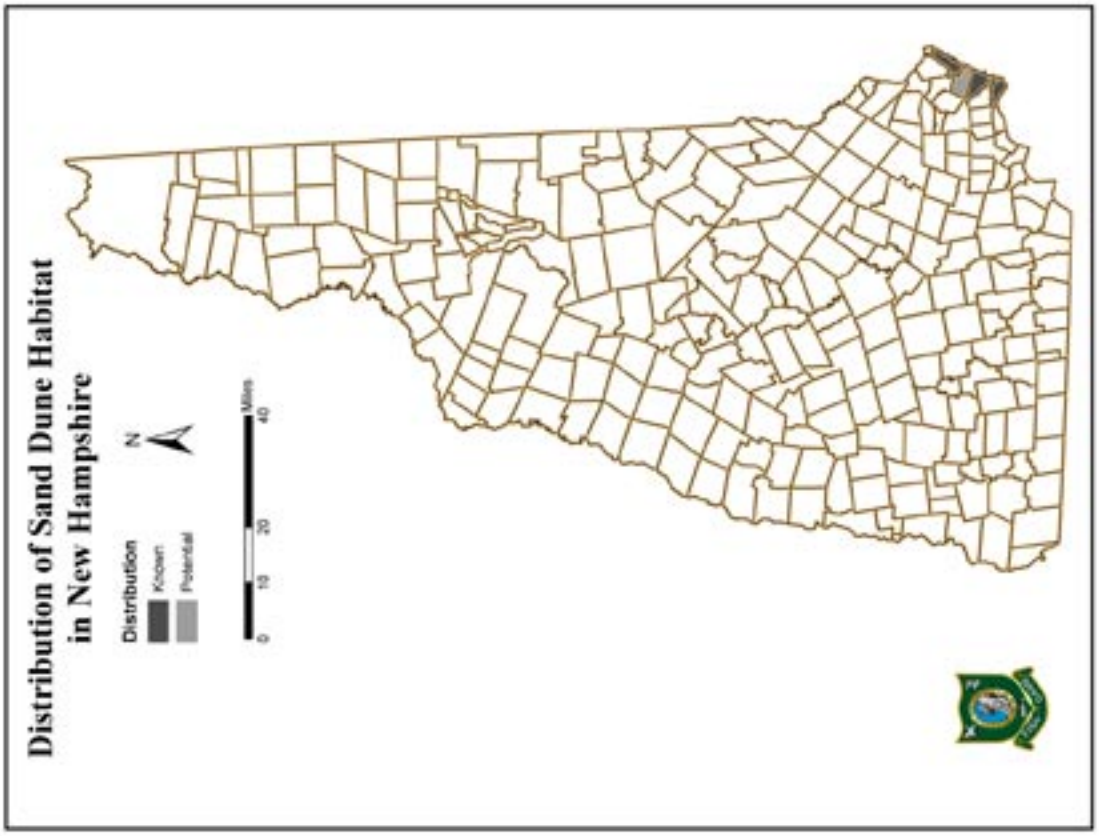

Distribution of Alpine Habitat in New Hampshire
Distribution
Known
N
0 10 20 40 Miles
Known = areas mapped from remotely sensed data and ground-truthed for accuracy as well as areas mapped in the field by AMC and NHB. See Element 2 text for more details.

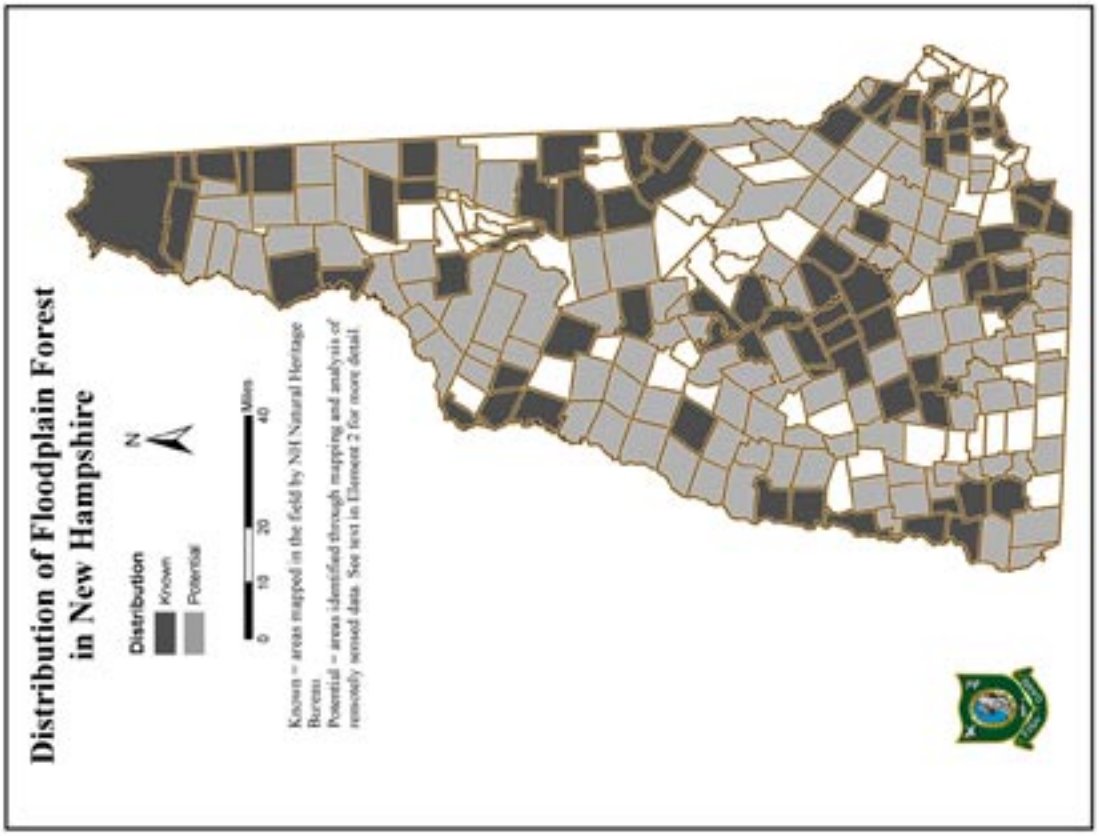

Distribution of Cliffs
in New Hampshire
N
0
10
20
40
Miles


Distribution of Bat Caves/Mines
in New Hampshire
Distribution
Known
Potential
N
0
10
20
40
Miles
Known = areas mapped from previous surveys as reported in the NH Natural Heritage Element Occurrence database.
Potential = areas identified as potential hibernacula via a search of caverns/mine related databases, published literature, and consultation with state agencies, local spelunkers, historical societies, and landowners

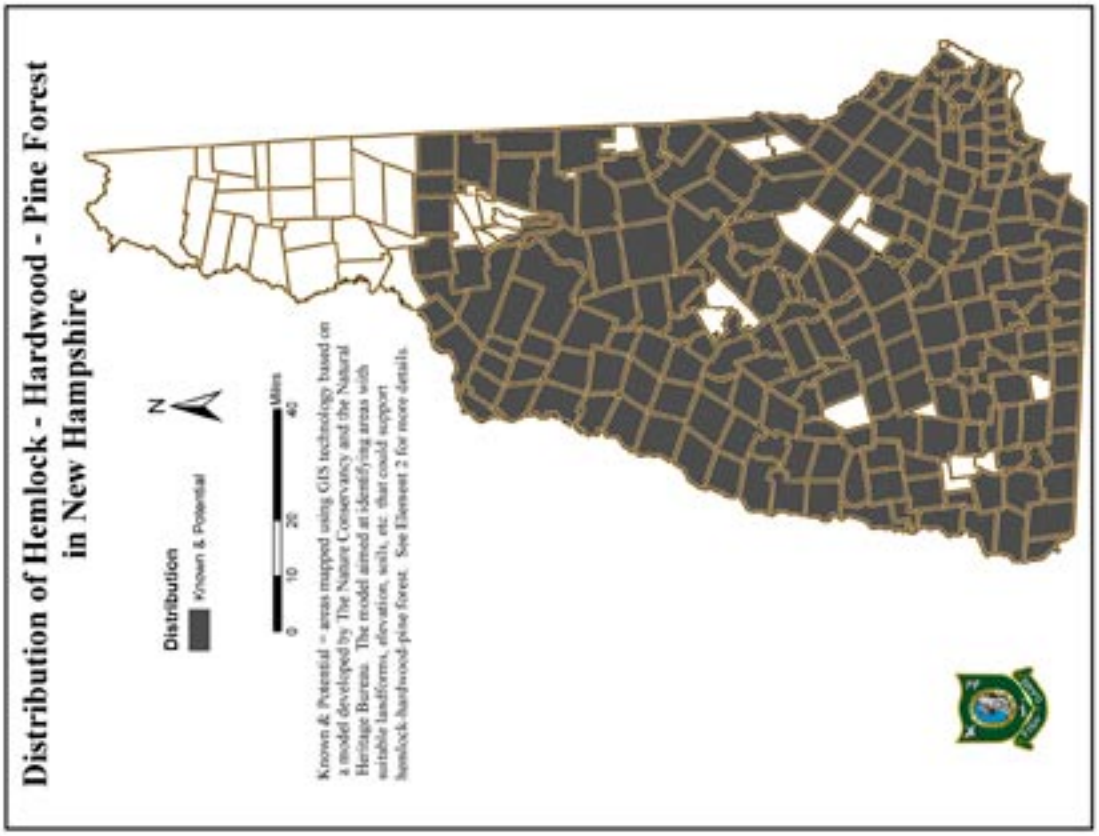

Watershed Groupings:
CONNECTICUT
RIVER
MAINSTEM
N
0 15 30 Miles

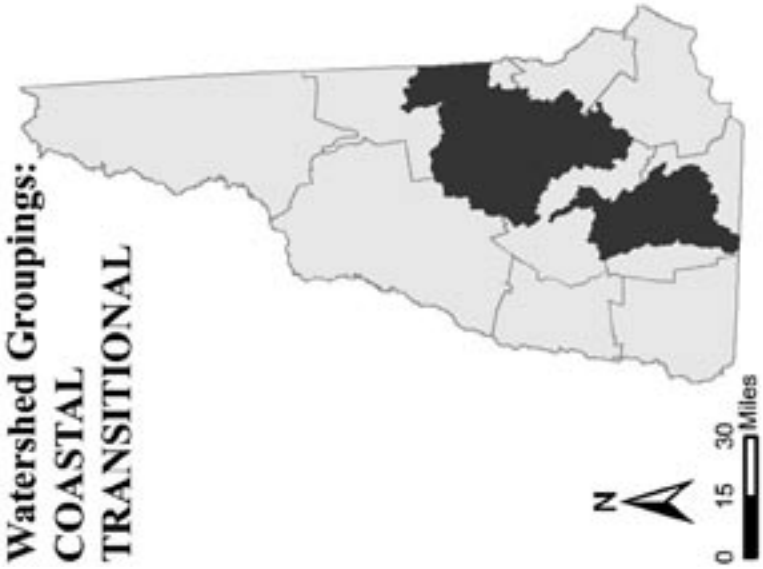

Distribution of Coastal Islands
in New Hampshire
Distribution
Known
N
0 10 20 40 Miles


Distribution of Sand Dune Habitat
in New Hampshire
Distribution
Known
Potential
N
0
10
20
40
Miles

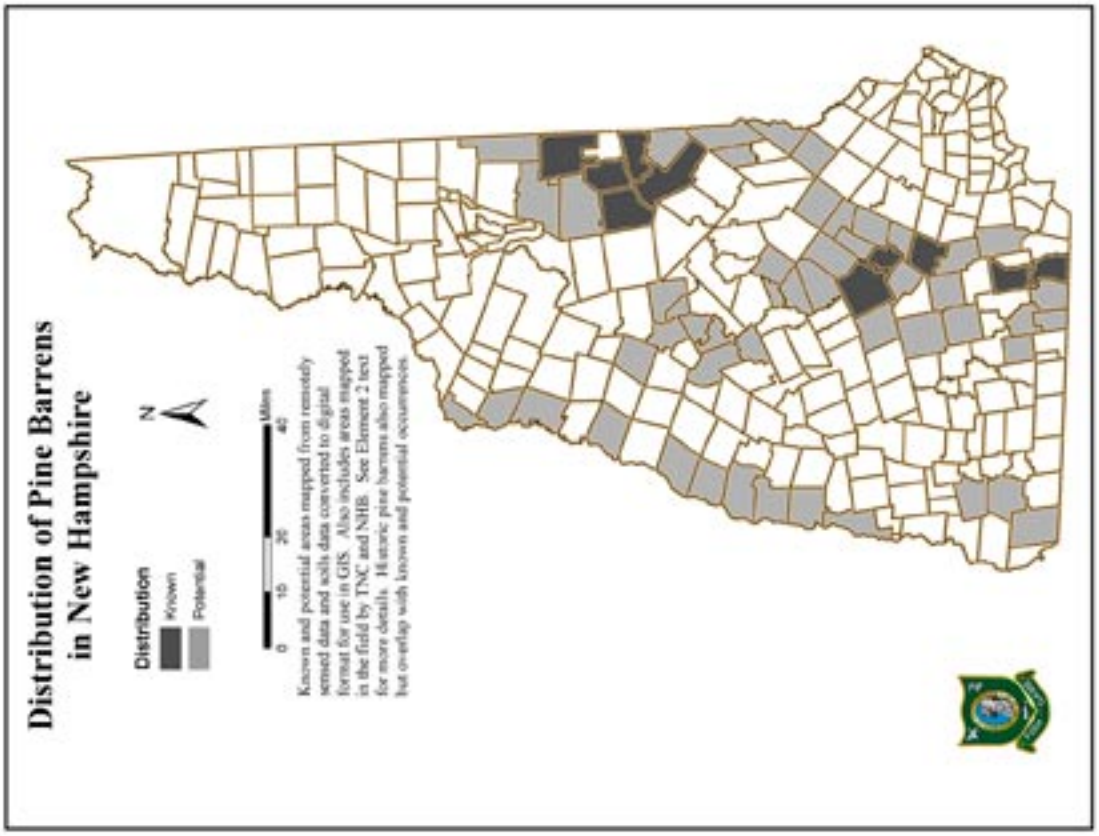

Distribution of Floodplain Forest
in New Hampshire
Distribution
Known
Potential
N
0
10
20
40
Miles
Known = areas mapped in the field by NH Natural Heritage Bureau
Potential = areas identified through mapping and analysis of remotely sensed data. See text in Element 2 for more detail

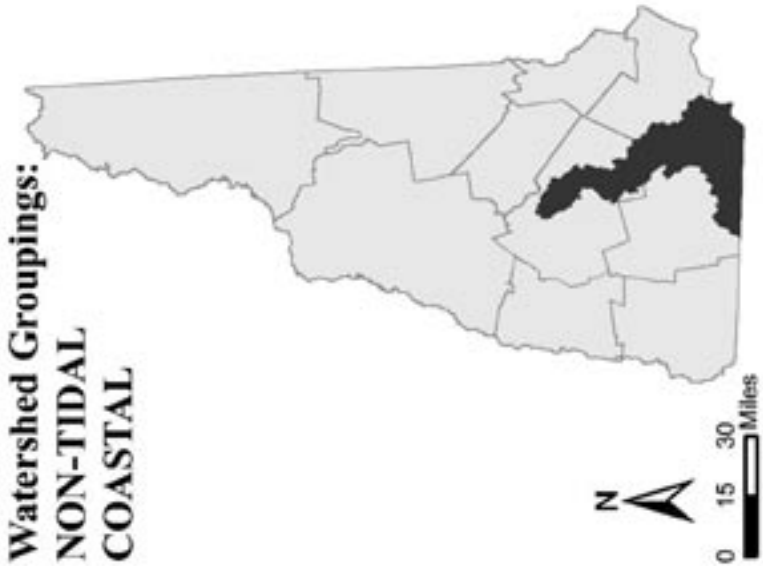
Distribution of Extensive Grasslands in New Hampshire
Distribution
Known
N
0
10
20
40
Miles

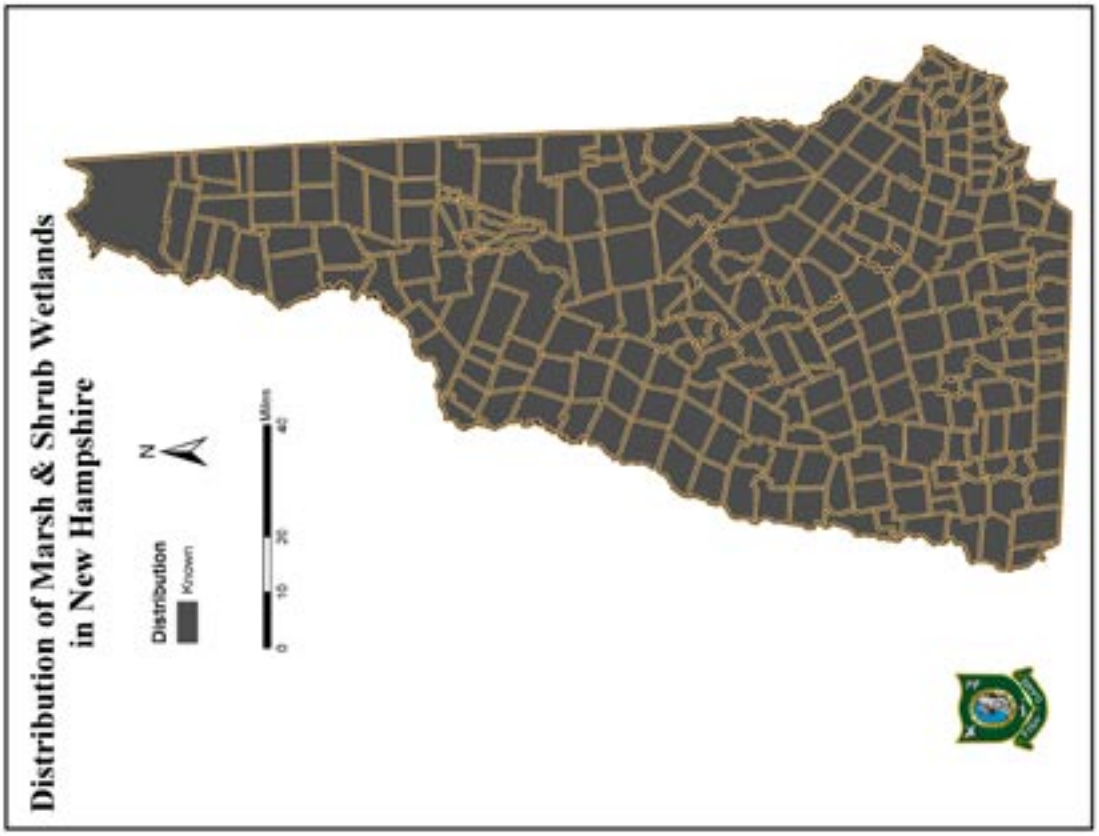

Distribution of Hemlock - Hardwood - Pine Forest in New Hampshire
Distribution
Known & Potential
N
0
10
20
40
Miles
Known & Potential = areas mapped using GIS technology based on a model developed by The Nature Conservancy and the Natural Heritage Bureau. The model aimed at identifying areas with suitable landforms, elevation, soils, etc. that could support hemlock-hardwood-pine forest. See Element 2 for more details.

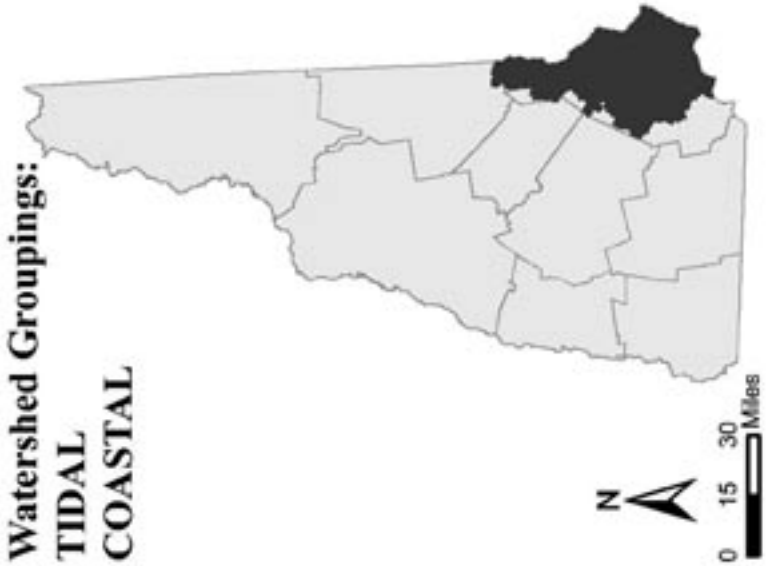

Watershed Groupings:
COASTAL
TRANSITIONAL
N
0 15 30 Miles

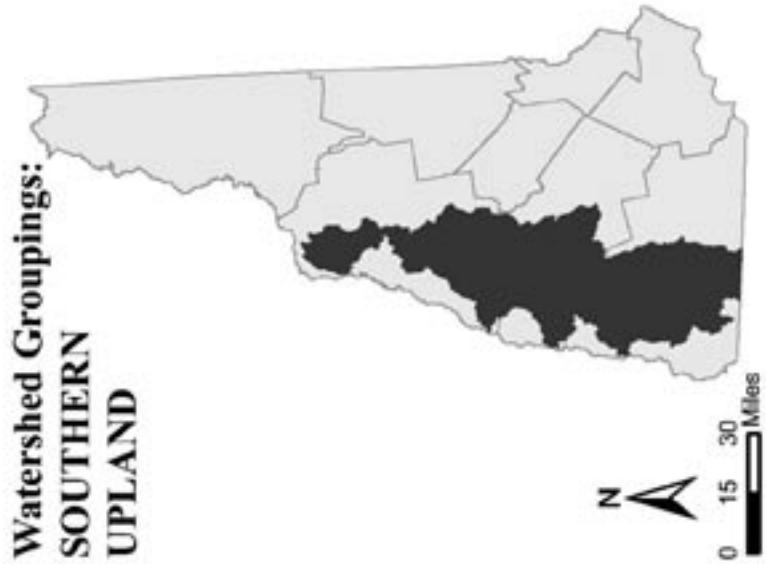
Distribution of High-Elevation Spruce-Fir Habitat
in New Hampshire
N
0 10 20 40 Miles

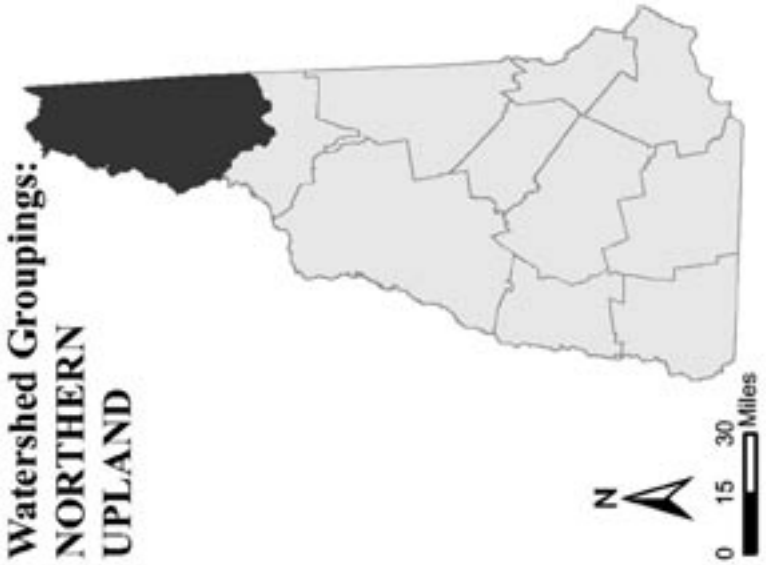

Distribution of Pine Barrens
in New Hampshire
Distribution
Known
Potential
N
0 15 30 45 Miles
Known and potential areas mapped from remotely sensed data and soils data converted to digital format for use in GIS. Also includes areas mapped in the field by TNC and NHB. See Element 2 text for more details. Historic pine barrens also mapped but overlap with known and potential occurrences.

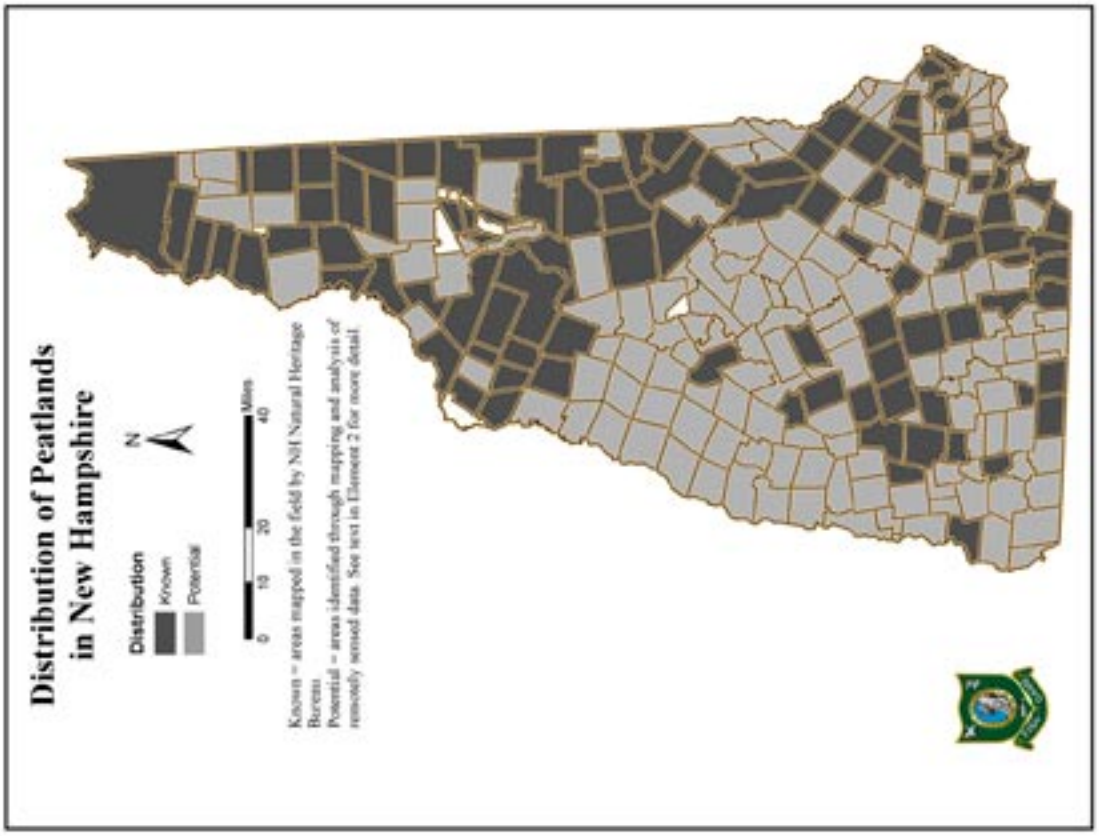

Watershed Groupings:
NON-TIDAL
COASTAL
N
0 15 30 Miles

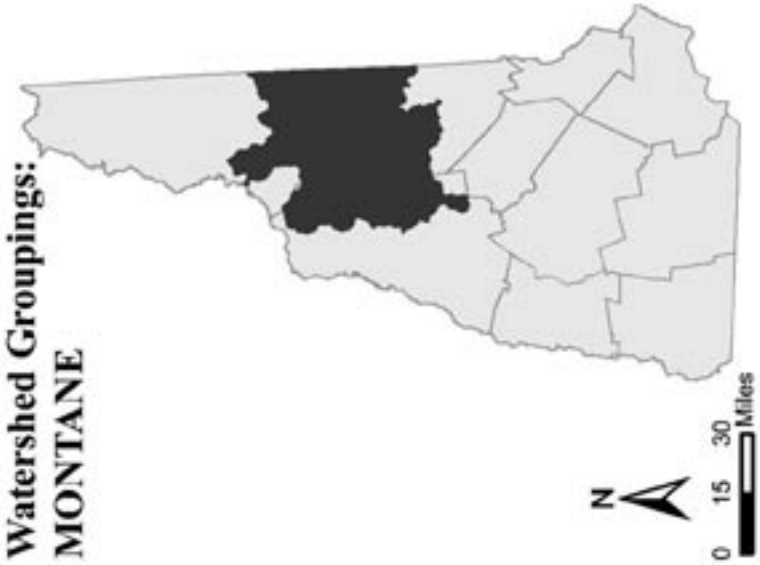

Distribution of Marsh & Shrub Wetlands
in New Hampshire
Distribution
Known
N
0
10
20
40
Miles

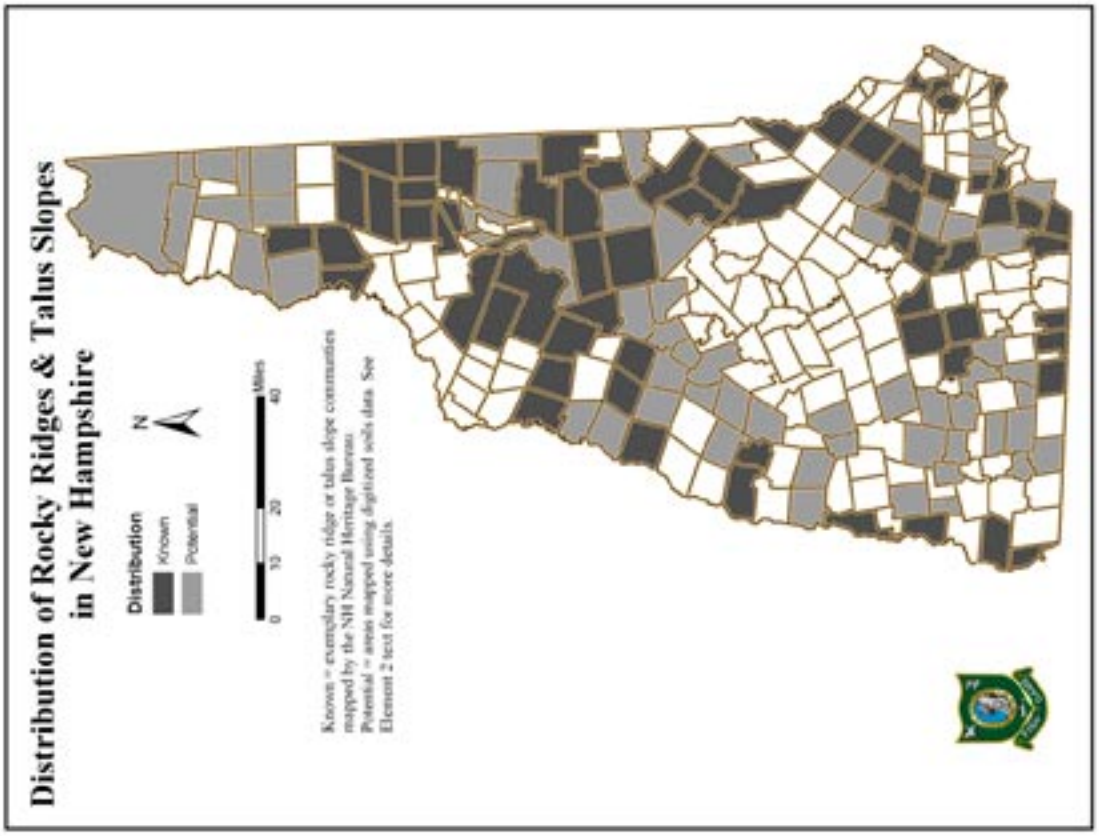

Watershed Groupings:
TIDAL
COASTAL
N
0
15
30
Miles


Watershed Groupings:
SOUTHERN
UPLAND
N
0 15 30 Miles

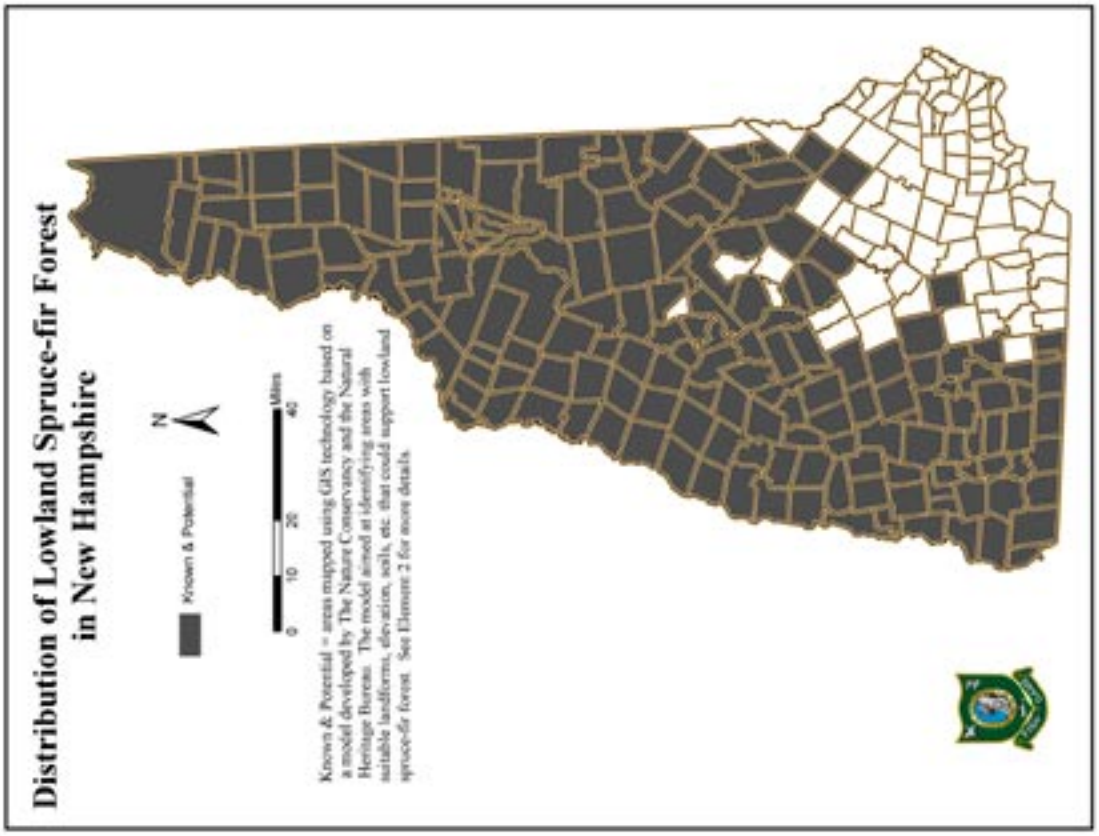

Watershed Groupings:
NORTHERN
UPLAND
N
0 15 30 Miles

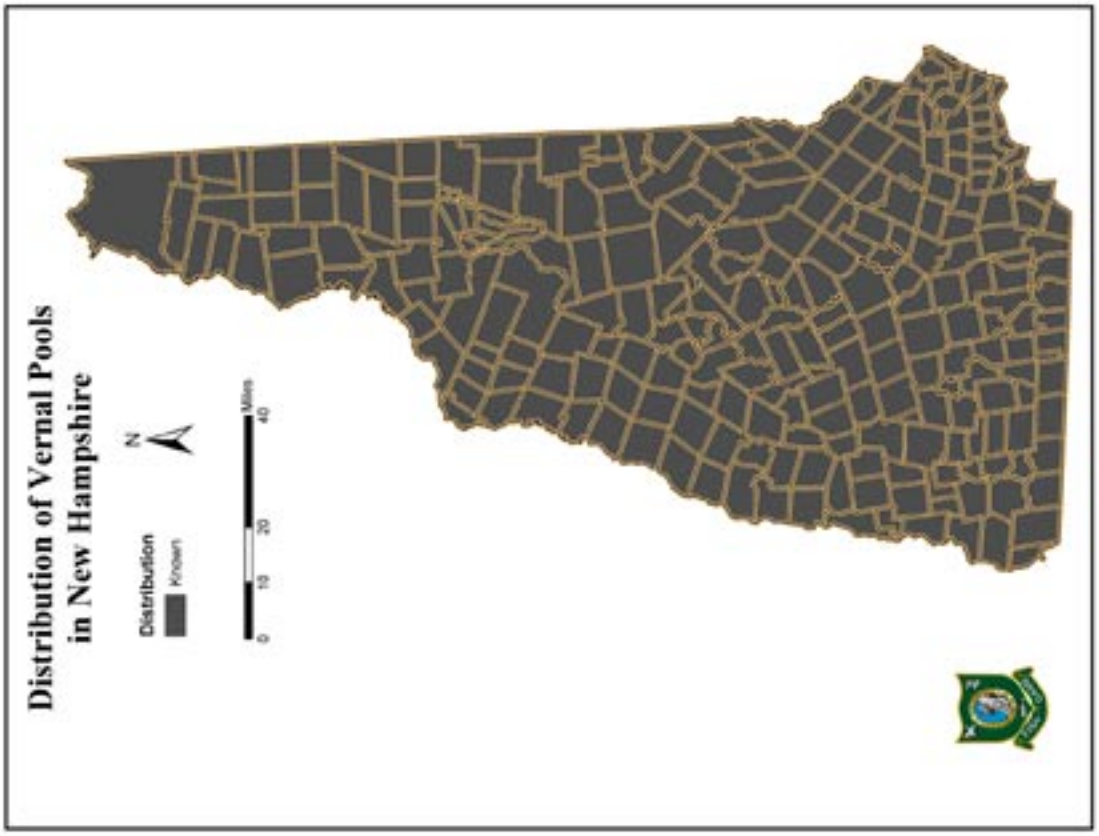

Distribution of Peatlands in New Hampshire
Distribution
Known
Potential
N
0 10 20 40 Miles
Known = areas mapped in the field by NH Natural Heritage Bureau
Potential = areas identified through mapping and analysis of remotely sensed data. See text in Element 2 for more detail

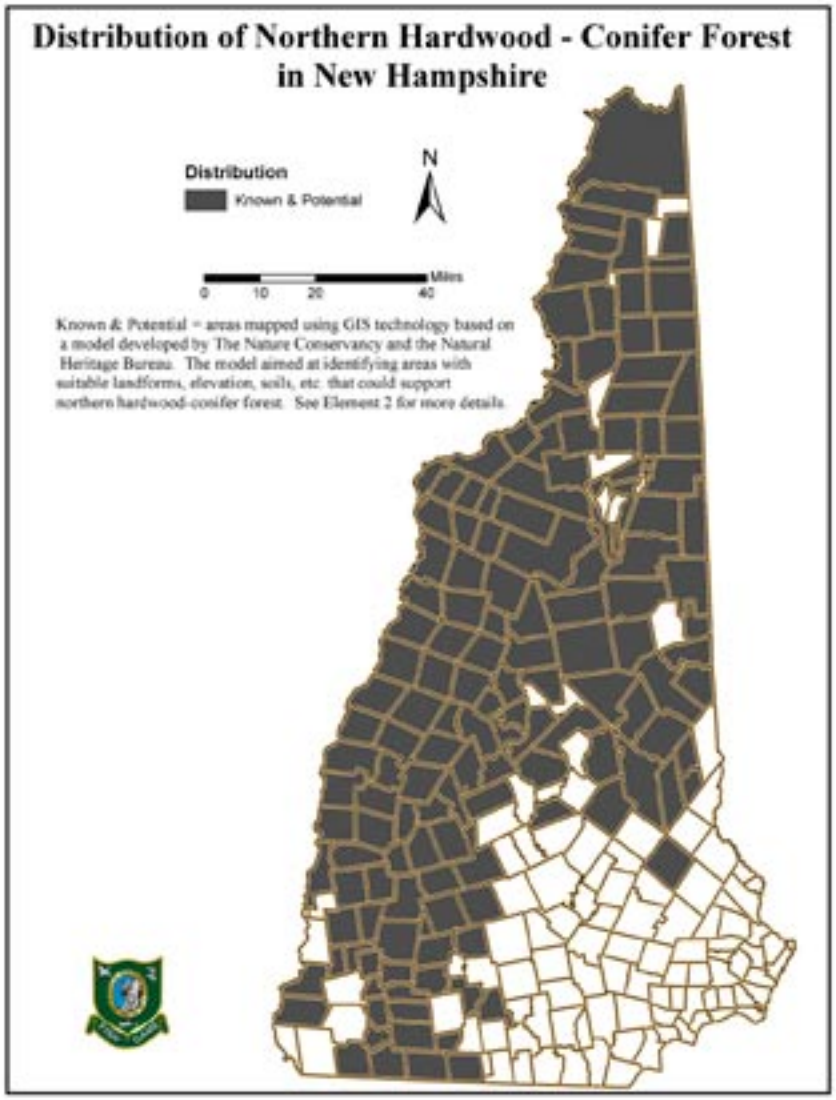

Watershed Groupings: MONTANE
N
0 15 30 Miles


Distribution of Rocky Ridges & Talus Slopes in New Hampshire
Distribution
Known
Potential
N
0
10
20
40
Miles
Known = exemplary rocky ridge or talus slope communities mapped by the NH Natural Heritage Bureau.
Potential = areas mapped using digitized soils data. See Element 2 text for more details.

Distribution of Saltmarsh in New Hampshire
Distribution
Known
N
0
10
20
40
Miles


Distribution of Lowland Spruce-fir Forest
in New Hampshire
Known & Potential
N
0 10 20 40
Miles
Known & Potential = areas mapped using GIS technology based on a model developed by The Nature Conservancy and the Natural Heritage Bureau. The model aimed at identifying areas with suitable landforms, elevation, soils, etc. that could support lowland spruce-fir forest. See Element 2 for more details.


Distribution of Vernal Pools
in New Hampshire
Distribution
Known
N
0 10 20 40
Miles


Distribution of Northern Hardwood - Conifer Forest in New Hampshire
Distribution
Known & Potential
N
Miles
0
10
20
40
Known & Potential = areas mapped using GIS technology based on a model developed by The Nature Conservancy and the Natural Heritage Bureau. The model aimed at identifying areas with suitable landforms, elevation, soils, etc. that could support northern hardwood-conifer forest. See Element 2 for more details.

Appendix C

New Hampshire's natural communities, natural community systems, and corresponding CWS habitat type. System abbreviations: LSF= Lowland Spruce - Fir Forest; HESF = High-Elevation Spruce - Fir Forest; NHC = Northern Hardwood - Conifer Forest; HHP = Hemlock - Hardwood - Pine Forest; AOP = Appalachian Oak - Pine Forest.

System	Component Natural Communities	Diagnostic (D) or Peripheral/ Occasional (P/O)	Primary Associated Matrix Forest System	Corresponding CWS Habitat Type
Alpine tundra	Diapensia shrubland	D	Above HESF	Alpine
Alpine tundra	Alpine heath snowbank	D	Above HESF	Alpine
Alpine tundra	Bigelow's sedge meadow	D	Above HESF	Alpine
Alpine tundra	Sedge - rush - heath meadow	D	Above HESF	Alpine
Alpine tundra	Felsenmeer	D	Above HESF	Alpine
Alpine tundra	Black spruce/balsam fir krummholz	P/O	Above HESF	Alpine
Alpine tundra	Labrador tea heath - krummholz	P/O	Above HESF	Alpine
Alpine tundra	Montane landslide	P/O	Above HESF	Alpine
Alpine tundra	Alpine herbaceous snowbank/rill	P/O	Above HESF	Alpine
Alpine tundra	Moist alpine herb - heath meadow	P/O	Above HESF	Alpine
Alpine tundra	Alpine cliff	P/O	Above HESF	Alpine
Alpine ravine/snowbank	Alpine herbaceous snowbank/rill	D	Above HESF	Alpine
Alpine ravine/snowbank	Alpine ravine shrub thicket	D	Above HESF	Alpine
Alpine ravine/snowbank	Black spruce/balsam fir krummholz	D	Above HESF	Alpine
Alpine ravine/snowbank	Montane landslide	D	Above HESF	Alpine
Alpine ravine/snowbank	Alpine cliff	D	Above HESF	Alpine
Alpine ravine/snowbank	Alpine heath snowbank	D	Above HESF	Alpine
Alpine ravine/snowbank	Subalpine cold-air talus barren	D	Above HESF	Alpine
Alpine ravine/snowbank	Labrador tea heath - krummholz	P/O	Above HESF	Alpine
Alpine ravine/snowbank	Subalpine sliding fen	P/O	Above HESF	Alpine
Alpine ravine/snowbank	Moist alpine herb - heath meadow	P/O	Above HESF	Alpine
Alpine ravine/snowbank	Sedge - rush - heath meadow	P/O	Above HESF	Alpine
bald	Dwarf shrub - bilberry - rush barren	D	Above HESF	Alpine
bald	Black spruce/balsam fir krummholz	D	Above HESF	Alpine
bald	Labrador tea heath - krummholz	D	Above HESF	Alpine

bald	Sheep laurel - Labrador tea heath - krummholz	D	Above HESF	Alpine
bald	Subalpine rocky bald	D	Above HESF	Alpine
bald	Diapensia shrubland	P/O	Above HESF	Alpine
bald	Red spruce - heath - cinquefoil rocky ridge	P/O	Above HESF	Alpine
bald	Montane heath woodland	P/O	Above HESF	Alpine
Montane cliff	Montane acidic cliff	D	HESF, NHC	Cliffs
Montane cliff	Montane circumneutral cliff	D	HESF, NHC	Cliffs
Montane cliff	Cliff seep	D	HESF, NHC	Cliffs
Montane cliff	Red spruce - heath - cinquefoil rocky ridge	P/O	HESF, NHC	Cliffs
Montane cliff	Circumneutral rocky ridge	P/O	HESF, NHC	Cliffs
Montane cliff	Alpine cliff	P/O	HESF, NHC	Cliffs
Temperate cliff	Lowland acidic cliff	D	HHP, AOP	Cliffs
Temperate cliff	Lowland circumneutral cliff	D	HHP, AOP	Cliffs
Temperate cliff	Cliff seep	D	HHP, AOP	Cliffs
Temperate cliff	Appalachian oak - pine rocky ridge	P/O	HHP, AOP	Cliffs
Montane rocky ridge	Red spruce - heath - cinquefoil rocky ridge	D	HESF, NHC, HHP	Rocky ridge & Talus slope - Rocky ridge
Montane rocky ridge	Red pine rocky ridge	D	HESF, NHC, HHP	Rocky ridge & Talus slope - Rocky ridge
Montane rocky ridge	Red oak - pine rocky ridge	D	HESF, NHC, HHP	Rocky ridge & Talus slope - Rocky ridge
Montane rocky ridge	Jack pine rocky ridge woodland	D	HESF, NHC, HHP	Rocky ridge & Talus slope - Rocky ridge
Montane rocky ridge	Montane heath woodland	D	HESF, NHC, HHP	Rocky ridge & Talus slope - Rocky ridge
Montane rocky ridge	Montane acidic cliff	P/O	HESF, NHC, HHP	Rocky ridge & Talus slope - Rocky ridge
Appalachian oak rocky ridge	Appalachian oak - pine rocky ridge	D	AOP, HHP	Rocky ridge & Talus slope - Rocky ridge
Appalachian oak rocky ridge	Chestnut oak forest/woodland	D	AOP, HHP	Rocky ridge & Talus slope - Rocky ridge
Appalachian oak rocky ridge	Dry Appalachian oak - hickory forest	P/O	AOP, HHP	Rocky ridge & Talus slope - Rocky ridge
Appalachian oak rocky ridge	Red oak - ironwood - Pennsylvania sedge woodland	P/O	AOP, HHP	Rocky ridge & Talus slope - Rocky ridge
Appalachian oak rocky ridge	Red oak - pine rocky ridge	P/O	AOP, HHP	Rocky ridge & Talus slope - Rocky ridge
Montane acidic talus	Spruce - birch - mountain maple wooded talus	D	HESF, NHC	Rocky ridge & Talus slope - Talus slope
Montane acidic talus	Subalpine cold-air talus barren	D	HESF, NHC	Rocky ridge & Talus slope - Talus slope
Montane acidic talus	Montane lichen talus barren	D	HESF, NHC	Rocky ridge & Talus slope - Talus slope
Montane acidic talus	Montane landslide	D	HESF, NHC	Rocky ridge & Talus slope - Talus slope
Montane acidic talus	Alpine/subalpine pond	P/O	HESF, NHC	Rocky ridge & Talus slope - Talus slope
Temperate acidic talus	Red oak - black birch wooded talus	D	HHP, AOP	Rocky ridge & Talus slope - Talus slope
Temperate acidic talus	Red oak - hickory wooded talus	D	HHP, AOP	Rocky ridge & Talus slope - Talus slope
Temperate acidic talus	Temperate lichen talus barren	D	HHP, AOP	Rocky ridge & Talus slope - Talus slope
Pitch pine sand plain	Pitch pine - scrub oak woodland	D	AOP, HHP	Pine barrens
Pitch pine sand plain	Mixed pine - red oak woodland	D (Ossipee)	AOP, HHP	Pine barrens
Pitch pine sand plain	Red pine - white pine - balsam fir forest	D (Ossipee)	AOP, HHP	Pine barrens

Pitch pine sand plain	Pitch pine - Appalachian oak - heath forest	D (Merrimack)	AOP, HHP	Pine barrens
Pitch pine sand plain	Dry red oak - white pine forest	P/O	AOP, HHP	Pine barrens
Pitch pine sand plain	Dry Appalachian oak - hickory forest	P/O	AOP, HHP	Pine barrens
Pitch pine sand plain	Dry river bluff	P/O	AOP, HHP	Pine barrens
Coastal sand dune	Beach grass grassland	D	AOP	Dunes
Coastal sand dune	Bayberry - beach plum maritime shrubland	D	AOP	Dunes
Coastal sand dune	Coastal interdunal marsh/swale	D	AOP	Dunes
Coastal sand dune	Maritime wooded dune	D	AOP	Dunes
Coastal sand dune	Coastal shoreline strand/swale	P/O	AOP	Dunes
Maritime rocky shore	Maritime shrub thicket	D	AOP	Coastal islands
Maritime rocky shore	Maritime rocky barren	D	AOP	Coastal islands
Maritime rocky shore	Maritime intertidal rocky shore	D	AOP	Coastal islands
Maritime rocky shore	Coastal shoreline strand/swale	D	AOP	Coastal islands
Maritime rocky shore	Short graminoid - forb emergent marsh/mud flat	P/O	AOP	Coastal islands
Maritime rocky shore	Highbush blueberry - winterberry shrub thicket	P/O	AOP	Coastal islands
Maritime rocky shore	Coastal rocky headland	P/O	AOP	Coastal islands
Rich mesic forest	Rich mesic forest	D	NHC, HHP, AOP	Matrix forest - Inclusion
Rich mesic forest	Semi-rich mesic sugar maple forest	D	NHC, HHP, AOP	Matrix forest - Inclusion
Rich mesic forest	Rich sugar maple - oak - hickory terrace forest	D	NHC, HHP, AOP	Matrix forest - Inclusion
Rich mesic forest	Semi-rich Appalachian oak - sugar maple forest	P/O	NHC, HHP, AOP	Matrix forest - Inclusion
Rich north-temperate talus/rocky woods	Rich red oak rocky woods	D	HHP, NHC	Rocky ridge & Talus slope - Talus slope
Rich north-temperate talus/rocky woods	Red oak - black birch wooded talus	D	HHP, NHC	Rocky ridge & Talus slope - Talus slope
Rich north-temperate talus/rocky woods	Temperate lichen talus barren	D	HHP, NHC	Rocky ridge & Talus slope - Talus slope
Rich north-temperate talus/rocky woods	Rich mesic forest	D	HHP, NHC	Rocky ridge & Talus slope - Talus slope
Rich north-temperate talus/rocky woods	Semi-rich mesic sugar maple forest	D	HHP, NHC	Rocky ridge & Talus slope - Talus slope
Rich north-temperate talus/rocky woods	Spruce - birch - mountain maple wooded talus	P/O	HHP, NHC	Rocky ridge & Talus slope - Talus slope
Rich north-temperate talus/rocky woods	Montane lichen talus barren	P/O	HHP, NHC	Rocky ridge & Talus slope - Talus slope
Rich Appalachian oak rocky woods	Rich Appalachian oak rocky woods	D	AOP, HHP	Rocky ridge & Talus slope - Talus slope
Rich Appalachian oak rocky woods	Red oak - ironwood - Pennsylvania sedge woodland	D	AOP, HHP	Rocky ridge & Talus slope - Talus slope
Rich Appalachian oak rocky woods	Red oak - hickory wooded talus	D	AOP, HHP	Rocky ridge & Talus slope - Talus slope
Rich Appalachian oak rocky woods	Rich mesic forest	D	AOP, HHP	Rocky ridge & Talus slope - Talus slope
Rich Appalachian oak rocky woods	Semi-rich Appalachian oak - sugar maple forest	D	AOP, HHP	Rocky ridge & Talus slope - Talus slope
Rich Appalachian oak rocky woods	Appalachian oak - pine rocky ridge	P/O	AOP, HHP	Rocky ridge & Talus slope - Talus slope
Rich Appalachian oak rocky woods	Chestnut oak forest/woodland	P/O	AOP, HHP	Rocky ridge & Talus slope - Talus slope
Rich Appalachian oak rocky woods	Temperate lichen talus barren	P/O	AOP, HHP	Rocky ridge & Talus slope - Talus slope
High-elevation spruce-fir forest	High-elevation spruce - fir forest	D	HESF	Matrix forest - High-elevation spruce - fir
High-elevation spruce-fir forest	High-elevation balsam fir forest	D	HESF	Matrix forest - High-elevation spruce - fir

High-elevation spruce-fir forest	Northern hardwood - spruce - fir forest	P/O	HESF	Matrix forest - High-elevation spruce - fir
High-elevation spruce-fir forest	Montane landslide	P/O	HESF	Matrix forest - High-elevation spruce - fir
Northern hardwood - conifer forest	Sugar maple - beech - yellow birch forest	D	NHC	Matrix forest - Northern hardwood - conifer forest
Northern hardwood - conifer forest	Hemlock - spruce - northern hardwood forest	D	NHC	Matrix forest - Northern hardwood - conifer forest
Northern hardwood - conifer forest	Hemlock - beech - northern hardwood forest	D	NHC	Matrix forest - Northern hardwood - conifer forest
Northern hardwood - conifer forest	Semi-rich mesic sugar maple forest	D	NHC	Matrix forest - Northern hardwood - conifer forest
Northern hardwood - conifer forest	Northern hardwood - spruce - fir forest	D	NHC	Matrix forest - Northern hardwood - conifer forest
Northern hardwood - conifer forest	Beech forest	P/O	NHC	Matrix forest - Northern hardwood - conifer forest
Northern hardwood - conifer forest	Hemlock forest	P/O	NHC	Matrix forest - Northern hardwood - conifer forest
Hemlock - hardwood - pine forest	Hemlock - beech - oak - pine forest	D	HHP	Matrix forest - Hemlock - hardwood - pine forest
Hemlock - hardwood - pine forest	Hemlock forest	D	HHP	Matrix forest - Hemlock - hardwood - pine forest
Hemlock - hardwood - pine forest	Beech forest	D	HHP	Matrix forest - Hemlock - hardwood - pine forest
Hemlock - hardwood - pine forest	Hemlock - white pine forest	D	HHP	Matrix forest - Hemlock - hardwood - pine forest
Hemlock - hardwood - pine forest	Dry red oak - white pine forest	D	HHP	Matrix forest - Hemlock - hardwood - pine forest
Hemlock - hardwood - pine forest	Semi-rich mesic sugar maple forest	D	HHP	Matrix forest - Hemlock - hardwood - pine forest
Hemlock - hardwood - pine forest	Hemlock - beech - northern hardwood forest	P/O	HHP	Matrix forest - Hemlock - hardwood - pine forest
Appalachian oak - pine forest	Dry Appalachian oak - hickory forest	D	AOP	Matrix forest - Appalachian oak - pine forest
Appalachian oak - pine forest	Mesic Appalachian oak - hickory forest	D	AOP	Matrix forest - Appalachian oak - pine forest
Appalachian oak - pine forest	Appalachian oak - mountain laurel forest	D	AOP	Matrix forest - Appalachian oak - pine forest
Appalachian oak - pine forest	Semi-rich Appalachian oak - sugar maple forest	D	AOP	Matrix forest - Appalachian oak - pine forest
Appalachian oak - pine forest	Pitch pine - Appalachian oak - heath forest	P/O	AOP	Matrix forest - Appalachian oak - pine forest
Appalachian oak - pine forest	Chestnut oak forest/woodland	P/O	AOP	Matrix forest - Appalachian oak - pine forest
Appalachian oak - pine forest	Dry river bluff	P/O	AOP	Matrix forest - Appalachian oak - pine forest
Alpine/subalpine bog	Wet alpine/subalpine bog	D	HESF and above	Peatland-Open
Alpine/subalpine bog	Wooded subalpine bog/heath snowbank	D	HESF and above	Peatland-Open
Alpine/subalpine bog	Subalpine sliding fen	D	HESF and above	Peatland-Open
Kettle hole bog	Liverwort/horned bladderwort mud-bottom	D	Multiple	Peatland-Open
Kettle hole bog	*Sphagnum rubellum* - small cranberry moss carpet	D	Multiple	Peatland-Open
Kettle hole bog	Leather-leaf - black spruce bog	D	Multiple	Peatland-Open
Kettle hole bog	Highbush blueberry - mountain holly wooded fen	D	Multiple	Peatland-Open
Kettle hole bog	Marshy moat	D	Multiple	Peatland-Open
Kettle hole bog	Large cranberry - short sedge moss lawn	P/O	Multiple	Peatland-Open
Kettle hole bog	Water willow - *Sphagnum* lagg	P/O	Multiple	Peatland-Open
Kettle hole bog	Leather-leaf - sheep laurel dwarf shrub bog	P/O	Multiple	Peatland-Open
Poor level fen/bog	*Sphagnum rubellum* - small cranberry moss carpet	D	Multiple	Peatland-Open
Poor level fen/bog	Leather-leaf - black spruce bog	D	Multiple	Peatland-Open
Poor level fen/bog	Leather-leaf - sheep laurel dwarf shrub bog	D	Multiple	Peatland-Open

Poor level fen/bog	Highbush blueberry - mountain holly wooded fen	D	Multiple	Peatland-Open
Poor level fen/bog	Large cranberry - short sedge moss lawn	P/O	Multiple	Peatland-Open
Poor level fen/bog	Marshy moat	P/O	Multiple	Peatland-Open
Poor level fen/bog	Water willow - *Sphagnum* lagg	P/O	Multiple	Peatland-Open
Medium level fen	Sweet gale - meadowsweet - tussock sedge fen	D	Multiple	Peatland-Open
Medium level fen	Hairy-fruited sedge - sweet gale fen	D	Multiple	Peatland-Open
Medium level fen	Large cranberry - short sedge moss lawn	D	Multiple	Peatland-Open
Medium level fen	Bog rosemary - sweet gale - sedge fen	D	Multiple	Peatland-Open
Medium level fen	shrub thicket	D	Multiple	Peatland-Open
Medium level fen	Winterberry - cinnamon fern wooded fen	D	Multiple	Peatland-Open
Medium level fen	Sweet pepperbush wooded fen	D	Multiple	Peatland-Open
Medium level fen	Speckled alder wooded fen	D	Multiple	Peatland-Open
Medium level fen	Floating marshy peat mat	P/O	Multiple	Peatland-Open
Medium level fen	Marshy moat	P/O	Multiple	Peatland-Open
Medium level fen	Water willow - *Sphagnum* lagg	P/O	Multiple	Peatland-Open
Medium level fen	Speckled alder - lake sedge intermediate fen	P/O	Multiple	Peatland-Open
Montane sloping fen	Montane sloping fen	D	LSF, NHC	Peatland-Open
Montane sloping fen	Montane alder - heath shrub thicket	D	LSF, NHC	Peatland-Open
Montane sloping fen	Montane heath woodland	D	LSF, NHC	Peatland-Open
Patterned fen	Liverwort/horned bladderwort mud-bottom	D	LSF, NHC	Peatland-Open
Patterned fen	*Sphagnum rubellum* - small cranberry moss carpet	D	LSF, NHC	Peatland-Open
Patterned fen	Large cranberry - short sedge moss lawn	D	LSF, NHC	Peatland-Open
Patterned fen	Circumneutral - calcareous flark	D	LSF, NHC	Peatland-Open
Patterned fen	Leather-leaf - black spruce bog	D	LSF, NHC	Peatland-Open
Patterned fen	Northern white cedar circumneutral string	D	LSF, NHC	Peatland-Open
Calcareous sloping fen	Calcareous sedge - moss fen	D	LSF, NHC	Peatland-Open
Black spruce peat swamp	Black spruce - larch swamp	D	Multiple	Peatland-Forested
Black spruce peat swamp	Acidic northern white cedar swamp	D	Multiple	Peatland-Forested
Black spruce peat swamp	Highbush blueberry - mountain holly wooded fen	D	Multiple	Peatland-Forested
Black spruce peat swamp	Red spruce swamp	P/O	Multiple	Peatland-Forested
Black spruce peat swamp	Northern white cedar - balsam fir swamp	P/O	Multiple	Peatland-Forested
Coastal conifer peat swamp	swamp	D	AOP, HHS	Peatland-Forested
Coastal conifer peat swamp	Inland Atlantic white cedar swamp	D	AOP, HHS	Peatland-Forested
Coastal conifer peat swamp	Atlantic white cedar swamp	D	AOP, HHS	Peatland-Forested
Coastal conifer peat swamp	Atlantic white cedar - giant rhododendron swamp	D	AOP, HHS	Peatland-Forested
Coastal conifer peat swamp	Seasonally flooded Atlantic white cedar swamp	D	AOP, HHS	Peatland-Forested
Coastal conifer peat swamp	Pitch pine - heath swamp	D	AOP, HHS	Peatland-Forested

Coastal conifer peat swamp	Sweet pepperbush wooded fen	D	AOP, HHS	Peatland-Forested
Coastal conifer peat swamp	Highbush blueberry - mountain holly wooded fen	D	AOP, HHS	Peatland-Forested
Coastal conifer peat swamp	Red maple - *Sphagnum* basin swamp	D	AOP, HHS	Peatland-Forested
Coastal conifer peat swamp	Black gum - red maple basin swamp	P/O	AOP, HHS	Peatland-Forested
Coastal conifer peat swamp	Highbush blueberry - winterberry shrub thicket	P/O	AOP, HHS	Peatland-Forested
Temperate peat swamp	Red maple - *Sphagnum* basin swamp	D	AOP, HHS	Peatland-Forested
Temperate peat swamp	Black gum - red maple basin swamp	D	AOP, HHS	Peatland-Forested
Temperate peat swamp	Swamp white oak basin swamp	D	AOP, HHS	Peatland-Forested
Temperate peat swamp	Highbush blueberry - winterberry shrub thicket	D	AOP, HHS	Peatland-Forested
Temperate peat swamp	Highbush blueberry - mountain holly wooded fen	D	AOP, HHS	Peatland-Forested
Temperate peat swamp	Winterberry - cinnamon fern wooded fen	D	AOP, HHS	Peatland-Forested
Temperate peat swamp	Hemlock - cinnamon fern forest	P/O	AOP, HHS	Peatland-Forested
Temperate peat swamp	Red maple - red oak - cinnamon fern forest	P/O	AOP, HHS	Peatland-Forested
Temperate peat swamp	Red maple - sensitive fern swamp	P/O	AOP, HHS	Peatland-Forested
Temperate peat swamp	Seasonally flooded red maple swamp	P/O	AOP, HHS	Peatland-Forested
Temperate peat swamp	Red spruce swamp	P/O	AOP, HHS	Peatland-Forested
swamp	Northern white cedar - balsam fir swamp	D	LSF, NHC	Peatland-Forested
swamp	Acidic northern white cedar swamp	D	LSF, NHC	Peatland-Forested
swamp	Northern white cedar swamp	D	LSF, NHC	Peatland-Forested
swamp	Northern white cedar - hemlock swamp	D	LSF, NHC	Peatland-Forested
swamp	Speckled alder wooded fen	D	LSF, NHC	Peatland-Forested
swamp	Calcareous sedge - moss fen	P/O	LSF, NHC	Peatland-Forested
swamp	Northern hardwood - black ash - conifer swamp	P/O	LSF, NHC	Peatland-Forested
Lowland spruce - fir forest/swamp	Red spruce swamp	D	LSF	Matrix Forest - Lowland spruce - fir forest
Lowland spruce - fir forest/swamp	Lowland spruce - fir forest	D	LSF	Matrix Forest - Lowland spruce - fir forest
Lowland spruce - fir forest/swamp	Montane black spruce - red spruce forest	D	LSF	Matrix Forest - Lowland spruce - fir forest
minerotrophic swamp	Northern hardwood - black ash - conifer swamp	D	LSF, NHC	Matrix Forest - Inclusion
minerotrophic swamp	Seasonally flooded boreal swamp	D	LSF, NHC	Matrix Forest - Inclusion
minerotrophic swamp	Speckled alder wooded fen	D	LSF, NHC	Matrix Forest - Inclusion
Temperate minerotrophic swamp	Red maple - sensitive fern swamp	D	HHP, AOP	Matrix Forest - Inclusion
Temperate minerotrophic swamp	Red maple - black ash - swamp saxifrage swamp	D	HHP, AOP	Matrix Forest - Inclusion
Temperate minerotrophic swamp	Red maple - lake sedge swamp	D	HHP, AOP	Matrix Forest - Inclusion
Temperate minerotrophic swamp	Circumneutral seepage swamp	D	HHP, AOP	Matrix Forest - Inclusion
Temperate minerotrophic swamp	Highbush blueberry - winterberry shrub thicket	D	HHP, AOP	Matrix Forest - Inclusion
Temperate minerotrophic swamp	Hemlock - cinnamon fern forest	P/O	HHP, AOP	Matrix Forest - Inclusion
Temperate minerotrophic swamp	Red maple - red oak - cinnamon fern forest	P/O	HHP, AOP	Matrix Forest - Inclusion
Temperate minerotrophic swamp	Red maple - *Sphagnum* basin swamp	P/O	HHP, AOP	Matrix Forest - Inclusion

Temperate minerotrophic swamp	Red maple - elm - lady fern silt forest	P/O	HHP, AOP	Matrix Forest - Inclusion
Temperate minerotrophic swamp	Seasonally flooded red maple swamp	P/O	HHP, AOP	Matrix Forest - Inclusion
Forest seep/seepage forest	Subacid forest seep	D	Multiple	Matrix Forest - Inclusion
Forest seep/seepage forest	Acidic *Sphagnum* forest seep	D	Multiple	Matrix Forest - Inclusion
Forest seep/seepage forest	Circumneutral hardwood forest	D	Multiple	Matrix Forest - Inclusion
Forest seep/seepage forest	Northern hardwood seepage forest	D	Multiple	Matrix Forest - Inclusion
(No system)	Vernal woodland pool		Multiple	Vernal pool
(No system)	Vernal floodplain pool		Multiple	Vernal pool
Emergent marsh - shrub swamp	Tall graminoid emergent marsh	D	Multiple	Meadow
Emergent marsh - shrub swamp	Northern medium sedge meadow marsh	D	Multiple	Meadow
Emergent marsh - shrub swamp	Peaty marsh	D	Multiple	Meadow
Emergent marsh - shrub swamp	Short graminoid - forb emergent marsh/mud flat	D	Multiple	Meadow
Emergent marsh - shrub swamp	Medium-depth emergent marsh	D	Multiple	Meadow
Emergent marsh - shrub swamp	Deep emergent marsh - aquatic bed	D	Multiple	Meadow
Emergent marsh - shrub swamp	Cattail marsh	D	Multiple	Meadow
Emergent marsh - shrub swamp	Aquatic bed	D	Multiple	Meadow
Emergent marsh - shrub swamp	Herbaceous seepage marsh	D	Multiple	Meadow
Emergent marsh - shrub swamp	Mixed tall graminoid - scrub-shrub marsh	D	Multiple	Marsh & Shrub Wetland - Shrub Wetland
Emergent marsh - shrub swamp	Highbush blueberry - winterberry shrub thicket	D	Multiple	Marsh & Shrub Wetland - Shrub Wetland
Emergent marsh - shrub swamp	Buttonbush basin swamp	D	Multiple	Marsh & Shrub Wetland - Shrub Wetland
Emergent marsh - shrub swamp	Alder alluvial shrubland	D	Multiple	Marsh & Shrub Wetland - Shrub Wetland
Emergent marsh - shrub swamp	Alder - dogwood - arrowwood alluvial thicket	D	Multiple	Marsh & Shrub Wetland - Shrub Wetland
Emergent marsh - shrub swamp	Meadowsweet alluvial thicket	D	Multiple	Marsh & Shrub Wetland - Shrub Wetland
Emergent marsh - shrub swamp	Alluvial mixed shrub thicket	D	Multiple	Marsh & Shrub Wetland - Shrub Wetland
Emergent marsh - shrub swamp	Seasonally flooded red maple swamp	D	Multiple	Marsh & Shrub Wetland - Shrub Wetland
Emergent marsh - shrub swamp	Seasonally flooded boreal swamp	D	Multiple	Marsh & Shrub Wetland - Shrub Wetland
Sandy pond shore	Sweet gale - speckled alder shrub thicket	D	AOP, HHP	Marsh & Shrub Wetland
Sandy pond shore	Twig-rush sandy turf pond shore	D	AOP, HHP	Marsh & Shrub Wetland
Sandy pond shore	Bulblet umbrella-sedge open sandy pond shore	D	AOP, HHP	Marsh & Shrub Wetland
Sandy pond shore	Water lobelia aquatic sandy pond shore	D	AOP, HHP	Marsh & Shrub Wetland
Sandy pond shore	Hudsonia inland beach strand	D	AOP, HHP	Marsh & Shrub Wetland
Sand plain basin marsh	Highbush blueberry - winterberry shrub thicket	D	AOP, HHP	Vernal pool
Sand plain basin marsh	Meadowsweet - robust graminoid sand plain marsh	D	AOP, HHP	Meadow; 2) Vernal pool
Sand plain basin marsh	Meadow beauty sand plain marsh	D	AOP, HHP	Meadow; 2) Vernal pool
Sand plain basin marsh	Three-way sedge - manna-grass mud flat marsh	D	AOP, HHP	Meadow; 2) Vernal pool
Sand plain basin marsh	Spike-rush - floating-leaved aquatic mud flat	D	AOP, HHP	Meadow; 2) Vernal pool
Sand plain basin marsh	Sharp-flowered manna-grass shallow peat marsh	D	AOP, HHP	Meadow; 2) Vernal pool

Sand plain basin marsh	Montane sandy basin marsh	D	AOP, HHP	Meadow; 2) Vernal pool
Sand plain basin marsh	Red maple - *Sphagnum* basin swamp	P/O	AOP, HHP	Marsh & Shrub Wetland
Sand plain basin marsh	Swamp white oak basin swamp	P/O	AOP, HHP	Marsh & Shrub Wetland
Sand plain basin marsh	Pitch pine - heath swamp	P/O	AOP, HHP	Marsh & Shrub Wetland
Low-gradient silty-sandy riverbank	Cobble - sand river channel	D	Multiple	Watershed Groupings
Low-gradient silty-sandy riverbank	Herbaceous sandy river channel	D	Multiple	Watershed Groupings
Low-gradient silty-sandy riverbank	Twisted sedge low riverbank	D	Multiple	Watershed Groupings
Low-gradient silty-sandy riverbank	Herbaceous riverbank/floodplain	D	Multiple	Watershed Groupings
Low-gradient silty-sandy riverbank	riverbank/floodplain	D	Multiple	Watershed Groupings
Low-gradient silty-sandy riverbank	Alder alluvial shrubland	D	Multiple	Watershed Groupings
Low-gradient silty-sandy riverbank	Alder - dogwood - arrowwood alluvial thicket	D	Multiple	Watershed Groupings
Low-gradient silty-sandy riverbank	Meadowsweet alluvial thicket	D	Multiple	Watershed Groupings
Low-gradient silty-sandy riverbank	Short graminoid - forb emergent marsh/mud flat	D	Multiple	Watershed Groupings
Low-gradient silty-sandy riverbank	Medium-depth emergent marsh	D	Multiple	Watershed Groupings
Low-gradient silty-sandy riverbank	Cattail marsh	D	Multiple	Watershed Groupings
Low-gradient silty-sandy riverbank	Deep emergent marsh - aquatic bed	D	Multiple	Watershed Groupings
Low-gradient silty-sandy riverbank	Aquatic bed	D	Multiple	Watershed Groupings
riverbank	Hudsonia - silverling river channel	D	Multiple	Watershed Groupings
riverbank	Dwarf cherry river channel	D	Multiple	Watershed Groupings
riverbank	Boulder - cobble river channel	D	Multiple	Watershed Groupings
riverbank	Cobble - sand river channel	D	Multiple	Watershed Groupings
riverbank	Herbaceous sandy river channel	D	Multiple	Watershed Groupings
riverbank	Willow low riverbank	D	Multiple	Watershed Groupings
riverbank	Twisted sedge low riverbank	D	Multiple	Watershed Groupings
riverbank	Herbaceous low riverbank	D	Multiple	Watershed Groupings
riverbank	Herbaceous riverbank/floodplain	D	Multiple	Watershed Groupings
riverbank	Herbaceous/wooded riverbank/floodplain	D	Multiple	Watershed Groupings
riverbank	riverbank/floodplain	D	Multiple	Watershed Groupings
riverbank	Riverbank/floodplain fern glade	D	Multiple	Watershed Groupings
riverbank	Alder alluvial shrubland	D	Multiple	Watershed Groupings
riverbank	Alluvial mixed shrub thicket	D	Multiple	Watershed Groupings
riverbank	Acidic riverbank outcrop	D	Multiple	Watershed Groupings
riverbank	Circumneutral riverbank outcrop	D	Multiple	Watershed Groupings
riverbank	Acidic riverside seep	D	Multiple	Watershed Groupings
riverbank	Calcareous riverside seep	D	Multiple	Watershed Groupings
High-gradient rocky riverbank	Boulder - cobble river channel	D	Multiple	Watershed Groupings
High-gradient rocky riverbank	Cobble - sand river channel	D	Multiple	Watershed Groupings

High-gradient rocky riverbank	Alder alluvial shrubland	D	Multiple	Watershed Groupings
High-gradient rocky riverbank	Herbaceous/wooded riverbank/floodplain	D	Multiple	Watershed Groupings
High-gradient rocky riverbank	Riverbank/floodplain fern glade	D	Multiple	Watershed Groupings
High-gradient rocky riverbank	Acidic riverbank outcrop	D	Multiple	Watershed Groupings
High-gradient rocky riverbank	Circumneutral riverbank outcrop	D	Multiple	Watershed Groupings
High-gradient rocky riverbank	Acidic riverside seep	D	Multiple	Watershed Groupings
High-gradient rocky riverbank	Calcareous riverside seep	D	Multiple	Watershed Groupings
Montane/near-boreal floodplain	forest	D	NHC, HHP	Floodplain forest
Montane/near-boreal floodplain	forest	D	NHC, HHP	Floodplain forest
Montane/near-boreal floodplain	Balsam fir floodplain/silt plain	D	NHC, HHP	Floodplain forest
Montane/near-boreal floodplain	Herbaceous riverbank/floodplain	D	NHC, HHP	Floodplain forest
Montane/near-boreal floodplain	Herbaceous/wooded riverbank/floodplain	D	NHC, HHP	Floodplain forest
Montane/near-boreal floodplain	riverbank/floodplain	D	NHC, HHP	Floodplain forest
Montane/near-boreal floodplain	Riverbank/floodplain fern glade	D	NHC, HHP	Floodplain forest
Montane/near-boreal floodplain	Alder alluvial shrubland	D	NHC, HHP	Floodplain forest
Montane/near-boreal floodplain	Alluvial mixed shrub thicket	D	NHC, HHP	Floodplain forest
Montane/near-boreal floodplain	Oxbow marsh	D	NHC, HHP	Floodplain forest
Montane/near-boreal floodplain	forest	P/O	NHC, HHP	Floodplain forest
Major river silver maple floodplain	forest	D	HHP, AOP	Floodplain forest
Major river silver maple floodplain	forest	D	HHP, AOP	Floodplain forest
Major river silver maple floodplain	Herbaceous riverbank/floodplain	D	HHP, AOP	Floodplain forest
Major river silver maple floodplain	riverbank/floodplain	D	HHP, AOP	Floodplain forest
Major river silver maple floodplain	Alder alluvial shrubland	D	HHP, AOP	Floodplain forest
Major river silver maple floodplain	Alder - dogwood - arrowwood alluvial thicket	D	HHP, AOP	Floodplain forest
Major river silver maple floodplain	Oxbow marsh	D	HHP, AOP	Floodplain forest
Major river silver maple floodplain	Oxbow buttonbush swamp	D	HHP, AOP	Floodplain forest
Major river silver maple floodplain	Aquatic bed	D	HHP, AOP	Floodplain forest
Major river silver maple floodplain	forest	D	HHP, AOP	Floodplain forest
Major river silver maple floodplain	Red maple floodplain forest	P/O	HHP, AOP	Floodplain forest
Temperate minor river floodplain	Red maple floodplain forest	D	HHP, AOP	Floodplain forest
Temperate minor river floodplain	forest	D	HHP, AOP	Floodplain forest
Temperate minor river floodplain	Balsam fir floodplain/silt plain	D	HHP, AOP	Floodplain forest
Temperate minor river floodplain	Sycamore floodplain forest	D	HHP, AOP	Floodplain forest
Temperate minor river floodplain	Swamp white oak floodplain forest	D	HHP, AOP	Floodplain forest
Temperate minor river floodplain	forest	D	HHP, AOP	Floodplain forest
Temperate minor river floodplain	Herbaceous riverbank/floodplain	D	HHP, AOP	Floodplain forest
Temperate minor river floodplain	riverbank/floodplain	D	HHP, AOP	Floodplain forest

Temperate minor river floodplain	Alder alluvial shrubland	D	HHP, AOP	Floodplain forest
Temperate minor river floodplain	Alder - dogwood - arrowwood alluvial thicket	D	HHP, AOP	Floodplain forest
Temperate minor river floodplain	Meadowsweet alluvial thicket	D	HHP, AOP	Floodplain forest
Temperate minor river floodplain	Oxbow marsh	D	HHP, AOP	Floodplain forest
Temperate minor river floodplain	Oxbow buttonbush swamp	D	HHP, AOP	Floodplain forest
Salt marsh	Low salt marsh	D	AOP	Salt Marsh
Salt marsh	High salt marsh	D	AOP	Salt Marsh
Salt marsh	Salt pannes and pools	D	AOP	Salt Marsh
Salt marsh	Brackish marsh	P/O	AOP	Salt Marsh
Salt marsh	Coastal salt pond marsh	P/O	AOP	Salt Marsh
Brackish tidal riverbank marsh	Low brackish tidal riverbank marsh	D	AOP	Salt Marsh
Brackish tidal riverbank marsh	High brackish tidal riverbank marsh	D	AOP	Salt Marsh
Brackish tidal riverbank marsh	Brackish marsh	P/O	AOP	Salt Marsh
Sparsely vegetated intertidal	Coastal shoreline strand/swale	D	AOP	Salt Marsh
Sparsely vegetated intertidal	Intertidal rocky shore	D	AOP	Salt Marsh
Sparsely vegetated intertidal	Saline/brackish intertidal flat	D	AOP	Salt Marsh
Subtidal system	Saline/brackish subtidal channel/bay bottom	D		Watershed Grouping-Tidal Coastal Watersheds
Subtidal system	Tidal creek bottom	D		Watershed Grouping-Tidal Coastal Watersheds
Subtidal system	Eelgrass bed	D		Watershed Grouping-Tidal Coastal Watersheds
Subtidal system	Oyster bed	D		Watershed Grouping-Tidal Coastal Watersheds

Appendix D

New Hampshire's species of greatest need of conservation and associated habitats. Habitats are marked (X) for a particular species if they are important for completing life history cycles. Habitats only occasionally used by species were generally excluded. This table is intended to be a cross reference for users of the plan when selecting species and associated habitat profiles of interest.

Watershed Groupings
1. Connecticut River Mainstem Watersheds
2. Southern Upland Watersheds
3. Northern Upland Watersheds
4. Montane Watersheds
5. Coastal Transitional Watersheds
6. Non-Tidal Coastal Watersheds
7. Tidal Coastal Watersheds

Matrix Forest Types
8. Appalachian Oak-Pine Forest
9. High-Elevation Spruce-Fir Forest
10. Lowland Spruce-Fir Forest
11. Northern Hardwood-Conifer Forest
12. Hemlock-Hardwood-Pine Forest

Medium and Small-Scale Habitats
13. Alpine
14. Anthropogenic Grassland
15. Anthropogenic Shrublands
16. Caves and Mines
17. Cliffs
18. Coastal Islands
19. Dunes
20. Floodplain Forests
21. Marsh and Shrub Wetlands
22. Peatlands
23. Pine Barrens
24. Rocky Ridges and Talus Slopes
25. Salt Marshes
26. Vernal Pools

Species	Watershed Groupings							Matrix Forest Types					Medium and Small-Scale Habitats													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Invertebrates																										
Barrens itame																							X			
Barrens xylotype																							X			
Broad-lined catopyrrha																							X			
Brook floater		X			X	X	X																			
Cobblestone tiger beetle	X																									
Cora moth																							X			
Dwarf wedgemussel	X	X	X																							
Eastern pond mussel	X	X				X	X																			
Frosted elfin butterfly																							X			
Karner blue butterfly																							X			
Persius duskywing																							X			
Phyllira tiger moth																							X			
Pine barrens zanclognatha moth																							X			
Pine pinion moth																							X			
Puritan tiger beetle																										
Ringed boghaunter																					X	X				
Sleepy duskywing																							X			
White Mountain arctic													X													
White Mountain fritillary													X													
Fish																										
Alewife						X	X																			
American brook lamprey						X	X																			
American eel	X		X		X	X	X																			
American shad	X					X	X																			
Atlantic salmon	X	X	X	X	X	X	X																			
Atlantic sturgeon						X	X																			
Banded sunfish		X			X	X	X														X					
Blueback herrring	X					X	X																			
Bridle shiner					X	X	X																			
Burbot	X	X	X	X	X	X	X																			
Eastern brook trout	X	X	X	X	X	X	X																			
Finescale dace			X																							
Lake trout		X	X		X																					
Lake whitefish			X		X																					

Species	Watershed Groupings							Matrix Forest Types					Medium and Small-Scale Habitats													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Northern redbelly dace		X	X																							
Rainbow smelt		X	X	X	X	X	X																			
Redfin pickerel						X	X																			
Round whitefish		X	X		X																					
Sea lamprey	X				X	X	X																			
Shortnose sturgeon						X	X																			
Slimy sculpin	X	X	X	X	X	X																				
Sunapee trout		X			X																					
Swamp darter					X	X	X																			
Tessellated darter	X	X	X		X	X																				
Amphibians																										
Blue-spotted salamander								X			X	X									X					X
Fowler's toad								X				X									X		X			
Jefferson salamander								X			X	X								X	X					X
Marbled salamander								X			X	X														X
Mink frog			X	X						X	X									X	X	X				
Northern leopard frog	X		X	X	X		X							X						X	X					
Reptiles																										
Black racer								X				X		X	X								X	X		
Blanding's turtle					X	X	X	X				X		X						X	X	X				X
Eastern box turtle								X				X			X								X			
Eastern hognose snake								X				X		X	X								X			
Ribbon snake								X			X	X								X	X	X				X
Spotted turtle		X			X	X	X	X			X	X								X	X	X				X
Smooth green snake								X			X	X		X	X						X		X			
Timber rattlesnake								X			X	X			X									X		
Wood turtle	X	X	X	X	X	X	X	X		X	X	X		X	X					X						
Birds																										
American bittern														X	X						X					
American black duck																					X				X	
American pipit									X				X													
American woodcock								X			X	X		X	X					X	X					
Arctic tern																		X								
Bald eagle (breeding/wintering)	X	X	X		X	X	X	X		X	X	X														
Bay-breasted warbler									X	X																

Species	Watershed Groupings							Matrix Forest Types					Medium and Small-Scale Habitats													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Bicknells thrush									X																	
Black guillemot																		X								
Canada warbler								X			X	X								X						
Cerulean warbler								X				X								X						
Common loon	X	X	X		X	X	X																			
Common nighthawk								X															X	X		
Common tern																		X							X	
Cooper's hawk								X		X	X	X								X						
Common moorhen																					X					
Eastern meadowlark														X												
Eastern towhee								X				X			X							X	X			
Golden eagle																	X									
Golden-winged warbler															X						X					
Grasshopper sparrow														X												
Great blue heron																					X				X	
Horned lark														X					X							
Least bittern																					X					
Least tern																		X	X							
Nelson's sharp-tailed sparrow																									X	
Non breeding birds	X	X	X	X	X	X	X	X	X		X	X		X	X			X	X	X	X				X	
Northern goshawk								X		X	X	X														
Northern harrier														X	X						X				X	
Osprey	X	X	X		X	X	X														X					
Palm warbler										X												X				
Peregrine falcon																	X									
Pied-billed grebe																					X					
Piping plover																			X							
Purple finch										X	X	X			X											
Purple martin														X												
Purple sandpiper																		X								
Red shouldered hawk												X								X	X					
Roseate tern																		X								
Ruffed grouse								X			X	X			X											
Rusty blackbird										X											X	X				
Salt marsh sharp-tailed sparrow																									X	

Species	Watershed Groupings							Matrix Forest Types					Medium and Small-Scale Habitats													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Seaside sparrow																									X	
Sedge wren																					X					
Semipalmated sandpiper																			X						X	
Spruce grouse									X	X												X				
Three-toed woodpecker									X	X																
Turkey*								X			X	X														
Upland sandpiper														X												
Veery								X			X	X								X						
Vesper sparrow														X												
Whip-poor-will								X				X		X	X								X			
Willet																									X	
Wood thrush								X			X	X								X						
Mammals																										
American marten									X	X																
Black bear*								X		X	X	X			X									X		
Bobcat								X			X	X			X									X		
Canada lynx									X	X	X				X											
Eastern pipistrelle								X			X	X				X										
Eastern red bat								X			X	X								X	X					
Eastern small-footed bat											X	X				X	X									
Hoary bat										X	X															
Indiana bat											X					X										
Moose*								X	X	X	X	X			X						X					
New England cottontail								X				X			X						X		X			
Northern bog lemming										X												X				
Northern myotis (long-eared bat)								X			X	X				X										
Silver-haired bat								X			X	X								X	X					
White-tailed deer*								X		X	X	X		X	X					X			X		X	
Wolf										X	X															

* Species that are included in the NH Big Game Management Plan; Not ranked as species of highest conservation concern in Comprehensive Wildlife Strategy

NEW HAMPSHIRE BIG GAME PLAN

Species Management Goals and Objectives

2006-2015

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Introduction

This Big Game Plan represents the stated goals and objectives of the New Hampshire Fish and Game Department for deer, moose, black bear and wild turkey management for the period January 2006 through December 2015. Our ability to achieve these goals and objectives is influenced by a variety of factors including the availability of human and technical resources, the accuracy of the wildlife information we gather, the level of support we receive from our constituents, the decisions made by the Fish and Game Commission, health and available habitat and even weather variables that influence wildlife reproduction, survival, and hunting season harvest rates.

Authorities

From a general perspective the Department, under statute RSA 207:58, is given guidance which states: "The legislature finds it is in the best interests of the state and its citizens to regulate, protect, restore, and conserve the wildlife resources of the state under a uniform scheme of management through the fish and game department. The general court further finds that it is in the best interest of the state and its citizens that the fish and game department recognize, preserve, and promote our special heritage of hunting, fishing, trapping, and wildlife viewing by providing opportunities to hunt, fish, trap, and view wildlife in accordance with title XVIII."

Statutory authority for setting deer seasons is found in RSA 208:2 which states in part: "The executive director, after consulting with the commission, shall have the authority to open and close the seasons for the taking of wild deer, to fix the number and sex limitation for wild deer, and any other conditions governing the methods and manner of taking and reporting of the same, subject to …"

Statutory authority for setting moose season is found in RSA 208:1-a which states in part: "No person shall hunt, take, or possess any moose or any part of the carcass of a moose taken in this state without first, obtaining a valid license for such activities from the department of fish and game. The executive director of fish and game, with the consent of the commission, may establish, by rules adopted under RSA 541-A, a hunting season for moose in any county of the state, or any portion thereof."

Statutory authority for setting bear seasons is found in RSA 208:22 which states in part: "The executive director, with the consent of the commission, shall adopt rules, pursuant to RSA 541-A, relative to opening and closing the seasons for the taking of wild black bear, fixing the number of wild black bear that may be taken and any other conditions governing the methods and manner of taking and reporting of the same. The authority of the executive director as granted by this section may be exercised with reference to the state as a whole or for any specified county or part of a county."

Statutory authority for setting turkey seasons is found in RSA 209:12-a which states in part: "The executive director shall adopt rules, pursuant to RSA 541-A, relative to: (a)Establishing seasons and bag limits, and issuing wild turkey permits. (b)Establishing registration stations and registration agent fees for wild turkey. (c)Specifying the methods for taking and registering wild turkeys. (d)The enhancement, protections, and propagation of wild turkeys."

Process

New Hampshire's wildlife resources are held in trust by the state for the benefit of our citizenry. Therefore, it is important that wildlife management plans incorporate public input and to the degree practicable are consistent with public desires. Our first big game management plan spanned the period 1997 through 2005. Information considered in the formulation of that plan included a comprehensive public survey, eight public listening sessions, questionnaires from attendees of three public hearings and results from two 1-day stakeholder meetings.

This Big Game Management Plan was formulated over the course of 10-months, by a group of approximately 30 key wildlife stakeholders identified by the Fish and Game Department and referred to as the Big Game Public Working Group (PWG) (see appendix 1 for a list of Public Working Group members and their affiliations). Baseline information used by the PWG included results from a comprehensive public survey of randomly selected New Hampshire citizens and the most comprehensive species assessment reports ever written by Fish and Game Department staff. The process entailed monthly daylong meetings during which staff presented species information and answered questions. The PWG then proceeded to identify and rank key management issues and to promulgate regional species goals and objectives. All PWG meetings were professionally facilitated. Upon completion of the draft plan, the PWG received and considered staff comments, considerations and concerns. The draft plan will be subject to 4 one and one-half hour open house sessions held in Concord and Lancaster. Following incorporation of public input, the final draft plan will be submitted to the Executive Director of the NH Fish and Game Department and the NH Fish and Game Commission for their final review and approval.

Implementation

This plan will serve as the basis for deer, moose, bear and turkey management in New Hampshire for the next 10-years. Regional population objectives will serve as operational targets for Fish and Game biologists, as they strive to achieve desired population levels over the course of the 10-year period. It is important to note that strategies (e.g. the number of days of either-sex hunting for deer, the timing and length of bear seasons, the number of moose permits issued, and the turkey hunting season framework) will continue to be subject to public input through our biennial season-setting process as described in RSA 541-A. This process includes informal and ongoing dialogue with user groups and a very formal process which involves public hearings and the incorporation of verbal and written public comment. These strategies will be used to achieve our population objectives, as defined in this Big Game Plan. Readers should note that this approach is not new; we have been using the 1997-2005 plan for the past 7 years. Based on the statistical variability of the various indexes used to monitor population levels, it was determined that population levels at +/- 12.5% of the stated population objective would be considered "at goal", and not require a management action intended to make a population adjustment. This will help to stabilize season structure once the population objectives are reached. This approach reduces annual or biennial adjustments which might be needed to affect small adjustment, and will improve hunter satisfaction. Our intent is to review hunting season structure every two years through biennial season setting. However, if severe winter weather or other unpredictable events occur which require immediate action, seasons may be adjusted annually. In the worst case scenario, where conditions create a short-term vulnerability which is unacceptable, emergency closure will be implemented.

The primary advantage of long-term planning is that it provides consistency of mission. That is, it allows the Department to focus its limited resources on specific goals and objectives over an extended period of time. This approach preempts false starts, unscheduled reversals of direction, changes in data needs, and other unproductive resource expenditures that can result from unclear or changing management mandates. Generally speaking, big game management goals and objectives are best achieved through slow, steady, consistent movement. Thus, management plans serve the greater good by defining long-term goals and objectives, providing for management and data consistency, and minimizing resource waste.

Limitations

Wildlife diversity, viability and abundance depends on diverse and abundant wildlife habitat. Protection and/or management of wildlife habitat benefits a myriad of species, including moose, deer, bear and turkey. Management of game populations at levels identified in this plan will protect and achieve diverse cultural, recreational, economic and ecological values for the significant benefit of New Hampshire's citizenry. The effects moose and deer can have on habitat structure, and thereby suitability for other species and uses, was a major topic of discussion during the objective setting component of those species plans. The population goals set for those species reflect the group's best effort to balance the economic and recreational value of higher populations with the resulting economic and ecological consequences.

According to the Society for the Protection of New Hampshire Forests, "*New Hampshire has been the fastest-growing state in New England – and in the entire nine-state Northeast region - for four straight decades.*" In addition "*New Hampshire has lost forest and cropland to development at a rate of more than 20,000 acres per year in the past five years*".

Human population growth and development threatens New Hampshire's wildlife resources by diminishing and/or degrading our habitat base and in the case of big game species, by limiting (due to sprawl and fragmentation) our ability to effectively manage game populations. Thus, unbridled development threatens our ability to achieve the goals and objectives identified in this plan. While it is beyond the scope of this plan to resolve all the challenges posed by existing trends in New Hampshire's human population, it is important for us to acknowledge that these challenges are daunting, and that many of the wildlife goals, objectives and values we ascribe to in New Hampshire are imperiled by these trends. Despite and because of these challenges, the Fish and Game Department will continue to work in partnership with local, regional and statewide land conservation interests, by providing technical and financial assistance when possible, to protect significant wildlife habitat.

WHITE-TAILED DEER

New Hampshire's statewide deer population estimate is approximately 77,000 animals. If the Department is successful in reaching all the Wildlife Management Unit objectives identified in this plan, the deer population will approach 98,000 deer (a statewide increase of 27%). The Department anticipates it will take from 5 to 10 years to achieve these objectives, and/or to determine whether they are achievable. If achieved, New Hampshire will still have one of the lowest density deer herds in the eastern United States. This is the result of balancing low soil productivity (and therefore potential to carry deer on the landscape), the public's desire for a deer population with certain age and sex ratio characteristics, and known impacts deer can have on habitat for other species.

Goal 1: NH will regionally manage white-tailed deer populations by balancing and incorporating social, economic, ecological and public safety factors using the best available science/knowledge.

Objectives: Population objectives are summarized in the following table.

Table 1. Deer population objectives by wildlife management unit (WMU) expressed in terms of adult (1 ½ years old and older) buck kill during the fall hunting seasons.

WMU*	CURRENT LEVEL[1]	1997-2005 OBJECTIVE	2006-2015 OBJECTIVE[2]	MANAGEMENT ACTION REQUIRED[3]
A	310	335	335	None
B	120	125	125	None
C1	52	99	100	Increase
C2	69	125	125	Increase
D	553	788	790	Increase
E	56	188	100	Increase
F	60	167	150	Increase
G	339	532	530	Increase
H1	362	464	460	Increase
H2	534	799	750	Increase
I1	165	331	330	Increase
I2	174	360	360	Increase
J1	241	487	375	Increase
J2	809	938	940	Increase
K	585	734	735	Increase
L	538	561	525	None
M	719	535	535	Decrease

* See Appendix 2 for a map of Deer Wildlife Management Units[1] – A 2-year average of adult buck kill during the hunting seasons is used as the index to deer populations. This "Current Level" is the average of 2003 and 2004 adult buck kills.

[2] – Population objectives will be achieved when the adult buck kill is within plus or minus 12.5% of the specified objective.

[3] – If the "Current Level" is ±12.5% of the 2006-2015 objective no management action is required, others are as indicated.

Table 2. Deer population objectives by wildlife management unit (WMU) expressed in terms of buck kill per square mile of habitat.

WMU	CURRENT LEVEL	1997-2005 OBJECTIVE	2006-2015 OBJECTIVE[1]	MANAGEMENT ACTION REQUIRED[3]
A	0.56	0.61	0.61	None
B	0.37	0.38	0.38	None
C1	0.27	0.51	0.51	Increase
C2	0.30	0.55	0.55	Increase
D	0.84	1.20	1.20	Increase
E	0.08	0.27	0.15	Increase
F	0.13	0.37	0.33	Increase
G	0.55	0.86	0.86	Increase
H1	0.96	1.23	1.21	Increase
H2	0.82	1.23	1.16	Increase
I1	0.50	1.01	1.01	Increase
I2	0.49	1.01	1.01	Increase
J1	0.55	1.12	0.86	Increase
J2	1.09	1.26	1.27	Increase
K	1.00	1.26	1.26	Increase
L	1.30	1.35	1.26	None
M	1.35	1.00	1.00	Decrease

[1] – Population objectives will be achieved when the adult buck kill is within plus or minus 12.5% of the specified objective.
[2] – Change in Objective refers to the difference between the objective set in the 1997-2005 plan and this 2006-2015 plan.
[3] – If the "Current Level" is ±12.5% of the 2006-2015 objective no management action is required, others are as indicated.

Objective for WMUs A and B: The objective for these units is to maintain deer populations at approximately the current level since the quantity and quality of available natural deer wintering habitat is such that it appears to be at it's long-term ability to sustain the current population.

Objective for WMUs C1 and C2: The objective for these units is to increase deer numbers approximately 86% from current levels. Current densities are relatively low and winter habitat is capable of supporting higher deer numbers.

Objective for WMU D: The objective for this unit is to increase deer numbers 43% from current levels. Both summer and winter habitat is capable of supporting these densities and the potential for human/deer conflicts is relatively low.

Objective for WMU E: The objective for this unit is to increase deer numbers 79% from current levels. The unit comprises the central White Mountain area and while winters are severe and habitat productivity relatively low, current deer densities are also low and habitat is capable of sustaining higher deer numbers.

Objective for WMU F: The objective for this unit is to increase deer numbers 154% from current levels. While also including significant portions of the White Mountains, this unit also has areas with less severe winters and better habitat productivity than WMU-E.

Objective for WMUs G and J1: The objective for these units is to increase deer numbers 56% from current levels. These units lie in central NH south of the White Mountains and currently have similar deer densities with adequate habitat capabilities and low potential for human/deer conflicts.

Objective for WMU H1: The objective for this unit is to increase deer numbers 26% from current levels. The quality of the habitat, less severe winters, and low potential for deer/human conflicts indicate an increase of this magnitude is within the unit's long-term habitat carrying capacity.

Objective for WMU H2: The objective for this unit is to increase deer numbers 41% from current levels. The current population level is somewhat below that in WMU H1. Habitat quality and human population density in this region indicate that this increase will be socially acceptable and within the habitat's capability.

Objective for WMUs I1 and I2: The objective for these units is to increase deer numbers approximately 104% from current levels. Current deer densities are lower than other portions of central New Hampshire and the habitat is capable of supporting increased deer numbers.

Objective for WMUs J2 and K: The objective for these units is to increase deer numbers approximately 21% from current levels. While providing generally good habitat quality and with milder winters than areas further north, these units also have a higher potential for deer/human conflicts due to development and human population increases. Modest increases in deer numbers are believed acceptable.

Objective for WMU L: The objective for this unit is to maintain the population at approximately its current level. The habitat is capable of sustaining current deer numbers but in light of the increasing development and human population, increasing deer numbers above current levels could increase the potential for deer/human conflicts to unacceptable levels.

Objective for WMU M: The objective for this unit is to decrease deer numbers 26% from current levels. The southeast portion of New Hampshire continues to exhibit the highest levels of human population growth and development. The potential for deer/human conflicts and socially unacceptable high deer densities are greatest in this portion of the state.

Goal 2: The NH deer population will be managed to maintain a desirable age and sex composition.

Objective 2-1: Manage regional deer populations to ensure that yearling males don't exceed 50% of the adult male population.

Objective 2-2: To the extent this does not conflict with the male age distribution objective above, manage deer populations to achieve a balanced sex ratio of adult does to adult bucks.

Goal 3: NH deer will be managed at levels within the carrying capacity of suitable habitat without supplemental feeding programs, while maintaining animal and plant biodiversity.

Goal 4: The New Hampshire Fish and Game Department will work alone and in partnership with state, federal, and public and private partners to minimize the loss of critical deer habitat and to conserve, protect and enhance deer habitat on state, federal and private lands, through education and through the expenditure of technical and financial resources.

Objective 4-1: Identify critical deer habitat to facilitate protection and to educate landowners and other land stewards.

Objective 4-2: Promote use of the Department GIS Coarse Filter habitat identification capabilities.

Objective 4-3: Assist local, state, federal and private conservation groups and organizations to protect, conserve and manage critical deer habitat.

MOOSE

As of 2005, the estimated statewide moose population was 6,400 animals. If all the population objectives in this plan are achieved (including the proposed reduction of up to 30% in the new Connecticut Lakes Region) approximately 6,100 moose will reside in New Hampshire. This represents a net state-wide reduction of approximately 5%. Because the proposed reduction in moose numbers in the Connecticut Lakes region will be implemented in incremental steps, achievement of that specific objective will occur earlier than the tail-end of this 10-year plan.

Goal 1: New Hampshire will regionally manage moose populations by balancing and incorporating social, economic, public safety and ecological factors, using the best available science.

Objectives: Population objectives are summarized in the following table.

Table 1. Moose population objectives by management region expressed in terms of moose seen per 100 hunter hours from the deer hunter mail survey.

REGION[1]	CURRENT LEVEL[2]	1997-2005 OBJECTIVE	2006-2015 OBJECTIVE	MANAGEMENT ACTION REQUIRED[3]
Conn. Lakes (A1, A2)	10.59	8.63	7.4[4]	Decrease
North (B, C2, D1)	6.35		6.0	None
White Mtn. (C1, D2, E1, E2, E3, F)	2.39	3.94	3.0	Increase
Central (G, H1, I1, I2, J1, J2)	1.64	1.50	1.5	None
South West (H2, K)	0.95	1.34	1.3	Increase
South East (L, M)	0.60	0.50	0.5	Decrease

[1] – Note that in the 1997-2005 management plan, Units A1, A2, B, C2, and D1 were combined as the North region. See Appendix 3 for moose units and regions.
[2] – A 3-year average of moose observation rates is used as the index to moose populations. This "Current Level" is the average of 2002-2004 moose observation rates.
[3] – If the "Current Level" is ±12.5% of the 2006-2015 objective no management action is required, others are as indicated.
[4] – This represents the full 30% reduction, see objective 1-1 below.

Objective 1-1: In the Connecticut Lakes Region (WMUs A1 and A2), reduce the population by up to 30% by 2015 to obtain a population density of 7.4 moose seen per 100 hunter hours. It is felt that a population reduction would help reduce browse impacts without significantly impacting viewing or hunting opportunities.

The reduction should occur in 10% increments at three-year intervals. It is anticipated that implementation of the Connecticut Lakes Timber Company Stewardship Plan will result in enhanced moose habitat carrying capacity in the region. Implementation of the Stewardship Plan and its affect on moose habitat will be monitored at each 3-year interval to help assess subsequent moose population objectives in this region. At each 3-year interval, public input will also be sought to assist moose management decision-making.

Objective 1-2: In the North Region (WMUs B, C2 and D1), maintain the moose population at a density of 6.0 moose seen per 100 hunter hours. This moose population will maintain satisfactory viewing and hunting opportunities without impacting regeneration or causing an increase in vehicle collision rates.

Objective 1-3: In the White Mountains region (WMUs C1, E, F and D2), reduce the population density objective to 3.0 moose seen per 100 hunter hours. This reduction will help reduce vehicle collision rates without causing a serious reduction in viewing or hunting opportunities.

Objective 1-4: In the Central region (WMUs H1, I1, I2, J1, J2 and G), retain the current objective of keeping the moose density at 1.5 moose seen per 100 hunter hours. The current density provides good hunting and viewing opportunities without causing high vehicle collision rates or browse levels.

Objective 1-5: In the Southwest region (WMUs H2 and K), meet the 1995 objective of increasing the moose population to 1.3 moose seen per 100 hunter hours. It's anticipated that this population increase will increase viewing and hunting opportunities without adversely impacting vehicle collision rates. Brain worm and relatively high ambient temperatures may complicate efforts to reach this objective.

Objective 1-6: In the Southeast region (WMUs L and M), maintain the moose density at 0.5 moose seen per 100 hunter hours. The high human population densities in this region are considered to be incompatible with a higher moose population due to increased opportunities for human/moose interactions.

Objective 1-7: The New Hampshire Fish and Game Department will Cooperatively work with the Department of Transportation, the Department of Safety, local law enforcement interests and other organizations, on laws, road design and educational programs designed to reduce wildlife/vehicle collisions.

Goal 2: New Hampshire residents and visitors will understand, appreciate and value moose in New Hampshire.

Objective 2-1: The New Hampshire Fish and Game Department will continue to use the educational and communication tools at its disposal to encourage people to drive safely in moose country, to view moose safely and to value and live with moose.

Objective 2-2: The New Hampshire Fish and Game Department will seek to educate and inform the motoring public about the risks, causes, and avoidance of moose/vehicle collisions to make our roads safer for wildlife and people.

Goal 3: New Hampshire residents and visitors will understand the role of Moose in New Hampshire's ecosystems.

Objective 3-1: The New Hampshire Fish and Game Department will continue to use the educational and communication tools at its disposal to help people learn how to: live with moose, view moose safely, drive safely in moose country, and value, protect and manage moose habitat.

Goal 4: The New Hampshire Fish and Game Department will work alone and in partnership with state, federal, and public and private partners to minimize the loss of critical moose habitat and to conserve, protect and enhance moose habitat on state, federal and private lands, through education and through the expenditure of technical and financial resources.

Objective 4-1: Identify critical moose habitat to facilitate protection and to educate landowners and other land stewards.

Objective 4-2: Promote use of the Department GIS Coarse Filter habitat identification capabilities.

Objective 4-3: Assist local, state, federal and private conservation groups and organizations to protect, conserve and manage critical moose habitat.

BLACK BEAR

Upon conclusion of 2004 bear season, there was an estimated 5,100 black bears in the state of New Hampshire. This represents a 33% increase over the 1990 bear population estimate of 4,000 bears. If the objectives of this plan are achieved, there will still be roughly 5,100 bears (no net change) in New Hampshire, although the regional density of bears will have changed. Past experience suggests that it will take from 5 to 10 years to achieve the objectives specified in this plan.

Goal 1: New Hampshire will regionally manage bear populations by balancing and incorporating social, economic, public safety and ecological factors, using the best available science.

Objectives: Population objectives are summarized in the following table.

Table 1. Black bear population objectives by management region expressed in terms of estimated bear density in number per square mile.

REGION*	CURRENT LEVEL[1]	1997-2005 OBJECTIVE	2006-2015 OBJECTIVE	MANAGEMENT ACTION REQUIRED[2]
North (A, B, C2, D1)	0.63	0.56	0.6	None
White Mtn. (C1, D2, E, F)	0.95	0.72	0.8	Decrease
Central (G, I1, J1, J2)	0.48	0.31	0.6	Increase
South West-1 (H1, I2)	0.70	0.30	0.5	Decrease
South West-2 (H2, K)	0.37	0.30	0.5	Increase
South East (L, M)	0.15	Low	0.2	Increase

*See Appendix 4 for map of bear Wildlife Management Units and regions.

[1] – Five-year age/sex data averages and 3-year deer hunter mail survey observation rate averages are used as the index to bear populations. This Current Level is the estimated 2004 bear density from model using 2000-2004 age/sex data and 2002-2004 observation rates from the deer hunter mail survey.

[2] – If the "Current Level" is ±12.5% of the 2006-2015 objective no management action is required, others are as indicated.

Objective for the North Region: The bear population objective in the North Region will remain relatively consistent and represents an effort to stabilize the population at current levels.

Objective for the White Mountains Region: This objective represents a modest (16%) reduction in the current estimated density.

Objective for the Central Region: This objective represents a 25% increase from the current estimated density based on the view that habitat quality and public interest warrant expanded bear numbers.

Objective for the Southwest-1 Region: The population objective in the Southwest-1 Region represents a 29% reduction from the current estimated density.

Objective for the Southwest-2 Region: The population objective in this region represents a 35% increase in the current density. This objective reflects the expressed desire of the PWG to have more bears in the region because of high quality habitat and strong public interest.

Objective for the Southeast Region: This objective represents a 33% increase from the current density estimate but continues to reflect a desire to maintain a low density in this urban region of the state.

Goal 2: The New Hampshire Fish and Game Department will implement public education efforts so that residents and visitors understand and appreciate black bears, and are familiar with methods to minimize bear/human conflicts.

Objective 2-1: To communicate critical messages to residents and visitors using mass media and face-to-face interaction.

Goal 3: New Hampshire residents and visitors will strive to minimize conflicts between bears and humans, using widely recognized practices endorsed and recommended by the Fish and Game Department.

Objective 3-1: To minimize bear complaints with success measured in the context of increased human population growth and on the basis of a reduced need to respond to complaints or invest in mitigation.

Goal 4: The New Hampshire Fish and Game Department will work alone and in partnership with state, federal, and public and private partners to minimize the loss of critical bear habitat and to conserve, protect and enhance bear habitat on state, federal and private lands, through education and through the expenditure of technical and financial resources.

Objective 4-1: Work with NH Dept. of Transportation and the Federal Highway Administration to identify, maintain and improve connectivity across major roads that intersect important and extensive documented bear habitat.

Objective 4-2: Promote use of the Department GIS Coarse Filter habitat identification capabilities.

Objective 4-3: Assist local, state, federal and private conservation groups and organizations to protect, conserve and manage critical bear habitat.

WILD TURKEY

There are significant differences in the population attributes of deer, bears and moose, as compared to wild turkeys. Large mammals have relatively modest reproductive rates and relatively high survival rates, as compared to turkeys. From a population dynamics perspective they are referred to as k-selected species. Unlike large mammals, wild turkeys are prone to dramatic fluctuations in reproduction and survival, and are referred to as r-selected species. Because of these characteristics, managers have less control over turkey populations than over large mammals. Simply stated, factors other than hunting heavily influence the rate and direction of turkey population change. As a result, wildlife managers can facilitate turkey population change, but don't precisely control it over the short-term. Our general posture is to facilitate turkey population growth by establishing conservative hunting frameworks. When turkey populations reach certain threshold values, we are then afforded the opportunity to liberalize turkey hunting seasons to take advantage of additional recreational and economic value.

During the fall of 2004, there were an estimated 26,000 turkeys in New Hampshire. This reflects a 10-fold increase in statewide turkey population since 1989. While it is impossible to quantify at this point in time, the department anticipates continued slow growth in our statewide population over the next 10-year period. This plan facilitates turkey population growth in 11 Wildlife Management Units, which have not yet met the threshold for liberalized seasons (the Department has set that threshold at 0.5 spring birds harvested per square mile of turkey habitat). The capacity for continued turkey population growth in these units is unknown. Six other units are identified as candidates for liberalized seasons due to their strong existing populations.

Goal 1. NH will regionally manage turkey populations by balancing and incorporating social, economic and ecological factors using the best science available.

Table 1. Wild turkey population status by wildlife management unit (WMU), expressed in terms of spring kill per square mile of forested land below 2,500 feet in elevation.

WMU*	CURRENT LEVEL[1]	1997-2005 OBJECTIVE	2006-2015 OBJECTIVE	HUNTING STRATEGY[2]
A	N/A	None		None
B	0.07	None	≥0.07	Maintain
C1	0.09	None	≥0.09	Maintain
C2	0.14	None	≥0.14	Maintain
D1	0.53	None	≥0.50	Liberalize
D2	0.68	None	≥0.50	Liberalize
E	0.09	None	≥0.09	Maintain
F	0.19	None	≥0.19	Maintain
G	0.41	None	≥0.41	Maintain
H1	0.88	None	≥0.50	Liberalize
H2	0.60	None	≥0.50	Liberalize
I1	0.50	None	≥0.50	Liberalize
I2	0.49	None	≥0.49	Maintain
J1	0.34	None	≥0.34	Maintain
J2	0.29	None	≥0.29	Maintain
K	0.56	None	≥0.50	Liberalize
L	0.25	None	≥0.25	Maintain
M	0.18	None	≥0.18	Maintain

*See Appendix 5 for map of turkey Wildlife Management Units.

[1] – A 2-year average of spring kills per square mile is used as the index to turkey population. This "Current Level" is the average of 2003 and 2004 spring kill per square mile.

[2] – If the "Current Level" is less than 0.50 birds killed /square mile the strategy is to Maintain current hunting seasons designed to allow potential growth. If the "Current Level" is at or above 0.50 birds killed/square mile hunting seasons could be Liberalized to increase take.

Objective 1-1: (WMUs A, B, C1, C2, E, F, G, I2, J1, J2, L and M): Accommodate turkey population growth. If populations reach or exceed spring harvest densities of 0.50, then consider liberalizing seasons to maximize recreational values and to stabilize population growth.

Objective1- 2: (WMUs D1, D2, G, H1, H2, I1 and K): Sustain spring harvest rates at or above 0.5 birds per square mile. These are our most productive turkey management units. They have the immediate potential for sustained high turkey populations, and provide the best opportunity for additional harvest.

Goal 2: The New Hampshire Fish and Game Department will work alone and in partnership with state, federal, public, private or other conservation partners to minimize the loss of critical turkey habitat and to conserve, protect and enhance turkey habitat on state,

federal and private lands, through education and through the expenditure of technical and financial resources.

Objective 2-1: Encourage active turkey habitat management on state, federal and private lands, by the provision of information, technical services, and financial resources and by partnering with other land management interests and turkey stakeholders.

Objective 2-2: Reduce mowing impacts on turkeys and other ground nesting birds through targeted education, and the development of techniques designed to minimize mowing losses.

Goal 3. New Hampshire residents and visitors will understand, appreciate and value wild turkeys in New Hampshire.

Objective 3-1: Provide information by way of multiple outreach methods, to educate and inform the public regarding turkey ecology, behavior, habitat needs, recreational opportunities, social values including public viewing and population management.

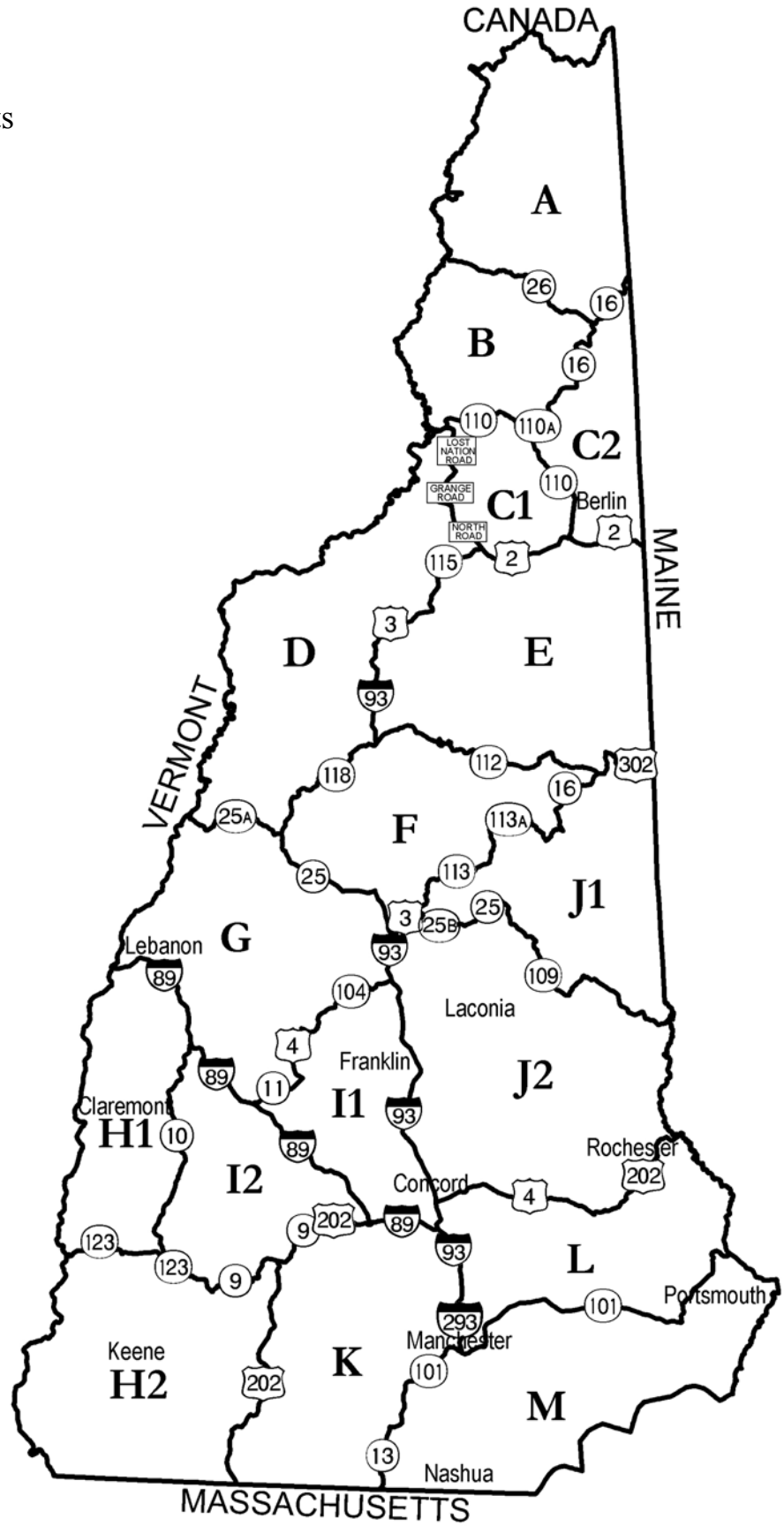
APPENDIX 1.

Public Working Group Members
For The 2004/2005 Big Game Planning Effort

1. Roscoe Blaisdell	NH Antler and Skull Club
2. Meade Cadot	Harris Center For Environmental Education
3. Bill Carney	Outdoor Writer/NHF&G Commissioner
4. Billy Dodd	Hunting Enthusiast
5. Bob Elwell	Farm Bureau
6. Rick Evans	NH Timberland Owners Ass./Forester
7. Carol Foss	NH Audubon/Ecologist
8. Suzanne Fournier	Speaking For Animals
9. Senator Gallus	New Hampshire State Senator
10. Raymond Grace	Granite State Bow Hunters
11. Rick Graham	NH Bear Hunters Association
12. Paul Karczmarczyk	Ruffed Grouse Society Regional Biologist
13. Ken Kreis, Sr	NH Wildlife Federation
14. Susan Mansfield	Graduate Student - Antioch
15. John McConnell	USDA Wildlife Services
16. Rep. McKinney	New Hampshire State Legislator
17. Buck Mercier	Registered Hunting Guide
18. Tom Morrow	CT Lakes Timber Company
19. Jim Morse	Retail Sporting Goods Store
20. Jim Neal	NH Farm Bureau/Deer Farmer
21. Glenn Normandeau	NHF&G Commissioner
22. Barry Parrish	USF&WS Refuge Biologist
23. Robert Phillipson, Jr.	NHF&G Commissioner
24. Robert Potter	Private Landowner/Conservationist
25. Scott Rolfe	NH DRED Forester
26. Bruce Schwegler	Private Landowner/Conservationist
27. Fred Shepard	NH Trappers Association
28. Kathy Starke	White Mountain National Forest Biologist
29. Matt Tarr	UNH Extension Forester
30. Edith Tucker	Reporter – Coos County Democrat
31. Keith Weaver	USF&WS Refuge Biologist
32. Charlie Williams	NH Chapter, National Wild Turkey Fed.
33. Scot Williamson	Wildlife Management Institute

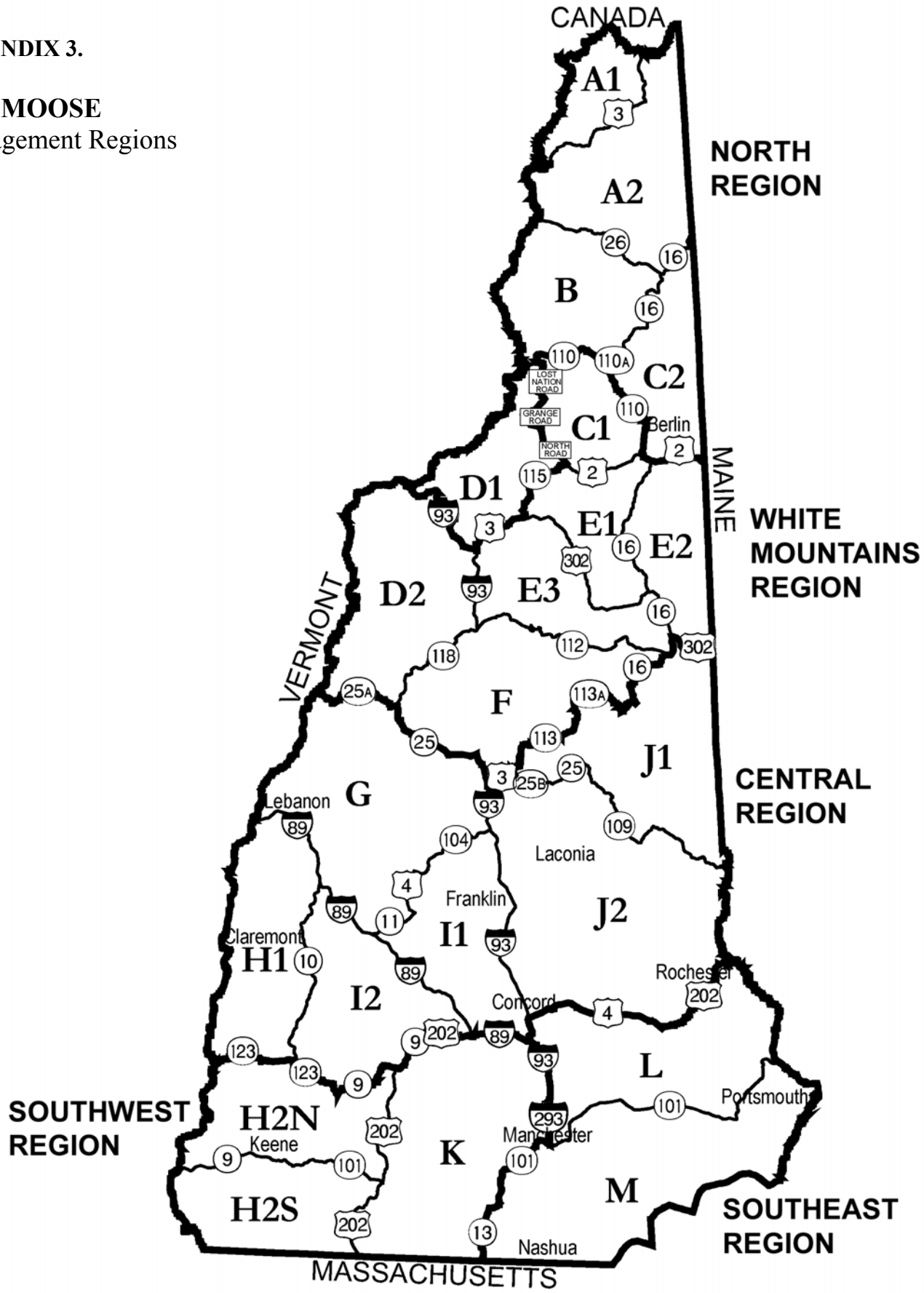
APPENDIX 2.

N.H. DEER
Wildlife Management Units



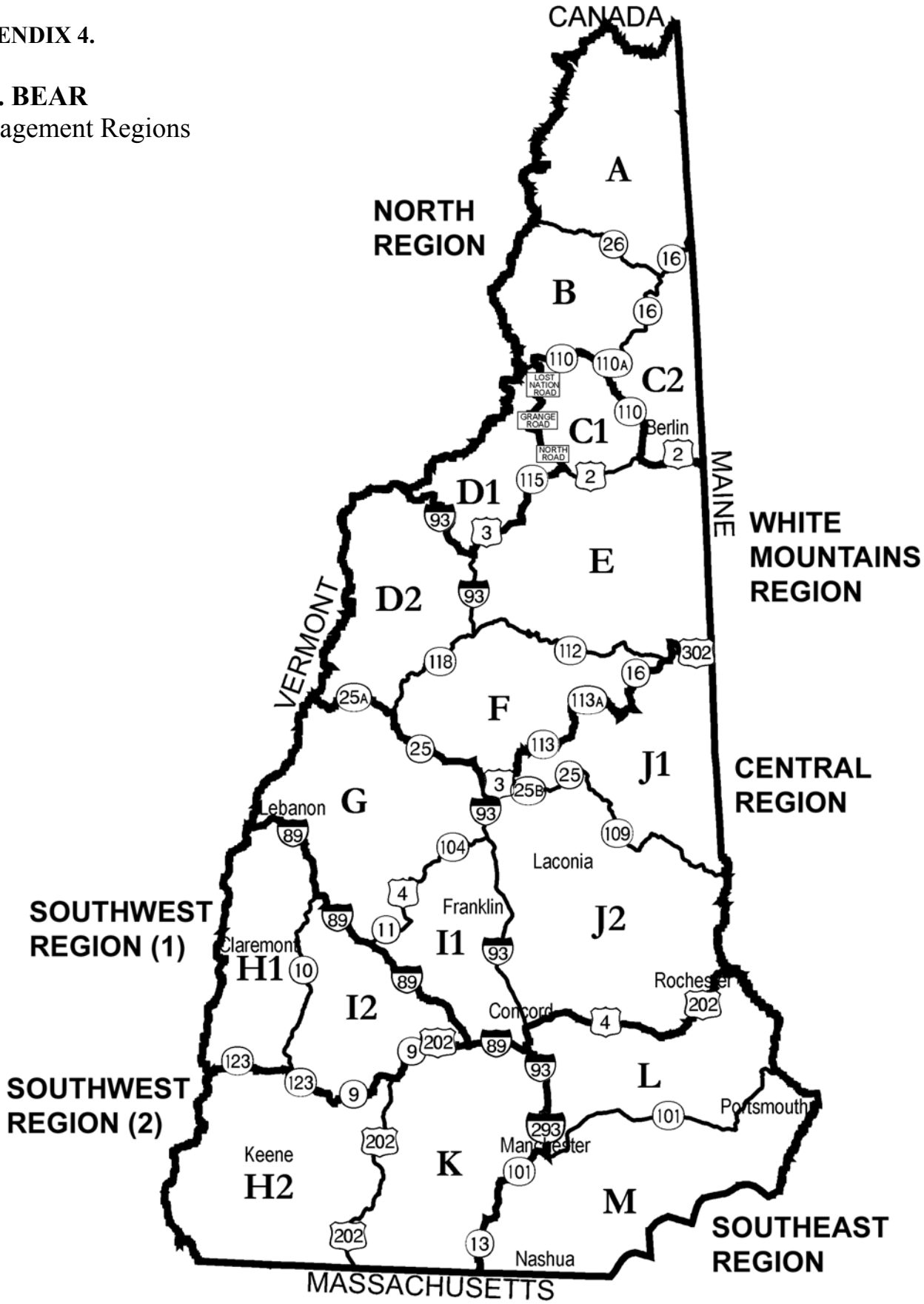
APPENDIX 3.

N.H. MOOSE
Management Regions



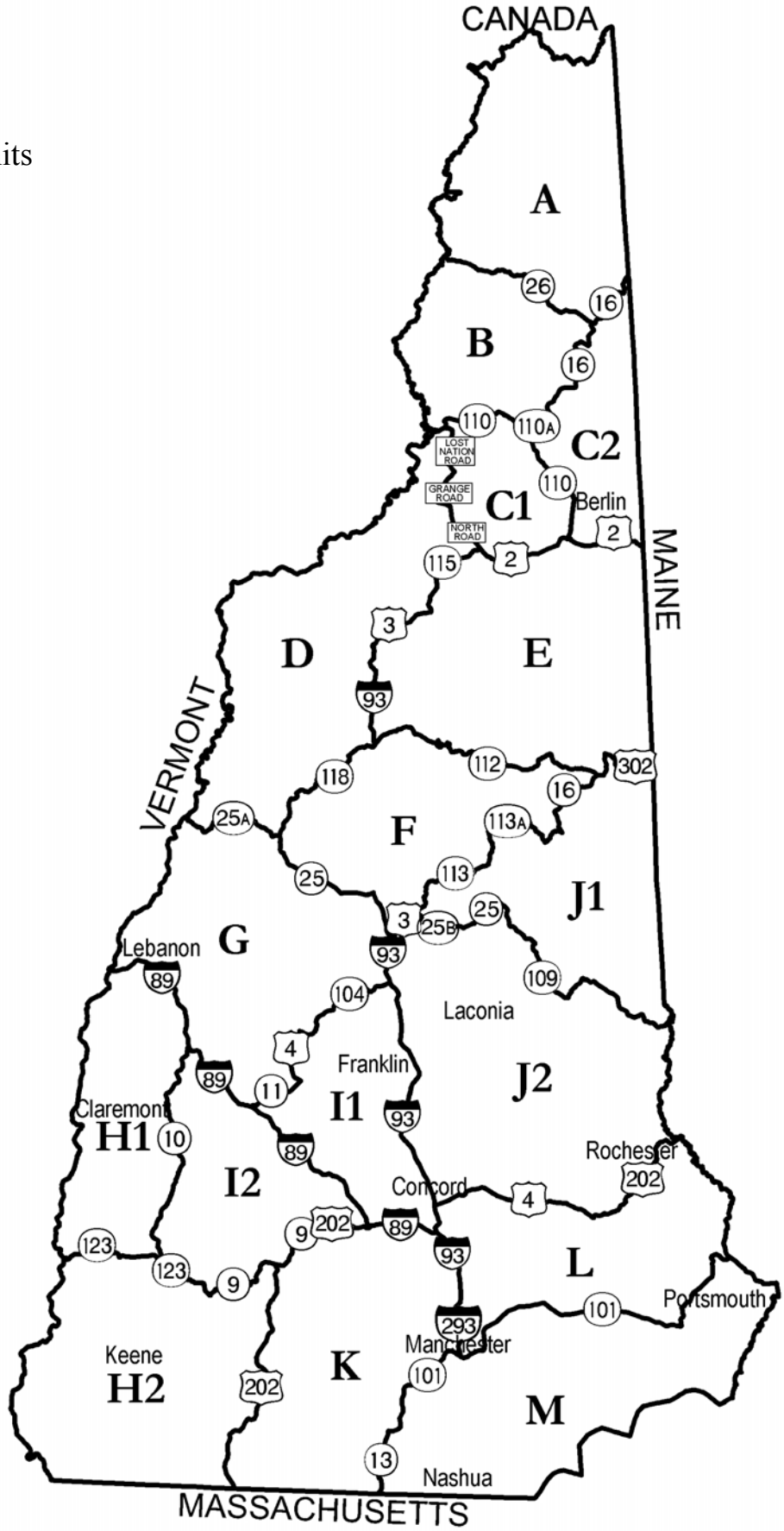
APPENDIX 4.

N.H. BEAR
Management Regions



APPENDIX 5.

N.H. TURKEY
Wildlife Management Units



Appendix F
WAP Planning Process

Developing the New Hampshire Comprehensive Wildlife Conservation Strategy
Author: Darrel Covell

New Hampshire Fish and Game worked with the University of New Hampshire Cooperative Extension to develop an overall organizational structure of teams to complete the WAP. We chose to have an overall Planning Team, a Core Biologist Team and a Communications and Outreach Team. The makeup of these teams was as follows:

Planning Team

Steve Weber, John Kanter, Darrel Covell, Charlie Bridges, Judy Stokes, John Nelson, Ellen Snyder. Members of the Planning Team represented the Fish and Game Department's Wildlife Division, Fisheries Division and Public Affairs Division, as well as UNH Cooperative Extension

Core Biologist Team

John Kanter, Darrel Covell, Michael Marchand, Steve Fuller, Jill Kelly, Jim Oehler, Matt Carpenter, Ben Nugent, John Magee, Karen Cleveland, and Ellen Snyder. These team members represented the Fish and Game Department's Wildlife Division and Fisheries Division, as well as UNH Cooperative Extension.

Communications and Outreach Team

Judy Stokes, Judy Silverberg, Darrel Covell, Liza Poinier, Isobel Parke, Doris Burke, Miranda Levin, Julie Klett, Ellen Snyder, Barbara Tetreault, Jim Graham, John Kanter, and Eric Aldrich. Members of the Communications and Outreach Team consisted of Fish and Game Department members of the Wildlife Division and Public Affairs Division; as well as external partners from the Audubon Society of New Hampshire; Public Service of New Hampshire (electric utility company); Jackson, Jackson & Wagner (public relations firm); UNH Cooperative Extension; Berlin Daily Sun (newspaper); Society for the Protection of New Hampshire Forests; and The Nature Conservancy.

UNIVERSITY of NEW HAMPSHIRE
Cooperative Extension

Wildlife Summit

Public Input on the Comprehensive State Wildlife Plan

Thursday, March 25, 2004
8:30 a.m. – 3:00 p.m.
Public Service of New Hampshire Headquarters,
Manchester

The University of New Hampshire Cooperative Extension is an equal opportunity educator and employer. UNH, U.S. Department of Agriculture and N.H. counties cooperating.

Agenda
Wildlife Summit – PSNH, Manchester
March 25, 2004

8:30-9:00	Check-in/registration
9:00 –10:30	Plenary Session – Welcome to PSNH. John MacDonald, PSNH VP of Operations
10:20-10:35	Break
10:35-10:50	Working Group Process. Charlie French, Communities Specialist, UNH Cooperative Extension
10:50-12:45	Wildlife Conservation Issues – Facilitated Working Groups
12:45	Lunch
1:00	Facilitators Combine Overlapping Issues
1:45	Report outs
2:15	Voting
2:45	Wrap Up and Evaluation
3:00	Adjourn

Wildlife Summit - Topical Issues to Address

1. Fish and Wildlife Habitat Loss and Degradation
As New Hampshire's population grows, people impact both the quantity and quality of fish and wildlife habitat.

New Hampshire has one of the highest growth rates of all states in the eastern U.S. Development is highest in the southern parts of our state, coinciding with the areas of greatest wildlife diversity. Recent census data projections indicate that the central portion of the state will grow rapidly, as well (e.g., Lakes Region). Fish and wildlife need quality habitat, and some species are at risk of being lost due to development pressure, especially in high-growth areas of New Hampshire. The presence of people can also degrade habitat even if it is not directly altered by development.

2. Human-Wildlife Interactions
Although most New Hampshire residents would like to maintain stable and healthy fish and wildlife populations, exactly how each individual defines a stable and healthy population varies according to how they interact with the environment.

Over the past decades, New Hampshire has experienced a shift from a rural to a more urbanized society. This shift is not only evident in land being developed into housing units and shopping malls but also in how people perceive wildlife and their relationship to it.

Human-wildlife interaction occurs when humans come in contact with wildlife either intentionally or unintentionally. These contacts may be either positive or negative, ranging from people enjoying feeding and watching birds, to deer eating shrubs, to potential life threatening events like moose-car collisions. Because of specific interactions, people may want certain fish and wildlife populations increased or reduced.

3. Private Lands Stewardship
Many of our state's fish and wildlife depend on privately owned lands for the food, water, cover and space they need to survive and thrive.

In 1949, renowned conservationist, Aldo Leopold, wrote,

> "I have read many definitions of what is a conservationist, and written not a few myself, but I suspect that the best one is written not with a pen, but with an axe. It is a matter of what a man thinks about while chopping, or while deciding what to chop. A conservationist is one who is humbly aware that with each stroke he is writing his signature on the face of his land. Signatures of course differ, whether written with axe or pen, and this is as it should be."

Most of NH's land (88%) is in private ownership. The quality of fish and wildlife habitat on private lands is dependent on the land use and management decisions of the landowners.

4. Successful Fish and Wildlife Conservation
Biologists know how to define conservation success from a biological point of view, such as numbers of active eagle nests, but other people might measure successful wildlife conservation in different ways.

"Planning for New Hampshire's wildlife future" perhaps best describes what the Comprehensive Wildlife Conservation Plan is all about. The main goal is to ensure that we maintain our state's fish and wildlife diversity. Successful fish and wildlife conservation will be measured in biological terms, but biologists will need to consider how other people might measure success.

Wildlife Summit Summary and Priorities

The following section is a summary of the major themes and issues that came up for each topic across all of the breakout groups – the issues recorded below were amalgamated/combined for all of the groups in order to eliminate duplicate data (i.e. if two groups said that education is a top issue for a given topic, it is only listed once below). Once the issues/themes were amalgamated for each topic area, each participant of the summit was allowed to vote on the top issue/theme for each topic area. They placed a vote on the issue/theme that they felt was most important and merits the most immediate attention.

Topic 1: Habitat Loss

- Lack of planning **(34 votes)**
  identification of critical habitats
  regulatory controls
  population growth
  lack of wildlife as a value in planning
- Dedicated funding **(24 votes)**
- Fragmentation **(8 votes)**
- Economic pressures **(6 votes)**
- Awareness/education **(5 votes)**
- Air and water quality **(2 votes)**

Topic 2: Human Wildlife Interactions

- Development/land conservation **(31 votes)**
- Communication and education **(19 votes)**
- Management and managing people **(4 votes)**
- Transportation/recreation **(3 votes)**

Topic 3: Private Lands Stewardship

- Education **(25 votes)**
- Economics **(18 votes)**
- Landowner rights and responsibilities **(14 votes)**
- Public use of private lands **(6 votes)**
- Government role **(2 votes)**

Topic 4: Successful Fish and Wildlife Conservation

- Maintain viable populations and habitats **(37 votes)**
- funding for protection monitoring and education **(15 votes)**
- Balancing conflicting desires **(5 votes**)
- Number and diversity of habitats **(3 votes)**
- People can see wildlife – residents & tourists **(1 vote)**

Wildlife Summit Breakout Group Issues and Actions

Breakout Group A
(Topics 1 and 2)

Facilitator: Frank Mitchell
Participants: Eric Aldrich (recorder), Alan Palmer (PSNH liaison), Barry Parrish, Karen P. Bennett, Lionel R. Chute, Ellen Snyder, Jan Woodbury, Allan Palmer, Jeffrey Hayes, Dan Anthony, Marilyn Bott, Chris Andrews, Kevin McCurley, Kara Glasgow, Leighlan Prout, Collis Adams, Carol R. Foss, Adair Mulligan, Joanna Pellerin, Peter Pekins, John McConnell, Sheridan Brown

Topic 1 (Group A): Fish and Wildlife Habitat Loss and Degradation: As New Hampshire's population grows, people impact both the quantity and quality of fish and wildlife habitat.

Issues:

- ATV's harming habitats
- Maintaining habitat connections
- Fragmentation habitat
- Isolation of habitats, need to monitor corridors
- Road development and improvement (fragmentation)
- Shrinking lot sizes (forest parcelization)
- Education as management strategy
- Increasing use lawn chemicals
- Land planning/zoning issues
    - lack of local planning and inability to implement
- Invasive species – plants and animals, pathogens
- Housing penetrating into landscape
    - invasives
- Environmental change – shrinking places/opportunities for wildlife
- Runoff from roads/development
- Development pressures vs. important habitats
- Protecting rare species on private lands
- Property taxes
- Recreation penetration into landscape
- Recreational access/activity
- $ incentives for private landowners to make habitat improvements
- Tourism promotion without safeguards
- Homogenization of landscape and habitat types
- Lack of resources for land use planning
    - conservation – minimizing/mitigating development impact
- Public access a problem for lakes
- Lack of easement holders for small parcels
- Limited time for conservation because development pressure
- Road mortality
    - impacts of roads

- Acid rains impacts on landscape pollution

Key Themes:

- Economics of conservation
- Environmental
- Development/planning
- Habitat fragmentation, degradation, loss

Priority Issues:

1. Impact of development and lack of planning
2. Trade-offs: promoting economy at expense of environment
3. Habitat/fragmentation/degradation

Actions Needed:

- Habitat
- Think beyond political boundaries
- Identify specific habitat activities; work with delegation
- Partnering with transportation agencies to minimize fragmentation and incorporate wildlife crossings
- Incorporate habitat protection into land use planning
- Education of options
- Identifying/mapping critical habitats
- Map dispersal corridors
    - education of that
- Promote road less areas
- Provide build-out analyses
- Replicate NEMO
- Focus on localized outreach
- Basic education/outreach

Topic 2 (Group A). Human-Wildlife Interactions: Although most New Hampshire residents would like to maintain stable and healthy fish and wildlife populations, exactly how each individual defines a stable and healthy population varies according to how they interact with the environment.

Issues:

- Invasives
- Pollution
- Recreation
- Damage/conflicts
- Diseases/vectors/pathogens
- Lack of information on effects human on wildlife interactions
- Impacts of pets
- Impacts of feeding wildlife
- Impacts of collection wildlife
- Newcomer's angst and impact

- Increasing awareness of wildlife control options
- Impacts of lights and structures on migrating birds and bats
- Road kill
- Human encroachment
- Needs to be better management multi-use trails
- Public sentiment for certain species
- Recreation only/transportation
- Juxtaposition of human activities with wildlife habitat
- Public attitudes
- Conflicts
    - disease/damage/interaction

Priority Issues:

1. Edge effect
2. Transportation/recreation
3. Managing humans

Actions Needed:

- Education – develop education strategy
    - re: human/wildlife interaction
- Establishing buffers and greenways
- Motorized recreation restrictions
- More study of all recreational impacts and other impacts
- More land conservation funding

Breakout Group B
(Topics 2 & 3)

Facilitator: Phil Auger
Participants: Laura Pfister (recorder), Doris Burke (PSHN liaison), Roberta Arbrea, Ken Kreis, Sr., Robert Phillipson, Suzann Fournier, David Tellman, Stacy Lemieux, Mary Wright, Rob Shanks, Robert Johnson, Jon Kart, Peter Spaulding, Paul Doscher, Dea Brickner-Wood, Torene Tango-Lowry, Carol Barleou

Topic 2 (Group B). Human-Wildlife Interactions: Although most New Hampshire residents would like to maintain stable and healthy fish and wildlife populations, exactly how each individual defines a stable and healthy population varies according to how they interact with the environment.

Issues:

- Lack of understanding education on human side of their actions interacting with wildlife
- Fear of what the don't know (bears)
- Feeding wildlife – doesn't benefit wildlife, unhealthy

- People don't know how to deal with living in "rural" areas and how to live with wildlife
- Education of hunters, e.g. impacts, coyotes
- Economic development – how +/- impacts are created by economic development
- Many population sectors not receiving information. Dissemination of information
- More collaboration between landowners, agencies, developers and businesses
- More interagency collaboration to achieve human-wildlife balance
- Media sensationalizes wildlife interactions (i.e. bear attacks)
- Not all interactions are equal – "management" of some species (for hunting, fish/trap)causes problems for other species
- People feed animals because they want to observe animals – need areas for designated observation
- Hunting – success rate
- NHFG needs to take a more proactive role in targeting problem areas
- Management of game and non-game species can have impacts on other species
- Zoning regulations/local regulations set up without any consideration of other humans
- As development and habitat – more pressure on agricultural lands
- Transportation as well as land use planning
- Development that creates jobs is considered higher value than benefits from wildlife
- Per capita land consumption
- Suburbanization/sprawl and impact on our traditional interactions with wildlife (hunting, etc)
- Protect predators and promote natural balance
- Balance of game and non game species and how they fit into ecosystem
- Getting people excited about <u>whole range</u> of wildlife
- Educate people about pet impacts
- Quantity vs. quality – overpopulation
- Wildlife ownership – public resource or private resource of landowner
- Human population outstripping wildlife population
- Encourage responsible use by public to ensure continued public access to private lands
- State financial support for land protection available to every community
- Cultural traditions – interaction with wildlife and land use
- Toxins/water supply/wildlife

Priority Issues:

1. Development/land conservation
    - planning/zoning
    - personal/public responsibilities
    - incentives and funding for land conservation

- economic development
- transportation

2. Management
   - stewardship
   - law enforcement
   - personal/public records
   - funding
   - collaboration (public/public+public/private)
   - diversity
3. Communication/education

Actions Needed:

- disseminate wildlife habitat maps
- improve education
- funding by all user groups
- establish a dialogue to improve opportunities to work together

Topic 3 (Group B). Private Lands Stewardship: Many of our state's fish and wildlife depend on privately owned lands for the food, water, cover and space they need to survive and thrive.

Issues:

- Promotion of sustainable development and design
- ATV pressure
- Conservation vs preservation
- Landowners rights/responsibilities
- Requirement to post (reverse)
- Share information for private landowners on land management
- More opportunities for landowners and hunters to positively interact
- Economic incentives for private landowners
- Responsible public use (all user groups)
- Tax incentives to encourage good management and/or public access
- Public education on what good management is – also need to define good management
- Recognition of good management (incentives)
- Controls on timber liquidation
- Education and assistance in invasive species management
- Collaboration – public/private and public/public
  - businesses, developers, municipalities included
- Better law enforcement
- Give cities and towns a say in wildlife management (rights to decide on hunting, fishing, etc)
- Outreach/education about what is special/unique at community level
- Share wildlife/habitat mapping

- Identify linkages between public and private lands and coordinate management of habitat, recreation and development
- Make NHI available communities (carefully)
- Encouraging conservation easements
- Funding

Priority Issues:

1. Landowner rights and responsibilities
   - how to balance regulations/incentives
   - open space preservation (incentive)
2. Government's Role
   - law enforcement
   - education of landowner and public/recreation uses
   - regulations, planning/zoning
   - incentives
   - including NGO's
3. Public Use of private lands
   - access
   - who decides? (state, town, landowner, etc)
   - what are the limits?
   - definition of "traditional uses"
   - what measurements are used to make these decisions

Actions Needed:

- Education
- Best forestry practices (standards)
- Enforcement of regulations and incentives
- Funding by All User Groups
- Improve markets for forest and farm products (promotion of local products) public
- Reexamine how we define access (NHFG)
- Establish a dialogue – opportunity for landowners to work together

Breakout Group C
(Topics 3 & 4)

Facilitator: Charlie French
Participants: Liza Poinier (recorder), Dick Durmore (PSNH liaison), Sylvia Bates, Margaret Joyce, Mary Jeppesen, Sam Doyle, Sue Mansfield, Walter Morse, Casey Hayes, Helen Hayes, Ray Whittemore, Dijit Taylor, Wendy Ward, Mark Kern, Marjory Swope, Sharon Guaraldi, Jim Taylor

Topic 3 (Group C). Private Lands Stewardship: Many of our state's fish and wildlife depend on privately owned lands for the food, water, cover and space they need to survive and thrive.

Issues:

- Losing 15-20 acres of land to private uses annually
- Fragmenting large land acres into smaller – impact on wildlife, birds, amphibians – access to H_2O
- Absentee landowners – policy no voice for advocacy
- Age of landowners/generational transfer
- Changing population: "Most livable state" people coming in with different mindsets, backgrounds, values
- Address education of non-owner uses/abuses of available land
- In case of development: size of lots, cluster vs. non-cluster, versus open space – how decide what is best/depends on place
- Education: "fear" of term "cluster development"
- Danger that open space will be developed to sell
- All local regulations are town by town – little effort to plan regionally (wildlife don't know boundaries)
- Large landowners – reward system for those who share lands with multiple users and protect instead of selling "not getting much out of it than seeing game" recognition
- Easements one way to benefit (habitat restoration – other options again need to educate/be active)
- Stakeholder/landowner relations (no decide –act-defend)
- Education/collaboration in planning
- Volunteer – "it's up to you" as landowner – people willing to help at local level – programs in place
- NH gets money for showing need – 10 problems and follow up, $ is there if people come voluntarily
- Demographic difference north vs. south
- Fear of words – land grab – "easement"
- Not enough money to involve all landowners who want to be involved
- Not enough money for professional staff
- Need to grow private conservation community
- Public access – land "being trashed" one landowner does not see this as problem so – approach of landowner/signage
- 200 acre parcels or less need emphasis – cost factors/management
- Lots of small, grouped lots near roads, lakes: our focus has been on large lots but fragmentation is problem
- Trails – people trails often wildlife trails
- Current use can help bad tax situation
- Timber management not always same as wildlife management
- Current use – people "not paying fair share" people trying to limit/abolish
- Escalating land values especially in south – economic pressure to develop or sell

- A way to get economic value for not developing
- Impact of growth
  - importance of involving land trusts/conservative commission in decision making – develop relations with landowner
- Education – re stewardship impact on future generations
  - must be innovative
- Taxes older people unable to afford land
- Incentives/economics
- Provide landowners with information to make proper decisions, how to manage for wildlife
- Those who can act can afford to
  - cost of dealing with issues "doesn't matter to me" get people to feel responsibility/educate

Priority Issues:

1. Education
   - conservation ethics
   - concentrate on private landowners
   - how to get people to "internalize" and take action
   - peer education – example Coverts Program
   - buy-in: "What's in it for me" as part of message
   - examples of successes and failures
   - describe techniques (case studies coming out soon – see digit/land conservation)
   - investigate success stories in other states
   - what educating about? Content (where to get help/information on programs, basic biology of wildlife, why help?, how as landowner one can do something, etc.)
   - partnerships

2. Economics
   - balance of growth vs. conservation "how much is enough?" (statewide pressures – jobs)
   - landowner perspective (how do individuals (they fit into larger strategic plan)
   - taxes – pressure to sell land for development
   - willingness to take risks – can we make this process (easements, etc) as seamless as private sector? Paperwork, appraisals, etc.
   - streamlining of process (see activity in Mass)
   - "we don't make it easy for people to do the right thing"
   - more resources, more staff needed
   - need infrastructure in place
   - include incentives
   - long-term; money available to pay for easements
   - money to have land agents available, surveys, etc.
   - lack of state funding – LCHIP

Actions Needed:

1. Education
    - Statewide land conservation conference (landowners/land activist workshops)
    - Audit of what's out there – help someone decide
    - Get beyond clutter – organize information and educational resources
    - Speaker's Bureau (address conservation commission, etc)
    - To interrupt regular course of action peer-to-peer, build trust
    - Find out what landowners want (Conservation Commission)
    - Attractive publications on unfamiliar wildlife (turtles, snakes, salamanders, etc) popular for general public
    - Backyards/small lots-schoolyard/backyard habitat – tell public what they can do
    - Find Americorps – get young people working
    - Develop action committee – see what's already out there, develop marketing strategy, partners, etc
    - "Develop constraints" map – does not include wildlife corridors (should…)
    - Get a feel for where elderly landowners are – hold workshops specific to them
    - Id everyone who deals with landowner and give information
    - PLT – wild – web etc.

2. Economics
    - Better LCHIP funding
    - Conservation license plates, expand regular to off road vehicles
    - Value of wildlife recreation – what it means to economy – add to messaging
    - Working with developers on "smart" development at planning level
    - Change state tax structure
    - Pay developers not to build (see ag. Example)
    - Stricter zoning
    - Taller buildings
    - Incentives for rehabbing – Brownfields funding
    - Build wall around state
    - Provide better/clearer incentive for "smart" development
    - Wetlands regulations – change to promote more infill development
    - Change federal highway policy to reduce sprawl
    - Look creatively at other costs of low-income housing/inappropriate regulations in regions
    - Tax write off…duplicates no tax
    - Current use look at backyard incentives/tax structure

Topic 4 (Group C). Successful Fish and Wildlife Conservation

Issues:

- Depends on point of view
  - number of species seen
  - number game bagged (fish caught…simply enjoying outdoors
- "The unknown" – measures we develop may be impacted in future – factors we can't control – global warming, etc.
- Knowing wildlife "is out there" and something is being done
- Measure success economically – stabilize tax base. Tourism revenue, retail, why people come here and why it's livable (wildlife can take some credit) recreation money > NH
- License sales fishing/hunting
- People need professional help/resources – number people interested rise is indicator
- Don't forget habitat – diversity, inventory
  - What do wildlife require?
  - Baseline of what you have so you can measure change
- Connectivity/corridors
- How is bio measurement defined
- Am I seeing wildlife? (If I see bunnies, deer, plan is working)
- Return on investment: show legislation/funders that creating opposite/habitat is good money investment
- "Body count"
- Update open space and study
- Improved water quality
- Depends on point of view (how measure success)
- Monitoring individual species
- Changes in conservation lands on GIS – fractile dimensions
- Tax-revenue stable base
- Value of your home
- Most livable state
- Value of hunting and fishing license
- Do I feel things are improving? Intangible
- Can we measure impact/value of wildlife economy
- People policymakers – how do they feel?
- Is a "healthy" wildlife doing too much damage? (deer)
- Moose populations – for tourism, hunting-damaging own habitat. There is a need to reach a healthy balance
- Conflicting measures need to be identified and a balance struck

Priority Issue:

1. There is a need to balance conflicting interests and ideas. How one measures success depends entirely on their point of view (i.e. from a biologist's standpoint, from a policymaker's standpoint, etc.

Actions Needed:

- Surveys – public opinion.
  - what would someone pay
  - attitudes toward wildlife
- County foresters – need WILDLIFE bios in every county to serve same role
- Hit hard in schools – count number that are doing things
- Return on investment – measure it
- State support – money leveraging
- Partnerships
- Increase citizen science opportunities/involvement
- Publications
- Monitor number of people involved
- T&T/F&G work more closely to promote opportunities

Breakout Group D
(Topics 1 and 4)

Facilitator: Minda Henderson
Participants: Judy Stokes (recorder), Curt Mooney (PSNH liaison), Dave Erler, Gail McWillliam Jellie, Steve Barba, Jim DiStefano, Bill Hauser, Miranda Levin, Paula Tracy, Tanya Tellman, Edith Tucker, Jasen Stock, John Bass, Curt Mooney, Fred Shepard, Ellis Hatch, Glenn Normandeau, Fred R. Allen, Michael Amaral

Topic 1 (Group D): Fish and Wildlife Habitat Loss and Degradation: As New Hampshire's population grows, people impact both the quantity and quality of fish and wildlife habitat.

Issues:

- Quality air/water (mercury, lead)
- Building and development
- Economics of land management (working costs vs. sales)
- Especially Seacoast – high cost waterfront (and lakefront) in combo with bad job of zoning regulations small lots vs. cluster development
- Land ownership change inherit land without connection or understanding > loss of habitat
- Lack of permanent conservation status for habitat
- Cost of creating conservation easement – money needed to help willing donors
- Industrial development/growth – need controls on emissions
- As development occurs in south puts pressure on North Country – job loss, targeting green activities on that area
- Long term land ownership
- Importance of plan coordinating efforts early on

- Address secondary impacts (residential/commercial) on highway improvements, integrate conservation/highways
- Human impact on resources
- Cultural changes impact resources farm life>reduced/no connection to land
- Leads to degradated habitats
- Lack of "patterns' in conservation fragmented
- Conservation commissions ready to act on plan when money and land becomes available (control/own land and waterfront is key)
- Economic incentives for land ownership
- Reward for keeping fields mowed or in use, open, early success habitat around edges
- F&G will pay for this kind of work (but limited in time?)
- Lack of understand of ag role in creating diverse wildlife habitat – at community level, save the farms
- No forest land study only occasion 4 states got together – this program (SWG) has the potential also – Walmart not in VT but in Lebanon, NH find cross border solutions – cross border planning
- Zoning regulations need to change from human aesthesis to critter concerns (wildlife needs)
- Limited number of public open spaces – multi uses will continue to grow. (ex. ATVs need a place to go, growing misuse vs. limited land open, effect on habitat)
- Motorized vs. non-motorized
- Even in no-motor like skiing and snowmaking needs
- Changing pressures from motorized
- 2 cycle engine damage to environment (phase out by 2006)
- Loss of working farms – the big lots
- Large landowners should have stewardship management plan (F&G can help with money)
- People don't know what to do or how to access help – country foresters, F& G etc.
- More reward for people who do the rights (current use is an example)
- Exotics replacing natives
- Collaborate with other agencies with money
- Balsams shows pictures over time of what land looked like – big educational value – town reports could get the word out
- VT – Act 250 travel ways
- NH – unique network of NGOS reduces need for litigation private property owners and towns are to solving issue
- Strategic planning for land acquisitions
- Encourage organic farming to meet demand and keep land open
- Soil based planning would be a desirable result

Priority Issues:

1. Air and water quality

2. Lack of planning associated with land development and population growth
   - limited ownership by NGO's agencies and local government
   - regulations vs. incentives
3. Awareness/education
4. Economics of land ownership and conservation

Actions Needed:

- Using current use model, created added (financial) incentive to encourage long-term ownership (20 years) higher penalty for leaving current use
- Priority system considering all values of land – set it forth and educate people why it needs to be preserved – involve more people/organization in mapping
- Provide state information to towns to make it usable (use interns) get it to Planning Boards and Conservation Commission
- Regulations federal, updated regularly to protect. Air/water quality and keep pace with science (if feds won't state must)
- Encourage conversation/understanding of tax for school and linked to rest of towns issues
- Value of open space and low cost but generates revenue tourism, license sales
- LCHIP, tap federal money to buy land

Topic 4 (Group D). Successful Fish and Wildlife Conservation: Biologists know how to define conservation success from a biological point of view, such as numbers of active eagle nests, but other people might measure successful wildlife conservation in different ways.

Issues:

- Measured by benefits of multiple species and piece of land
- "If you build (conserve) it they will come" have quality A&W including pathways to it
- Habitat is good – number of species, water cleansing action
- Human benefit for healthy habitats? Human connection should be enabled and charged for to keep land open
- Measure health of populations fish consumption guidelines gone
- Maintain naturally reproducing
- Native species present in abundant with the distribution so that they fulfill their role in nature and are available for consumption and non consumption uses as appropriate
- Education – most negative human/wildlife interactions are the result of lack of knowledge, consider cultural context and biological context moving closer together – ecotourism, important
- Measure by number and diversity of habitats
- Public needs to understand appreciation of wildlife management in general (biological needs and management)

- Wildlife areas need funds to keep up maintenance, the developed sites (Rt. 26 example) and if conservation organizations are to do all these jobs must add to their numbers
- Establish healthy habitat measure
- Success = make money for tourism around habitats and wildlife (ecotourism viable sector)
- Benchmarks to measure what we value
  - scientific measures
  - economic activity measures significant impact on shoulder season tourism (50% occupancy)
  - could get some room and meals tax if could substantiate connection
- Measure of Success = no loss of native NH species

Priority Issues:

1. Maintain naturally reproducing native species present in abundance and distribution so that they fulfill their role in nature and are available for consumptive and non-consumptive uses as appropriate
2. Eco-tourism
3. Number and diversity of habitats

Actions Needed:

- Use local component of or "cornerstone project" to id what habitats and measures
- Identify coordinating person/agency to get overall picture
- Quantitative measures A & W quality
- Develop a true measure of ecotourism numbers
- Feedback from human users (consumption and non consumption) on wildlife
- Ask non-consumption and consumption about their experience and how well we are doing
- Be careful where put our resources to save species common nearby
- Success = coordination of data among diverse organizations to really understand situation
- Use indicator species as a measure of success (ie. Atlantic Salmon)

Breakout Group E
(Topics 1 & 4)

Facilitator: Judy Silverberg
Participants: Allison Briggaman (recorder), Scott Borthwich, Joyce El Kouarti, Bob MacGregor, Marle West, Davis W. Finch, Jim Jones, Don Normandian, Nancy Christie, Lynn Tillotson, Daryl Burtnett, Charlie Niebling, Tom Wagner, Steven Shope, Paul Karczmarcsik, Steve Taylor, Andrew Major, Harry Vogel, Bob Potter, John Harrigan, Isadel Paske

Topic 1 (Group E): Fish and Wildlife Habitat Loss and Degradation: As New Hampshire's population grows, people impact both the quantity and quality of fish and wildlife habitat.

Issues:

- Population growth and increase recreation use approach with big picture
- Local town information – planning/zoning approaches
- Economic shift for local/natural resource processes
- More focus on uplands vs. just wetlands
- Connecting land base with habitat needs
- State financial support for habitat conservation
- Adequately influential as DOT
- Land fragmentation
- Wetland mitigation
- Invasive aquatic species/exotic species, economic & ecological
- Value to not develop an area – wildlife, etc.
- Habitat evaluation at town scale (funding)
- Educate decision makers – strategies
- Moronic media coverage – public education
- Fragmentation – buy/large tracts ASAP conserve
- Change laws to include habitat assessments
- Change ownership – large unfragmented blocks
- Public outreach/education – landowners
- Benefits of current use
- Change attitudes/perceptions
- Consider location of protected areas – other nearby land user?
- Preservation of open habitats – fields/meadows, balance/maintain mix
- Manage habitat lands
- Formal classroom education
- Now maintain functional ecosystems
- Triage of strategies to achieve
- Wildlife corridors
- Air pollution/development
- Id key habitats
- Funding LCHIP
- Getting everyone to pay

- Long term funding
- Landowners incentives for keeping open land (bed & belly tax)
- Septic
- Economic incentive to towns who require smart growth
- Coherent policy and motorized recreation
- Surface water quality and quantity
- Too much intrusive government

Priority Issues:

1. Identified and protected most important habitats with viable populations
2. Opportunities for people to see/enjoy/appreciate wildlife
3. Education

Actions: Not done for this group.

Topic 4 (Group E). Successful Fish and Wildlife Conservation: Biologists know how to define conservation success from a biological point of view, such as numbers of active eagle nests, but other people might measure successful wildlife conservation in different ways.

Issues:

- Have access to land and see wildlife
- People see and learn to appreciate wildlife in backyard
- Designated funding federal and state (land acquisition – buy easements, funding programs)
- Preservation of high quality habitats
- Self-sustain wild fishery in lakes and streams
- Contiguous 500+blocks in south east New Hampshire
- Multiple strategies for preserving habitat and carrying out
- Healthy documented populations for all species
- Keep track of what's happening – make information public
- Ecologically healthy lakes/ponds and recreational value
- Prevent spread of invasives marine/aquatic/terrestrial
- Funded plan monitoring and tracking results
- Balanced viable populations of predators and big game
- Opportunity to interact with native species within 10 minutes
- Adequate funding for F&G
- More sophisticated public awareness of wildlife/habitats
- Balance wildlife/human needs
- Viable populations and tracking
- Understanding biodiversity
- Sixteen and all species include T&E
- Development of wildlife success index – economic/social/biological
- Control of wildlife
- Education – formal system – school programs
- Elected officials in support of conservation

Priority Issue:

1. Designated funding for protection, monitoring and education

Actions: Not done for this group.

UNIVERSITY of NEW HAMPSHIRE
COOPERATIVE EXTENSION

Comprehensive Wildlife Plan Web Survey

The New Hampshire Fish and Game Department is coordinating a **Comprehensive Wildlife Conservation Plan** that will prioritize the state's wildlife and wildlife habitat conservation to safeguard our wildlife legacy. For more on this plan, click here. Our partners, including conservation organizations, agencies, researchers and others, are helping to develop this comprehensive plan. To ensure the plan's effectiveness, we need input from across the board -- biologists; local, state and federal agencies; conservation groups; business leaders; private landowners; and many others.

In March 2004 we held a "Wildlife Summit," gathering 100 people from around the state to identify major wildlife issues and goals to work toward achieving through the comprehensive wildlife conservation plan. This forum helped us better define priority wildlife issues and actions for addressing them. Many of the survey questions below are derived from the Wildlife Summit.

Now it's your turn! Tell us what you think about priority issues and actions for wildlife conservation in New Hampshire.

PLEASE ANSWER EACH OF THE FOLLOWING QUESTIONS. THANK YOU.

1) What do you feel are the most important issues affecting wildlife conservation in New Hampshire? (text box will expand as you type)

2) - 13) THESE ISSUES WERE DISCUSSED AT THE WILDLIFE SUMMIT (described above). PLEASE ANSWER EACH **QUESTION 2-13**, BASED ON HOW IMPORTANT IT IS TO YOU THAT WE ADDRESS EACH ISSUE IN THE COMPREHENSIVE WILDLIFE PLAN.

2) Loss of habitat.

- ○ 1 important
- ○ 2 somewhat important
- ○ 3 neutral

- ☐ 4 somewhat unimportant
- ☐ 5 unimportant

3) Interactions between people and wildlife.

- ☐ 1 important
- ☐ 2 somewhat important
- ☐ 3 neutral
- ☐ 4 somewhat unimportant
- ☐ 5 unimportant

4) Stewardship of private lands. (Stewardship is the thoughtful care of one's land.)

- ☐ 1 important
- ☐ 2 somewhat important
- ☐ 3 neutral
- ☐ 4 somewhat unimportant
- ☐ 5 unimportant

5) Planning for wildlife in the state.

- ☐ 1 important
- ☐ 2 somewhat important
- ☐ 3 neutral
- ☐ 4 somewhat unimportant
- ☐ 5 unimportant

6) Ensuring funding for protection, monitoring and education in order to be successful at conserving wildlife.

- ☐ 1 important
- ☐ 2 somewhat important
- ☐ 3 neutral
- ☐ 4 somewhat unimportant
- ☐ 5 unimportant

7) Human impact on wildlife due to development.

- ☐ 1 important
- ☐ 2 somewhat important
- ☐ 3 neutral

- ☐ 4 somewhat unimportant
- ☐ 5 unimportant

8) Communication/education to the public about the impacts of human-wildlife interactions.

- ☐ 1 important
- ☐ 2 somewhat important
- ☐ 3 neutral
- ☐ 4 somewhat unimportant
- ☐ 5 unimportant

9) Education about the importance of private lands stewardship.

- ☐ 1 important
- ☐ 2 somewhat important
- ☐ 3 neutral
- ☐ 4 somewhat unimportant
- ☐ 5 unimportant

10) Overcoming financial constraints so that private lands stewardship can benefit wildlife. (for example, by providing small grants or other financial incentives)

- ☐ 1 important
- ☐ 2 somewhat important
- ☐ 3 neutral
- ☐ 4 somewhat unimportant
- ☐ 5 unimportant

11) A balance between the rights of landowners and the responsibilities of land ownership.

- ☐ 1 important
- ☐ 2 somewhat important
- ☐ 3 neutral
- ☐ 4 somewhat unimportant
- ☐ 5 unimportant

12) Maintaining viable wildlife populations and their habitats.

- ☐ 1 important
- ☐ 2 somewhat important
- ☐ 3 neutral

- ☐ 4 somewhat unimportant
- ☐ 5 unimportant

13) A balance between regulations and incentives to benefit wildlife.

- ☐ 1 important
- ☐ 2 somewhat important
- ☐ 3 neutral
- ☐ 4 somewhat unimportant
- ☐ 5 unimportant

14) One of the goals of this comprehensive plan is to improve the efficiency of our investments in wildlife conservation. Please list existing activities or projects through which we may work to advance wildlife conservation in New Hampshire.

15) What actions do you think we should take to conserve wildlife?

16) What actions, activities or projects would you be willing to take part in to help conserve wildlife?

17) What additional tools would you find useful to help conserve wildlife in New Hampshire?

18) Of the following actions, which do you feel should be the top 3 priorities for wildlife conservation in New Hampshire? (**Please choose 3**)

- ☐ prevent loss of wildlife habitat
- ☐ manage wildlife habitat
- ☐ encourage stewardship of private lands
- ☐ improve land use planning for wildlife
- ☐ control invasive plants and animals
- ☐ manage recreational impacts on wildlife
- ☐ educate citizens about wildlife management and conservation issues

19) What town do you live in?

20) In what type of community do you live?

- ○ rural
- ○ suburban
- ○ urban

21) What is your gender?

- ○ female
- ○ male

22) What is your age?

23) How many years have you lived in New Hampshire?

24) What is the highest level of education that you have completed?

- ○ some high school
- ○ high school
- ○ some college

- ☐ 2-year college
- ☐ 4-year college
- ☐ some graduate school
- ☐ graduate school

25) Where do you get most of your conservation information? (you can choose more than one)

- ☐ web sites
- ☐ magazines
- ☐ newspapers
- ☐ newsletters
- ☐ TV
- ☐ word of mouth
- ☐ workshops
- ☐ books
- ☐ videos
- ☐ booklets

26) What is the source of most of your conservation information? (you can choose more than one)

- ☐ state agencies
- ☐ federal agencies
- ☐ local or regional groups
- ☐ conservation organizations
- ☐ general media sources
- ☐ universities
- ☐ cooperative extension
- ☐ amateur naturalists
- ☐ friends/family
- ☐ commercial source
- ☐ other

27) Of the following activities, in which have you participated in the last 2 years? (choose all that apply)

- ☐ wildlife watching
- ☐ fishing
- ☐ hunting

- [ ] trapping
- [ ] snowmobiling
- [ ] ATV riding
- [ ] camping
- [ ] hiking
- [ ] canoeing/kayaking
- [ ] boating
- [ ] cross-country skiing
- [ ] downhill skiing
- [ ] mountain biking
- [ ] snowshoeing

28) Comments.

Submit Reset

Appendix J: New Hampshire Comprehensive Wildlife Plan
Public Participation Record

Note: this does not include regular meetings of the Planning Team, Core Biologists Team and Communications and Outreach Team.

Event/Activity	Date	Location	# People	Presenter(s)/ Facilitator(s)	Description
NH Estuaries Program "State of the Estuaries Conference"	10/21/03	Portsmouth	50	Jim Oehler	Jim was asked to present specifically on the Comprehensive Plan during a 20 minute presentation (e.g., the info that the plan will contain, and how it can be used to support land conservation initiatives). Jim addressed the history of State Wildlife Grant funding, the purpose the Plan, the info will be contained within it, and timeline for completion.
NH Association of Conservation Commissions Annual Meeting	11/1/03	Concord	30	Darrel Covell	This was a 1-hour workshop on "Helping NH's Priority Birds." I presented on the topic and gathered input from conservation commission members on what additional information or resources would help them implement conservation for priority birds. I had 5 slides regarding the Comprehensive Wildlife Plan effort to make the connection between this workshop and that larger effort.
DES Rivers & Watersheds Conference	11/8/03	Concord	39	Jim Oehler	In a 25 minute presentation, Jim presented the habitat mapping process completed for the Piscassic and Lamprey River Watersheds. Preliminary results of this past summer's field verification surveys were also presented. Towards the end of the presentation, Jim transitioned to the state's Comprehensive Plan and presented five slides that addressed plan purpose and content.
NH GIS Advisory Committee Meeting	1/14/04	Concord	26	Katie Callahan	presentation on the Comprehensive Wildlife Conservation Plan. Focus on coarse filter wildlife habitat analysis, applied to the entire state, and based on the NH Fish and Game wildlife habitat manual, Kanter et al.
NH Fish & Game Commission Meeting	1/21/04	Concord	35	Darrel Covell	Briefly described the Wildlife Summit in the context of a public participation component of the Comprehensive Wildlife Conservation Plan. The overall Plan will be discussed with this group in more detail at a later meeting.
Forest Stewardship Committee Meeting	2/6/04	Manchester	12	Darrel Covell	20-minute oral presentation with handouts describing the Comprehensive Wildlife Conservation Plan.
NH Coverts Program Alumni Training	2/7/04	Manchester	16	Darrel Covell, Laura Deming	We decided to focus this training on wintering eagles along the Merrimack River to make the connection between priority habitats and species and relate that to the development of the Comprehensive Wildlife Plan. The overall program focused on eagles, but Darrel described the Comprehensive Wildlife Plan in general.

NH Fish and Game Docent Training	2/12/04	Concord	20	Allison Briggaman	The NH Fish and Game Docents are volunteers for the department who go into schools and give presentations to students about various fish and wildlife species. They have training sessions here at HQ's on a regular basis. I was asked to present to them about the State Comprehensive Wildlife Plan and also about the current status of many nongame, threatened and endangered species and projects the Nongame Program is currently working on.
Regional Blanding's Turtle Meeting	2/13/04	Concord	25	Michael Marchand	The goal of the meeting was to initiate a regional approach to conserving Blanding's turtles in the Northeast. I presented a summary of NH's Comprehensive Wildlife State Plan and how it relates to the conservation of that species.
Meeting with University of New Hampshire Natural Resources Professors	2/17/04	Durham	3	John Kanter, Mike Marchand, Mark Ellingwood and Jim Oehler	We presented on the Comp Plan to Dr. Litvaitis, Dr. Babbitt, and Dr. Taylor, and discussed their research and writing involvement in the plan.
Meeting with St. Anselms College faculty	2/20/04	Manchester	3	Mike Marchand, Jim Oehler, Alina Pyzikiewicz, John Kanter	Presented the Comp Plan and then discussed how faculty could potentially be involved in writing/ research.
NH Fish & Game Fisheries Division Staff Mtg.	3/8/04	Concord	9	Kim Tuttle	Gave a 1/2-hour presentation on the Comprehensive Wildlife Plan to the Fisheries Division.
Aquatics Forum	3/11/04	Concord	25	Michael Marchand and John Kanter	The goal of this meeting was to identify what has been done or is planned with aquatic systems in NH, identify information gaps and research needs, and identify individuals/groups that can assist with the completion of the aquatic portion of the Comprehensive State Plan.
Loon Preservation Committee-Policy Committee meeting	3/19/04	Moultonborough	20	Mike Marchand	Gave a presentation of the Comprehensive Wildlife Plan, State Wildlife Grants, and how loons and the 'loon profile' fits into the bigger picture. Included in the audience was Senator Johnson.
Wildlife Summit	3/25/04	Manchester	110	Darrel Covell, coordinator	Conservation leaders presented on elements of the plan to a broad group of local, state and federal governments/agencies, conservation groups, business leaders, private landowners. A facilitated session enabled participants to provide input on priority wildlife conservation issues.

NH Planning and Zoning Conference	5/8/04	Manchester	30	Darrel Covell and Laura Pfister	This was a 1.5-hour program, titled, "Planning for Wildlife." The Comprehensive Wildlife Plan information was described and an interactive, public participation session took place to address improved planning for wildlife.
NH Coverts Project Alumni Workshop	5/22/04	Exeter and Stratham	15	Darrel Covell	This was an all-day program for NH Coverts Cooperators (UNH Cooperative Extension volunteers working for wildlife). The content of the program focused on several critical habitats identified in the Comprehensive Wildlife Strategy - extensive grasslands, old fields, early successional forest, salt marsh and riparian/shoreland habitat.
Coarse Filter Wildlife Maps Presentation for Communities and Conservation Groups at Exeter River Local Advisory Group	5/25/04	Epping	32	Darrel Covell and Jim Oehler	We gave a 2-hour presentation, provided maps and data cd's to conservation commission and other community decision-makers. The topic was the Fish and Game's GIS-based analysis of significant wildlife habitat in New Hampshire, known as the "Coarse Filter Wildlife Maps." The program discussed this and its connection to the overall Comprehensive Wildlife Conservation Strategy.
Coarse Filter Wildlife Maps Presentation to Wildlife Division Staff	6/15/04	Concord	25	Darrel Covell and Jim Oehler	We gave a 1.5-hour presentation to Wildlife Division staff. The topic was the Fish and Game's GIS-based analysis of significant wildlife habitat in New Hampshire, known as the "Coarse Filter Wildlife Maps." The program discussed this and its connection to the overall Comprehensive Wildlife Conservation Strategy.
Squam Lakes natural resource mapping workshop	7/8/04	Holderness	25	Katie Callahan	30 min Presentation of coarse-filter wildlife habitat analysis in context of Squam watershed natural resources mapping project (vol., not as F&G rep.)
Coarse Filter Wildlife Maps Presentation for Communities and Conservation Groups	7/15/04	Concord	25	Darrel Covell and Eric Orff	We gave a 2-hour presentation, provided maps and data cd's to conservation commission and other community decision-makers. The topic was the Fish and Game's GIS-based analysis of significant wildlife habitat in New Hampshire, known as the "Coarse Filter Wildlife Maps." The program discussed this and its connection to the overall Comprehensive Wildlife Conservation Strategy.
Coarse Filter Wildlife Maps Presentation for Communities and Conservation Groups at Moose Mountains Greenway Meeting	7/20/04	Middleton	15	Darrel Covell	I gave a 2-hour presentation, provided maps and data cd's to conservation commission and other community decision-makers. The topic was the Fish and Game's GIS-based analysis of significant wildlife habitat in New Hampshire, known as the "Coarse Filter Wildlife Maps." The program discussed this and its connection to the overall Comprehensive Wildlife Conservation Strategy.
UNH Cooperative Extension Land Use and Water Quality Team Meeting	7/21/04	Boscawen	15	Darrel Covell	I solicited the groups input on water quality and agriculture-related strategies. Also worked with this group to include Extension-related Comprehensive Wildlife Conservation Strategy ideas into the Team's work plan.

Green Mountain Conservation Group: Watershed Weekend	7/24/04	Ossipee	30	Michael Marchand	Gave a 1 hour presentation of research and threats to turtles in NH and efforts that the Comprehensive State Plan is undertaking to protect turtles in the future. I explained the coarse filter analysis and gave examples of how we plan to map species specific habitat.
Coarse Filter Wildlife Maps at UNH Cooperative Extension Forestry and Wildlife Staff Meeting	7/26/04	Boscawen	15	Darrel Covell	Gave a 30-minute presentation, provided maps and data cd's to Extension Forestry and Wildlife Program staff. The topic was the Fish and Game's GIS-based analysis of significant wildlife habitat in New Hampshire, known as the "Coarse Filter Wildlife Maps." The presentation discussed this and its connection to the overall Comprehensive Wildlife Conservation Strategy.
Big Game Plan Public Working Group Meeting	8/10/04	Concord	28	Mark Ellingwood	Members of the Big Game Plan Public Working Group met to provide public input into the development of the Big Game Plan.
Big Game Plan Public Working Group Meeting	9/9/04	Holderness	26	Mark Ellingwood	Members of the Big Game Plan Public Working Group met to provide public input into the development of the Big Game Plan.
Big Game Plan Public Working Group Meeting	10/7/04	Concord	25	Mark Ellingwood	Members of the Big Game Plan Public Working Group met to provide public input into the development of the Big Game Plan.
Northeast Wildlife Diversity Technical Committee Meeting	10/25-26/04	Cape Charles, VA	30	Darrel Covell and John Kanter	Gave a 30-minute presentation to Comprehensive Wildlife Conservation Strategy coordinators and others. Described New Hampshire's public participation efforts and plans.
Big Game Plan Public Working Group Meeting	11/4/04	Concord	24	Mark Ellingwood	Members of the Big Game Plan Public Working Group met to provide public input into the development of the Big Game Plan.
Transportation and Wildlife Meeting	12/1/04	Concord	30	Mike Marchand, Darrel Covell	Members of the Core Biologists Team met with NH Department of Transportation staff and others interested in transportation issues as relates to the Comprehensive Wildlife Conservation Strategy. Discussed actions to take to improve
Big Game Plan Public Working Group Meeting	12/2/04	Concord	24	Mark Ellingwood	Members of the Big Game Plan Public Working Group met to provide public input into the development of the Big Game Plan.
Coastal Islands Habitat Conservation Partners Meeting	12/6/04	Concord	10	Steve Fuller, Darrel Covell	Individuals from the conservation community were brought together to review and rank coastal island habitat threats.
Big Game Plan Public Working Group Meeting	1/6/05	Concord	21	Mark Ellingwood	Members of the Big Game Plan Public Working Group met to provide public input into the development of the Big Game Plan.
Big Game Plan Public Working Group Meeting	2/3/05	Concord	28	Mark Ellingwood	Members of the Big Game Plan Public Working Group met to provide public input into the development of the Big Game Plan.
UNH Cooperative Extension Forestry and Wildlife Program Staff Meeting	2/15/05	Boscawen	14	Darrel Covell	Updated Extension staff on the Comprehensive Wildlife Conservation Strategy, and solicited input into the process and content related to forestry.

VINS Wildlife Habitat Mapping workshop	2/26/05	Lebanon	16	Katie Callahan	30-minute presentation of Comprehensive Wildlife Conservation Strategy (vol., not as F&G rep.)
Big Game Plan Public Working Group Meeting	3/3/05	Concord	21	Mark Ellingwood	Members of the Big Game Plan Public Working Group met to provide public input into the development of the Big Game Plan.
Big Game Plan Public Working Group Meeting	3/31/05	Concord	22	Mark Ellingwood	Members of the Big Game Plan Public Working Group met to provide public input into the development of the Big Game Plan.
Big Game Open House Plan Review and Input Session	4/26/05	Concord (2 sessions)	25	Mark Ellingwood	Open house information stations provided the public with the opportunity to view individual draft plans. Public circulated amongst stations and offered input verbally or in writing regarding draft plans for deer, moose, bear and turkey.
Big Game Open House Plan Review and Input Session	4/28/05	Lancaster (2 sessions)	20	Mark Ellingwood	Open house information stations provided the public with the opportunity to view individual draft plans. Public circulated amongst stations and offered input verbally or in writing regarding draft plans for deer, moose, bear and turkey.
Wildlife Conservation Strategy Forum	5/3/05	Concord	24	Darrel Covell, Judy Silverberg, Charlie French, Liza Poinier	Brought together individuals who had participated in the Wildlife Summit in March 2004. We developed some broad strategies and actions to address threats to our wildlife species and their habitats. We asked participants to identify additional strategies and actions and vote on priorities in the areas of habitat fragmentation, air and water quality, growth and development, and transportation.
Big Game Plan Public Working Group Meeting	5/12/05	Concord	20	Mark Ellingwood	Members of the Big Game Plan Public Working Group met to provide public input into the development of the Big Game Plan.
Selecting Biodiversity Indicators for Sustainable Forestry Workshop	5/19-20/05	Lancaster	40	Mark Zankel, John Roe, John Hagan, Andrew Whitman	This workshop brought together many partners interested in sustainable forestry concepts and provided insights into indicators that would be useful in the Comprehensive Wildlife Conservation Strategy. Members of the Core Biologists Team (Darrel Covell, Steve Fuller and Jim Oehler) provided input at the workshop and brought concepts back to use in Strategy development.
NH GIS Conservation Collaborative Meeting	5/24/05	Concord	15	Darrel Covell	Updated members of the GIS conservation community and funders on the Comprehensive Wildlife Conservation Strategy. Also received some input on the GIS approach and distribution possibilities.
Newfound Lake Region Association	7/2/05	Bridgewater	40	Katie Callahan	30 min. presentation Comprehensive Wildlife Conservation Strategy in context of Newfound wshed. natural resources mapping project (vol., not as F&G rep.)
NHF&G/UNHCE Watershed Ecology Institute 2005	7/26/05	Bow	10	Katie Callahan	1 day intro to GIS/GPS/wildlife habitat mapping, incl 20+/- min presentation on Comprehensive Wildlife Cons Strategy
TOTAL			1163		

UNIVERSITY of NEW HAMPSHIRE
Cooperative Extension

Wildlife Conservation Strategy Forum

NH Fish & Game Department
Concord, NH
May 3, 2005

Wildlife Conservation Strategy Forum
Fish and Game Department Headquarters, Concord, NH
Tuesday, May 3, 2005
8:30 – 12:00 noon

Agenda

8:30 Coffee and Refreshments
9:00 Welcome, Introductions and Wildlife Strategy Update (John Kanter)
9:20 Small Group Discussion Overview (Charlie French)
9:30 Early Morning Sessions (Habitat Fragmentation, 1A; Air and Water Quality, 1B)
10:15 Report Back on Habitat Fragmentation and Air & Water Quality
10:30 BREAK
10:45 Later Morning Sessions (Growth and Development, 2A; Transportation, 2B)
11:30 Report Back on Growth and Development and Transportation
11:45 Wrap-up
12:00 Adjourn

Facilitators: Charlie French (lead), UNH Cooperative Extension; Judy Silverberg, NH Fish & Game Department

Recorders: Darrel Covell, UNH Cooperative Extension; Liza Poinier, NH Fish & Game Department

Participants (24 people): Bill Hauser, NH Dept. of Transportation; Adair Mulligan, Connecticut River Joint Commissions; Mark Kern, U.S. Environmental Protection Agency; Ray Whittemore, Ducks Unlimited; Steve Wright, National Wildlife Federation; Nancy Christie, NH Lakes Association; Stacy Lemieux, White Mountain National Forest; Jeffrey Hayes, North Country Council; Dave Tellman, landowner/NH Coverts Cooperator/NH Tree Farmer; Tanya Tellman, landowner/NH Coverts Cooperator/NH Tree Farmer; Marjory Swope, NH Association of Conservation Commissions; Fred Allen, Pemigewasset Valley Fish and Game Club; Wendy Ward, USDA Natural Resources Conservation Service; Ellen Snyder, wildlife consultant; Scott Borthwick, NH Trappers Association; Bob Potter, landowner/NH Coverts Cooperator; Roberta Arbree, landowner; Fred Shepard, NH Trappers Association; Suzanne Fournier, Speaking for the Animals; Isobel Parke, Jackson, Jackson & Wagner (public relations firm); Andrew Major, U.S. Fish and Wildlife Service; Chris Andrew, Newts (consulting herpetologist); Dea Brickner-Wood, Great Bay Resource Protection Partnership; Sheridan Brown, Office of U.S. Senator John Sununu

The people who participated in this event were from the March 2004 Wildlife Summit. This was considered a continuation of their public participation work begun at that time.

As a part of the Comprehensive Wildlife Conservation Strategy, we developed some broad strategies and actions (see following pages) to address threats to our wildlife species and their habitats. These were relevant to the issues we addressed at this Wildlife Conservation Strategy Forum. The issues we focused on were habitat fragmentation, air and water quality, growth and development, and transportation (described below).

We enclosed relevant results from our March 2004 Wildlife Summit and the August-October 2004 Wildlife Plan Web Survey. These were sent ahead of the forum to help

participants prepare to contribute to the discussion. Specifically, we sought input on the strategies, actions and tools that would help us address the four issues mentioned above.

Issue Descriptions

1A. Habitat Fragmentation

Habitat fragmentation is the breaking up of habitat blocks into smaller sizes, as a result of roads and development. Smaller blocks of habitat reduce the number of wildlife species that can occupy an area. Due to the high number of fragmenting features in southern New Hampshire, blocks of a few hundred acres may be significant to wildlife. In northern New Hampshire blocks of a few thousand acres would be considered important to wide-ranging animals.

1B. Air and Water Quality

Fish and wildlife populations may decline if air or water quality is degraded substantially. Acid rain, caused by pollutant emissions, travels on winds for hundreds of miles and may impair air quality, acidify lakes and streams, harm sensitive ecosystems, and degrade visibility. Aquatic organisms, especially sensitive species, have been impacted. Acid rain in some areas has directly killed fish, caused reduced growth, deformed skeletons and failed reproduction. Emissions from large power plants in the Midwest and urban areas to the south of New Hampshire provide the vast majority of the pollution that causes unhealthy air quality, impaired visibility, acidification of lakes and forests, and mercury contamination in New Hampshire. However, local hotspots also occur near major emissions sources from within our state. Run-off from developed areas, agricultural fields, high-use recreation areas and other sources (a.k.a., non-point source pollution) can also degrade water quality from pesticides, salt, sedimentation, etc.

2A. Growth and Development

Clearing for houses, roads and associated utilities eliminates and fragments habitat and increases exposure to non-native and invasive plants and animals. New Hampshire has one of the highest growth rates of all states in the eastern U.S. Development is highest in the southern parts of our state, coinciding with the areas of greatest wildlife diversity. Recent census data projections indicate that the central portion of the state will grow rapidly, as well (e.g., Lakes Region). Fish and wildlife need quality habitat, and some species are at risk of being lost due to development pressure, especially in high-growth areas of New Hampshire. The presence of people can also degrade habitat even if it is not directly altered by development.

2B. Transportation

As New Hampshire's population grows, our transportation infrastructure grows with it. New Hampshire has one of the highest growth rates of all states in the eastern U.S. Development is highest in the southern parts of our state, coinciding with the areas of greatest wildlife diversity. Recent census data projections indicate that the central portion of the state will grow rapidly, as well (e.g., Lakes Region). Roads reduce and fragment habitat, subject wildlife to potential vehicle kill, and introduce additional disturbance and road salts into the environment.

Broad Strategies and Actions

Agency Regulation and Policy
1 Review Development Permits
2 Implement Access Control Measures
Conservation Planning
3 Prioritize Lands for Protection
4 Identify Unfragmented Blocks
5 Identify Landscape Connections
6 Identify High Risk Areas
7 Identify Focal Populations
8 Identify Critical Habitat Focal Areas
9 Restore Connectivity
Education and Outreach
10 Foster Supply/Demand for Native Plant Landscaping
11 Advocate BMP's for Agriculture
12 Advocate Adoption of Sustainable Forestry
13 Advocate Adoption of Alternatives to Pesticides
14 Advise Town Conservation Commissions
15 Advise Commercial Horticultural Organizations
Environmental Review and Mitigation
16 Review Ski area Expansion
17 Review Pesticide Permits
18 Review Forest Management Plans
19 Review Boating Access Projects
20 Mitigate Wildlife Impacts in Focal Areas
21 Mitigate Wildlife Impacts
Habitat Management
22 Develop Urban Wildlife Management Plan
Inter-Agency Regulation and Policy
23 Establish IRAT (Transportation)
24 Establish IRAT (Pollutants)
25 Establish IRAT (Development)
26 Develop BMP's For Agriculture
IRAT = Interagency Risk Assessment Team
Land Protection
27 Protect Unfragmented Blocks
28 Develop Land Protection Program
29 Advise Town Conservation Commissions
Landowner Incentive Program
30 Implement Backyard Habitat Program
Research
31 Test Experimental Road Crossing Structures
32 Research Terrestrial Pathways for Bio-accumulation
33 Restore Connectivity

Wildlife Summit Summary and Priorities

(from March 2004)

The following section is a summary of the major themes and issues that came up for each topic across all of the breakout groups – the issues recorded below were amalgamated/combined for all of the groups in order to eliminate duplicate data (i.e. if two groups said that education is a top issue for a given topic, it is only listed once below). Once the issues/themes were amalgamated for each topic area, each participant of the summit was allowed to vote on the top issue/theme for each topic area. They placed a vote on the issue/theme that they felt was most important and merits the most immediate attention.

Topic 1: Habitat Loss

- Lack of planning **(34 votes)**
  identification of critical habitats
  regulatory controls
  population growth
  lack of wildlife as a value in planning
- Dedicated funding **(24 votes)**
- Fragmentation **(8 votes)**
- Economic pressures **(6 votes)**
- Awareness/education **(5 votes)**
- Air and water quality **(2 votes)**

Topic 2: Human Wildlife Interactions

- Development/land conservation **(31 votes)**
- Communication and education **(19 votes)**
- Management and managing people **(4 votes)**
- Transportation/recreation **(3 votes)**

Topic 3: Private Lands Stewardship

- Education **(25 votes)**
- Economics **(18 votes)**
- Landowner rights and responsibilities **(14 votes)**
- Public use of private lands **(6 votes)**
- Government role **(2 votes)**

Topic 4: Successful Fish and Wildlife Conservation

- Maintain viable populations and habitats **(37 votes)**
- funding for protection monitoring and education **(15 votes)**
- Balancing conflicting desires **(5 votes**)
- Number and diversity of habitats **(3 votes)**
- People can see wildlife – residents & tourists **(1 vote)**

Topic 1: Habitat Loss (from Wildlife Summit)

Actions Needed (1st group):

- Habitat
- Think beyond political boundaries
- Identify specific habitat activities; work with delegation
- Partnering with transportation agencies to minimize fragmentation and incorporate wildlife crossings
- Incorporate habitat protection into land use planning
- Education of options
- Identifying/mapping critical habitats
- Map dispersal corridors
    - education of that
- Promote roadless areas
- Provide build-out analyses
- Replicate NEMO
- Focus on localized outreach
- Basic education/outreach

Actions Needed (2nd group):

- Using current use model, created added (financial) incentive to encourage long-term ownership (20 years) higher penalty for leaving current use
- Priority system considering all values of land – set it forth and educate people why it needs to be preserved – involve more people/organization in mapping
- Provide state information to towns to make it usable (use interns) get it to Planning Boards and Conservation Commission
- Regulations federal, updated regularly to protect. Air/water quality and keep pace with science (if feds won't state must)
- Encourage conversation/understanding of tax for school and linked to rest of towns issues
- Value of open space and low cost but generates revenue tourism, license sales
- LCHIP, tap federal money to buy land

Actions Needed (3rd group):

- Identify and protect most important habitats with viable populations
- Education

Topic 2: Human-Wildlife Interactions

Actions Needed (1st group):

- Establishing buffers and greenways
- Motorized recreation restrictions
- More land conservation funding

Actions Needed (2nd group):

- disseminate wildlife habitat maps
- improve education
- funding by all user groups
- establish a dialogue to improve opportunities to work together

<u>Topic 3: Private Lands Stewardship</u>
Actions Needed (1st group):

1. Education
    - Statewide land conservation conference (landowners/land activist workshops)
    - Audit of what's out there – help someone decide
    - Get beyond clutter – organize information and educational resources
    - Speaker's Bureau (address conservation commission, etc)
    - To interrupt regular course of action peer-to-peer, build trust
    - Find out what landowners want (Conservation Commission)
    - Attractive publications on unfamiliar wildlife (turtles, snakes, salamanders, etc) popular for general public
    - Backyards/small lots-schoolyard/backyard habitat – tell public what they can do
    - Find Americorps – get young people working
    - Develop action committee – see what's already out there, develop marketing strategy, partners, etc
    - "Develop constraints" map – does not include wildlife corridors (should…)
    - Get a feel for where elderly landowners are – hold workshops specific to them
    - Identify everyone who deals with landowner and give information
    - PLT – wild – web etc.
2. Economics
    - Better LCHIP funding
    - Conservation license plates, expand regular to off road vehicles
    - Value of wildlife recreation – what it means to economy – add to messaging
    - Working with developers on "smart" development at planning level
    - Change state tax structure
    - Pay developers not to build (see ag. Example)
    - Stricter zoning
    - Taller buildings
    - Incentives for rehabbing – Brownfields funding
    - Build wall around state
    - Provide better/clearer incentive for "smart" development
    - Wetlands regulations – change to promote more infill development
    - Change federal highway policy to reduce sprawl
    - Look creatively at other costs of low-income housing/inappropriate regulations in regions
    - Tax write off…duplicates no tax
    - Current use look at backyard incentives/tax structure

Topic 4: Successful Fish and Wildlife Conservation

Actions Needed (1st group):

- Surveys – public opinion.
  - what would someone pay
  - attitudes toward wildlife
- County foresters – need WILDLIFE bios in every county to serve same role
- Hit hard in schools – count number that are doing things
- Return on investment – measure it
- State support – money leveraging
- Partnerships
- Increase citizen science opportunities/involvement
- Publications
- Monitor number of people involved
- T&T/F&G work more closely to promote opportunities

Actions Needed (2nd group):

- Use local component of "cornerstone project" to identify what habitats and measures
- Identify coordinating person/agency to get overall picture
- Quantitative measures A & W quality
- Develop a true measure of ecotourism numbers
- Feedback from human users (consumption and non consumption) on wildlife
- Ask non-consumption and consumption about their experience and how well we are doing
- Be careful where put our resources to save species common nearby
- Success = coordination of data among diverse organizations to really understand situation
- Use indicator species as a measure of success (ie. Atlantic Salmon)

Actions Needed (3rd group):

- Get designated funding for protection, monitoring and education

Wildlife Plan Web Survey Results
(from August-October 2004)

Question 15. What actions do you think we should take to conserve wildlife? (950 respondents. Multiple responses possible.)
#1 Protect or provide habitat (22%)
#2 Educate about wildlife conservation (21%)
#3 Hunting or fishing related action (21%)
#4 Improve or manage habitat (9%)
#5 Smart growth – better planning for development (7%)

Question 16. Of the following actions, which ones should be the top three priorities for wildlife conservation in New Hampshire? (1256 respondents. Multiple responses possible.)
#1 Prevent loss of habitat (86%)
#2 Educate citizens about wildlife management (52%)
#3 Improve land use planning (40%)
#4 Encourage stewardship (36%)
#5 Manage recreational impacts (25%)

Wildlife Conservation Strategy Forum Results Summary

The following is a summary of those strategies and actions receiving 2 or more votes. Please see additional detail on these and other strategies, actions and tools in the pages that follow.

1A. Habitat Fragmentation

9 votes: Develop land protection program (includes the following)
- identifying funding mechanisms and political strategies
- enable communities to dedicate timber taxes to conservation

8 votes: Education strategies (includes the following)
- education packets with resources and funding sources
- education for agencies/regulators
- education strategy that targets schools/young people
- communicate with landowners
- more information sharing with general public

7 votes: Identify and prioritize lands for protection
6 votes: Protect unfragmented blocks
3 votes: Mitigate wildlife impacts (includes better mitigation/enforcement)
3 votes: Develop incentives for developers (includes the following)
- incentives to promote conservation of green corridors
- tax rules/laws to encourage these protections (closer look at current use)
- promote smart growth by encouraging "infill" developers in exchange for green corridors or other long term value parcels

2 votes: Advise town conservation commissions

1B. Air and Water Quality

12 votes: Land, water and wetland protection
6 votes: Identify high risk areas
4 votes: Education and outreach
3 votes: Environmental review and mitigation
2 votes: Inter-agency regulation and policy

2A. Growth and Development

9 votes: Land protection (includes the following)
- protect unfragmented blocks
- develop land protection program

8 votes: Advise town conservation commissions (and planning boards)
7 votes: Education and outreach (includes education through the Tree Farm Program)
5 votes: Agency regulation and policy (includes the following)
- encourage cluster zoning/tax incentives
- develop model ordinances/regulations to be used by towns/cities

4 votes: Conservation planning
3 votes: Prioritize lands for protection
3 votes: Research (includes test experimental road crossing structures)
2 votes: Identify critical habitat focal areas
2 votes: Environmental review and mitigation (includes mitigate wildlife impacts)

2B. Transportation

8 votes: Conservation planning – collaborate with Dept. of Transportation from beginning
4 votes: In-lieu fee proposal under consideration (pay mitigation fee to be used in conservation projects elsewhere)
4 votes: Education: advise town planning boards about best management practices for wildlife

Overview of Results: Specific actions, tools and comments suggested by participants on yellow sticky notes appear as "sub-bullets," indented, and in red. Priorities were done by sticky dots and are represented by numbers in front of the bullets.

1A. Habitat Fragmentation

Facilitator: Judy Silverberg; Recorder: Liza Poinier
Participants (15 people): Bill Hauser, NH Dept. of Transportation; Mark Kern, U.S. Environmental Protection Agency; Ray Whittemore, Ducks Unlimited; Steve Wright, National Wildlife Federation; Stacy Lemieux, White Mountain National Forest; Jeffrey Hayes, North Country Council; Fred Allen, Pemigewasset Valley Fish and Game Club; Scott Borthwick, NH Trappers Association; Bob Potter, landowner/NH Coverts Cooperator; Roberta Arbree, landowner; Fred Shepard, NH Trappers Association; Isobel Parke, Jackson, Jackson & Wagner (public relations firm); Chris Andrew, Newts (consulting herpetologist); Dea Brickner-Wood, Great Bay Resource Protection Partnership; Sheridan Brown, Office of U.S. Senator John Sununu

Agency Regulation and Policy

1 - Review Development Permits
- state permit review should be meaningful and thorough. Add staff especially for wetland review. Regulations should be tightened toward additional environmental protection. State should develop wetland mitigation bank to which regional/state entities have access to funds for conservation projects.
- Help prevent developmental loopholes and slow process down so organizations and agencies involved can make better informed decisions, especially wetlands!

Conservation Planning

2 - Prioritize Lands for Protection
- send letter to communicate with town governing bodies.

- Identify Unfragmented Blocks
- Identify Landscape Connections
- Identify High Risk Areas
- Identify Focal Populations

1 - Identify Critical Habitat Focal Areas
- State should participate/fund project area specific habitat inventory studies to further refine critical habitat areas.

- Restore Connectivity

Education and Outreach

- Advocate Adoption of Sustainable Forestry

2- Advise Town Conservation Commissions
- Some towns still do not have conservation commissions and/or planning boards. New State Law: mandate conservation commissions and planning boards.
- Help conservation commissions prioritize their activities. Provide funding to Cooperative Extension to do this.

Environmental Review and Mitigation

- Review Ski area Expansion
- Review Forest Management Plans
- Mitigate Wildlife Impacts in Focal Areas

2 - Mitigate Wildlife Impacts
- Charge developers with a fee when their project impacts wildlife resources in a significant way.
- Off-site mitigation on larger – connected areas.
- New protection of significant vernal pools; protect 3 acres for every acre of upland lost.

Inter-Agency Regulation and Policy

- Establish IRAT (Transportation)
- Establish IRAT (Development)

IRAT = Interagency Risk Assessment Team

Land Protection

6 - Protect Unfragmented Blocks
- Form groups around the state like the Great Bay Partnership and fund them well.
- Form/create statewide "conservation council" of groups, individuals to support appropriate political action.
- Develop regional plans for land protection.
- Provide more incentive for donation of land or conservation easements.
- Develop long-term funding source for land protection. Make available a portion of property – transfer tax for land protection (for example).
- Create additional tax or other incentives for landowners to protect critical habitats that they own.
- Upgrade timber harvesting regs. in view of current logging practices.
- Money for LCHIP (Land & Community Heritage Investment Program).

2 - Develop Land Protection Program
- Organize/coordinate all available state programs (include technical assistance and funding opportunities). Effectively communicate (clearinghouse through web site/state agency awareness and regional/single phone number contact). Clarify state land protection priorities and communicate.
- Develop a consistent and well endowed funding source for state land protection (LCHIP)
- Easier access to current use laws.

- Advise Town Conservation Commissions

Research

- Restore Connectivity

Additions to strategy/action list

1 • support wildlife issues in local master plans

5 • identifying/prioritizing lands for protection

- organized method of informing Conservation Commission
  - come up with formal education process for Conservation Commission across counties so all communities have the ability to be on same "page" and function efficiently and effectively
  - staff from Fish & Game to advise, educate and work with Conservation Commission
  - Conservation Commission should know Fish & Game laws before making decisions
  - Newsletter to conservation commission and planning boards
  - Utilize/fund regional planning commissions to provide outreach and education to Conservation Commission
  - Email listserv to share information throughout the conservation community
  - Conservation Commission and Planning Board receive copies of final report of forum/wildlife plan
- provide a review or overlay of regional/locally identified growth areas
- town Conservation Commission need a lot more help – get up to speed on "what's really happening"
  - a forum/meeting with town planners and Conservation Commission and Planning Board on this wildlife forum

- person at Fish & Game or a partner organization whose job is to interact with commissions and planning boards and give them information; same person could develop education packets, etc.

• more input/education – less politics at Conservation Commission level…"can't develop everything"

1 • better mitigation/enforcement
* pass and enforce laws that actually deter offenders and repeat violators other than small, insignificant fines

1 • coordination in planning efforts among agencies
* institute state agency planning clearinghouse to coordinate statewide planning and development initiatives

4 • Identifying <u>funding</u> mechanisms and <u>political strategies</u> for making it happen. Bringing in hunting and fishing communities
- form task group to identify funding sources and leverage funding. Form political action group to secure funding, promote conservation strategies thru rules and regulations.
- Fund conservation initiatives through broad-based tax system
- Identify potential partners/stakeholders

1 • contact and communicate with landowners

• figure out funding

• Conservation Commission need lots of education (e.g. sustainable forestry)
  - they are working on inconsequential things

1 • logging regulations need improvement

1 • even if Conservation Commissions knew more regarding wildlife…"we (Conservation Commission) have no teeth"…but one thing we can control is water
* give conservation commission the authority to ask developers for a wildlife impact plan on cluster developments

• possible for Conservation Commission to be given option to ask developers to consider needs of wildlife in planning (important study)

• small parcels becoming surrounded
  - need some money to buy development rights
  - could be some regional/planning for greenways in between small parcels?
  - new strategies for smaller parcels

1 • promote smart growth by encouraging "infill" developers in exchange for green corridors or other long term value parcels
* transferable development rights

• sometimes wetlands law promotes sprawl instead of reverse…

• move "restore connectivity"

1 • education – look at more information sharing with general public – choices they're making on their own land
* educate landowners of value and importance of critical habitat or resources on their property and importance of maintaining them

• developers to help them do this

1 • look at tax rules/laws to encourage these protections (closer look at current use)

1 • develop incentives for developers to promote conservation of green corridors

- discourage sprawl by giving financial incentives to developers to use cluster planning by installing sewer systems so that one acre was not necessary for individual septic systems
- highlight or celebrate towns and developments that take wildlife needs into their planning as a quality of life issue for residents on tourism
- develop committee of state and conservation organizations to work with commissions, legislators, developers, etc to search out funding and help agencies, town and individuals to get that funding

2 • develop education "packets" to discuss options…list resources and funding sources, etc.
- regional information meeting with state, federal and local officials to discuss wildlife issues and funding sources. Distribute funding information packets. Many conservation commission members may be unable to attend a day time meeting so a night time might be better.

• lack of planning – opportunity with federal grants for greater collaboration
• way to improve communications so Conservation Commission can collaborate with other conservation commissions…list servers?
• threats to tax benefits associated with giving conservation easements
2 • education for agencies/regulators to "know what they're talking about"
- state laws should be easy to read and understand

• cost-sharing programs (like Fish & Game's mowing program)
• most conservation organization have eyes on "big beautiful lands"...but help must be given to smaller parcels in south or they'll be gone
1 • add planning boards
3 • enable communities to dedicate timber taxes to conservation
- develop model legislation and solicit legislative sponsor
- educate/work with NH legislators for legislation enabling timber tax – conservation use

2 • education strategy that targets schools/young people – start early
* land stewardship should be required education
• enforce existing regulations like shoreline protection act

1B. Air & Water Quality

Facilitator: Charlie French; Recorder: Darrel Covell
Participants (8 people): Adair Mulligan, Connecticut River Joint Commissions; Nancy Christie, NH Lakes Association; Dave Tellman, landowner/NH Coverts Cooperator/NH Tree Farmer; Tanya Tellman, landowner/NH Coverts Cooperator/NH Tree Farmer; Wendy Ward, USDA Natural Resources Conservation Service; Ellen Snyder, wildlife consultant; Suzanne Fournier, Speaking for the Animals; Andrew Major, U.S. Fish and Wildlife Service

Conservation Planning
6 - Identify High Risk Areas
4 - Education and Outreach
- Model ordinance for towns.
- Advocate Adoption of Sustainable Forestry
- Partnerships

- Advocate Adoption of Alternatives to Pesticides
- Advise Town Conservation Commissions
- Advise Commercial Horticultural Organizations

3 - Environmental Review and Mitigation

- State technical committee request federal money (farm bill $) to go toward funding forest management plans and have money for review of plans (Cooperative Extension, Fish & Game, Fish & Wildlife) to promote sustainable forestry.

- Review Pesticide Permits
- Review Forest Management Plans
- Review Boating Access Projects

2 - Inter-Agency Regulation and Policy

- Establish IRAT (Pollutants)
- Develop BMP's For Agriculture

IRAT = Interagency Risk Assessment Team

12 - Land Protection (and water & wetland protection)

- Protect Unfragmented Blocks
- Develop Land Protection Program
- Advise Town Conservation Commissions

Research

- Research Terrestrial (and aquatic) Pathways for Bio-accumulation

- add soil to "Air & Water Quality"

<u>Missing</u>

- state
  - shoreland protection act
  - overlay district for buffers (e.g. for lower stream orders)
- local regulation
  - flood plain protection ordinances

<u>Education</u>

- boating as relates to invasive species
- separate strategy on "Water Protection"
  - identify pristine waters - difficult management
  - invasive keeping out, monitoring where

<u>Conservation Planning</u>

- identify pristine waters (e.g. like designated rivers)
- Land and Water Protection – riparian corridors connecting
- vernal pool protection especially not under wetlands protection
  - add strategy that NH Fish & Game is to actively support pro-environment bills (e.g. reduce mercury, reduce auto emissions)

<u>"Land & Water Wetlands Protection"</u>

- e.g. protect beavers creating habitat
- BMP's for agriculture > clarify "add to existing"

    - voluntary currently
    - are they following?
    - consequence for not
- regulating forestry/liquidation issue (e.g. Vermont & Maine laws)
- environmental review
    - evaluate T.M.D.L.'s in highest risk areas "total maximum daily load"
- enforce existing regulations (few staff)
- advise Conservation Commission
- - updating them on regulations/fact sheets
- Conservation Commission powers – authorize/not just advisory
- research – especially mercury issues > fish bioaccum
    - disagree that conservation commissions should be regulatory

<u>Conservation Planning</u>
- green infrastructure planning

<u>Inter-agency regulations/policies</u>
    - army corp policy – cutting down buffers
    - review old management plans/need new direction
- nitrogen in Great Bay (actions at that)
- targeted action items – geographically

<u>Land Protection</u>
- lobby 100% land use tax to conservation
- soil carrying materials > water
- how to deal with air quality?
    - lobbying Congress/agency > air quality standards
- state move on auto emissions
- key strategy – land and water protection
    - high risk areas/critical habitat
    - riparian connections
- model ordinances (especially for towns)
    - problem loss of O.S.P.
    - e.g. OSP > cell tower ordinance model
- water quality unifying concept (<u>the</u> issue)
    - broader, more inclusive justification in model ordinance (e.g. drinking H_2O, habitat, etc.)
- advocate – lawmakers at all levels (include state)

<u>Tools</u>
- web-based, update frequent, not just state maintained
- model ordinance
- empower/fund R.P.C's
- LCHIP, forest legislation, drink H_2O, etc = money
- raise RPC level of expertise
- ensure partnership use as a "tool"

- Dept. of Envt'l Services has a water quality standards advisory committee, wildlife interests should be better represented on issues such as TMDL's and nitrogen in Great Bay (Vern Lang is on this for USFWS, is Fish & Game well represented

2A. Growth and Development

Facilitator: Charlie French; Recorder: Darrel Covell

Participants (15 people): Ray Whittemore, Ducks Unlimited; Steve Wright, National Wildlife Federation; Nancy Christie, NH Lakes Association; Stacy Lemieux, White Mountain National Forest; Jeffrey Hayes, North Country Council; Dave Tellman, landowner/NH Coverts Cooperator/NH Tree Farmer; Fred Allen, Pemigewasset Valley Fish and Game Club; Wendy Ward, USDA Natural Resources Conservation Service; Scott Borthwick, NH Trappers Association; Bob Potter, landowner/NH Coverts Cooperator; Roberta Arbree, landowner; Fred Shepard, NH Trappers Association; Chris Andrew, Newts (consulting herpetologist); Dea Brickner-Wood, Great Bay Resource Protection Partnership; Sheridan Brown, Office of U.S. Senator John Sununu

3 - Agency Regulation and Policy

Review Development Permits

2 State agency review of existing rules and regulations and evaluation of effectiveness in terms of the protection of the intended environmental outcomes (i.e., wetland regulations, etc.)

Implement Access Control Measures

- Expand Shoreland Protection Act to 3rd order streams.

4 - Conservation Planning

3 - Prioritize Lands for Protection

3 Make a portion of property transfer tax available for habitat protection/management

4 Build statewide coalition of individuals/groups regarding wildlife conservation. Form statewide conservation council with representatives of all NH conservation groups. Convene annually for policy/ strategy discussion/debate.

Identify Unfragmented Blocks

Identify Landscape Connections

Identify High Risk Areas

Identify Focal Populations

2 - Identify Critical Habitat Focal Areas

Restore Connectivity

6 - Education and Outreach

Foster Supply/Demand for Native Plant Landscaping

- Stronger legislation on wooly adelgid and sudden oak death. Do not allow importation of plants or logs from infected areas.

1 - Advocate Adoption of Sustainable Forestry

5 - Advise Town Conservation Commissions

- Implement education programs for participants of conservation commissions who are not involved in conservation field and don't have critical skills needed for sound planning.
- Add staff at Fish & Game to advise, educate and work with conservation commissions when it comes to wildlife habitat.

Advise Commercial Horticultural Organizations

- Develop handout for new home owners relative to preferred species of plants to use for landscaping and what should be avoided. Distribute to real estate agents as well.

1 - Environmental Review and Mitigation

Review Ski Area Expansion

Mitigate Wildlife Impacts in Focal Areas
- DES wetlands rules allow an excellent, undisturbed forested wetland, for example, to be dredged and converted to an open pond, obliterating complex, natural habitat and substituting man-made habitat that is considerably less valuable. Revise wetlands rules?

1 - Mitigate Wildlife Impacts
- Develop broad-based funding mechanism for wildlife conservation. Develop political strategy for supporting wildlife conservation initiatives. Form political action groups regarding this element.

Habitat Management

Develop Urban Wildlife Management Plan

Inter-Agency Regulation and Policy ***(IRAT = Inter-agency Risk Assessment Team)***

Establish IRAT (Transportation)

Establish IRAT (Development)

4 - Land Protection

1 - Protect Unfragmented Blocks

4 - Develop Land Protection Program

2 - Advise Town Conservation Commissions
- Develop models of planning board and conservation commission Best Management Practices – they don't like to have to think and may lean "our way".
- Add staff at Fish & Game to advise, educate and work with conservation commissions on wetlands and other wildlife habitat.
- Report of this wildlife planning project to conservation commissions and planning boards. Website for their use for information /suggestions.

Landowner Incentive Program

Implement Backyard Habitat Program

1 - Research

2 - Test Experimental Road Crossing Structures

Restore Connectivity

5 communicate more (newsletter?) to town governing bodies, conservation commissions, planning boards. (Applies to all above).

6 Develop state-level conservation committee of state agency and conservation groups to compile and disseminate information, advise town commissions/boards & push strategies (Applies to multiple strategies above).

<u>Missing</u>

- local regulations under "regulations and policy"
- include regional regulations under "regulations and policy"
- include federal regulations under "regulations and policy"
- state regulations no logging >2500' elevation

1 • encourage cluster zoning/tax incentives

1 - * develop model ordinances/regulations that can be used by towns/cities

Conservation Planning

- think big –landscape features – let wildlife determine actions regardless of political boundaries
- prioritize water bodies (aquifers, lakes, rivers, wetland)
    - concern regarding private property in priority zone
- develop strategy for funding conservation projects (priorities)
- identify who is responsible for doing conservation planning
    - coordination of activities
- encourage cluster zoning/tax incentives

Education

- see habitat fragmentation education actions
- Fish & Game staff help with questions – Conservation Commission
    - website access point for that
    - training program for Conservation Commission

- Under #10 (Foster supply/demand for native plant landscaping) - hemlock wooly adelgid, sudden oak death (enforce regulations to prevent)
- include state lawmakers on policy issues
- include select boards
- laws against unsustainable forestry

1 • Tree Farm Program
    - education thru that to understand management planning
- mitigate wetland impacts
- preserve riparian corridors
- environmental (e.g. forest harvest>x acres) review process for forest management plans
    - no current laws have to do
- extend shoreland protection > 3rd order streams
- expand to add "forest" management plan
    - carrot incentive
- roadside planting, tree types
- discourage deliberate feeding
- develop lake management plans (inter-agency)

1 • provide more state staff/money to manage/restore state-owned lands/water
    - adequately fund (and fill) state staff positions (NH Fish & Game, Div. of Forests and Lands, stewardship program) to provide regular stewardship and management of state owned properties

Inter-agency

- concern over separating development and transportation into 2, maybe combine 1 rate

Land Protection

- add water and air to Land Protection
- comes back to good planning
- define "protection" – maybe open space planning when development

1 • add planning board to "Conservation Commission"

- work with congress regarding conservation easement tax benefits

- strengthen shoreland protection act
- consider exotic invasive
- concern regarding management of smaller protection parcels (tax incentives for donor to make money)
- umbrella organization to manage smaller parcels (money issue)

Landowner incentives
- see above too
- let people know what wildlife will come if you encourage wildlife

Research
  * need to research the economic impact of growth and development on our public waters; recreational value/use, the fisheries, loons and other wildlife
- "changing landscape" analysis at local/regional level
- state participate in habitat inventory studies on project basis
- research best plantings in developments (compile existing information)
  - information/recommend pamphlet or booklet/website to advise nurseries/landscapers.

2B. Transportation

Facilitator: Judy Silverberg; Recorder: Liza Poinier
Participants (8 people): Adair Mulligan, Connecticut River Joint Commissions; Mark Kern, U.S. Environmental Protection Agency; Tanya Tellman, landowner/NH Coverts Cooperator/NH Tree Farmer; Marjory Swope, NH Association of Conservation Commissions; Ellen Snyder, wildlife consultant; Suzanne Fournier, Speaking for the Animals; Isobel Parke, Jackson, Jackson & Wagner (public relations firm); Andrew Major, U.S. Fish and Wildlife Service

Agency Regulation and Policy
Review Development Permits
- Promote the Roads Scholar program and look at Vermont's Better Back Roads program for extra ideas. Train local road agents.

1 - Conservation Planning
- Develop GIS maps of riparian connectivity and unfragmented habitat blocks by region to guide location of roads and development away from these areas.
- **Information to local conservation commission & planning boards on which areas are most important.**

Prioritize Lands for Protection
Identify Unfragmented Blocks
Identify Landscape Connections
Identify High Risk Areas
Identify Focal Populations
Identify Critical Habitat Focal Areas
Restore Connectivity

Education and Outreach
- **Expand Fish & Game constituency: more Wildlife Journal readers; change flavor of Wildlife Journal to cover these key issues more often; reduce segregation into "nongame", "game", etc. – show connectedness not segregation.**
- Continue outreach/education on wildlife friendly driving - "brake for wildlife", Eric Orff's campaign.

Foster Supply/Demand for Native Plant Landscaping
- Fish & Game, DOT and other state agencies use native plantings in their project and on their lands.

- Keep the state nursery going strong and establish satellite nurseries around the state.
- Lists to be provided to nurseries for their inventory.
- A brochure for developers to avoid invasive species and offer native species.

Advise Town Conservation Commissions

Environmental Review and Mitigation

Review Boating Access Projects

Mitigate Wildlife Impacts in Focal Areas

2 - Mitigate Wildlife Impacts
- mitigation should be near to other protected lands; not isolated.

Habitat Management

Develop Urban Wildlife Management Plan

Inter-Agency Regulation and Policy ***(IRAT = Inter-agency Risk Assessment Team)***

Establish IRAT (Transportation)
- task IRAT with formulating state policy to address the issue of secondary development
- Fish & Game and DOT have a systematic approach to keeping each other informed of projects of mutual interest.

Establish IRAT (Development)

Land Protection

Protect Unfragmented Blocks

1 - Develop Land Protection Program
- support/provide fund for protection.

Advise Town Conservation Commissions

Research

1 - Test Experimental Road Crossing Structures
- have road crossing structure experiment on Route 2 in Randolph.

Restore Connectivity

5 • collaborate with DOT on planning from the beginning
  - educate towns on importance of early participation in DOT planning for road
  - create GIS layer (DOT) that maps out projected projects over the next 10 years. Overlay that with un-fragmented blocks, connections, critical habitat, etc. Identify where the conflicts are now to see whether rerouting project plans can be changed early
- support regional planning – local boards, etc.
- inter-agency includes state, federal

1 • DOT never includes riparian buffers…should be part of their MO
  - Dept. of Envt'l Services/Fish & Game insist that DOT back off on the riprap near streams and over plant wherever possible
  - provide list of buffer plants (native) and planting/maintenance requirements to DOT project managers (CRJC has posted at www.crjc.org/riparian buffers.htm)

1 • bridge and culvert inventory for aquatic connectivity

1 • green infrastructure concept could be integrated into all aspects of planning

1 • figuring out recreation/transportation/habitat balance in planning projects

- Identify and remove invasive plant species

- expand IPANE inventory
- education – brake for wildlife/drive with wildlife in mind type of "campaign"/materials (user friendly/suggestions)
- need process to discuss and establish mitigation "banking" and large scale, DOT bank, state funded (have done for Ammonoosuc)

4 • in lieu fee proposal under consideration
- provide political support for the in-lieu fee bill
  - has passed Senate, now in House
- continue to experiment with materials other than salt for snowy roads
- establish "test" sections of roadways and conduct a scientific study looking at efficiency of different de-icing agents
- look at runoff from parking lots (snow removal)
- railroad – may be able to work with them to not mow down riparian buffers
- wildlife passages between stored train cars
- under research – establish research for moose collisions
- developers could use advise on how to plan non-straight road systems…shared driveways, widths and surfaces of roads, less hardtop, etc.

4 • education: advise town planning boards (they must approve these road systems) "BMPs" for wildlife – implemented suggestions
- model ordinances for towns (Planning Boards) i.e. protect deer yards
- train private/consulting wildlife biologists to guide development/transportation projects (town level/private developers)
- are constructed wetlands still common DOT practice? (they've gotten better at locating but ecology still not top concern)
- focus on multiple small infiltration areas for stormwater rather than larger constructed wetlands that stay inundated and trap wildlife

1 • secondary development - to what degree does DOT or town take responsibility to protect habitat before planning? (currently, encouraged to provide for future access)

* DOT should provide money for likely secondary impacts to help with green infrastructure

- class V & VI roads – protection is fragile

1 • needs to be more private wildlife consultants who can guide planners/individuals - training programs?

* education & outreach tool for Fish & Game staff: NH Fish & Game to take an active role in advising about wildlife protection in regards to existing and planned roads.

- "Wildlife management" with transportation in mind

* Encourage population levels of species that would minimize potential for human-animal collisions

Appendix L: Species and Habitat Profile Template

Critical Habitat: [Name] *required for habitat profiles and species profiles*
Focal Species: [Name] *not required for habitat profiles*
Federal Listing: [Esa Listing Status] *not required for habitat profiles*
State Listing: [Rsa 212 Listing Status] *not required for habitat profiles*
Affected Species: [Species List] *not required for species profiles*
Global Rank: [Rank] *for habitats, list ranks of included NHB natural communities; for species, state species rank*
State Rank: [Rank] *for habitats, list ranks of included NHB natural communities; for species, state species rank*
Author: [Last Name, First Name, M.I.]
Affiliation: [Name]

NOTE: Italicized text should not be included in the profile. The format of the profile must follow the formatting of this template. Other formatting considerations such as time and date styles, abbreviations and acronyms, punctuation, citing literature in text, figure formats, etc. are covered in a separate document (Profile submission guidelines.doc). All bracketed fields must be completed to the extent possible.

Element 1: Distribution and Habitat

1.1 Habitat Description
[For habitat profiles, briefly list the key biotic and/or abiotic attributes that distinguish this habitat type from other habitat types. For species, briefly list habitat attributes that provide critical life history requirements.] *This field is a quick reference. Details about habitat health and quality will be described in subsequent fields where relevant. Citations for relevant literature on life history and habitat requirements should be included in Element 6.*

1.2 Justification:
[Briefly state the reason for conservation concern, the overall trend, or the pattern of change that indicates imperilment of the species and/or habitat (e.g., "throughout the northeast, alpine habitats are shrinking as timberline shifts upward in elevation"). Briefly justify the selection of this species/habitat and/or the exclusion of associated species (e.g., although species richness is typically lower in alpine habitats than adjoining systems, alpine habitats are rarer and generally have higher rates of endemism). Briefly link the health of the species/habitat to the health of taxonomically or ecologically associated species/habitats (e.g., changes in alpine communities may serve as an indicator of climate change, and provide early warning of impacts to wildlife at lower elevations).] *This field is a brief summary of the reasoning behind the inclusion of the species/habitat in the plan. Details about specific threats or anticipated benefits of conservation are described in subsequent fields where relevant.*

1.3 Protection and Regulatory Status:
[List pertinent (excluding ESA and RSA 212) federal, state, or local laws, ordinances, and rules regulating the take, transport, or use of the species and/or habitat.] *Proposed changes to NHB*

rankings, protection, or regulatory status should be addressed under Element 4 – Conservation Actions.

1.4 Population and Habitat Distribution:
[Briefly summarize the current and historic state range in a regional context (e.g. "approximately 75% of the northeastern population occurs within NH"). Describe spatial patterns of distribution within NH (e.g., biogeographical clustering vs. randomness, as in "clustered along northern rivers" or "scattered throughout the White Mountains"). Briefly identify patterns of isolation and fragmentation.] *This field is a brief summary of broad patterns of distribution. Details about specific locations will be described in subsequent fields.*

1.5 Town Distribution Map
[Map the distribution of species and/or habitats at the town level based on species occurrence data.] *To be provided by NHFG.*

1.6 Habitat Map
Completion of this field is required only for partners contracted to map species or habitat types. Relevant habitat maps will be provided to others that may require them to complete their habitat or species profiles.
[Describe the methodology used to map the locations of current, historical, and/or potential habitat patches, and evaluate limitations in the reliability of the resulting maps because of data, logistical, contractual, or methodological constraints.] *Provide a shapefile containing polygons delineating current, historical, and/or potential habitat patches. Further guidance will be provided to habitat-mapping contractors regarding information desired for shapefile attribute tables.*

1.7 Sources of Information:
[Briefly describe the sources or processes used (e.g., literature review, databases, meetings and forums, expert review or consultation) to gather information on the distribution of species/habitat during the planning process. Literature and other sources should be cited in text where applicable throughout the profile and full citations should be included in the profile bibliography in Element 6.]

1.8 Extent and Quality of Data:
[Justify the level of detail provided by describing the extent and quality of existing data on the distribution of the species/habitat across the state. Clearly identify gaps in knowledge about the distribution of the species/habitat.]

1.9 Distribution Research:
[List high priority survey, monitoring, and research efforts needed to provide unknown information about the distribution of the species/habitat.]

Element 2: Species/Habitat Condition

2.1 Scale:

[Identify an appropriate conservation planning unit (for use in Elements 2, 3, and 4) that directly links to polygons of species' populations and/or habitat patches. For instance, polygons may be: 1) grouped (e.g., by ecoregion subsection, Wildlife Management Unit, etc.), to reduce the number of units to a more manageable size for analysis; 2) split, to provide a more detailed ecological analysis (this may be the best option when polygons extend across a large geographic area); 3) treated individually. Spatial extent, configuration, and number of polygons should be considered.] *Scale will be resolved by the habitat mapper.*

2.2 Relative Health of Populations:
[Describe the relative abundance of the KEY populations/habitat occupying units mapped at the scale defined in section 2.1. Historical and potential occurrences should be included. Describe trends or viability of KEY populations in enough detail to identify where and what conservation actions need to take place under Element 4.]

2.3 Population Management Status:
Not required for habitat profiles. [Describe the relative efficacy of ongoing population management efforts with enough detail to identify populations potentially requiring conservation actions under Element 4, and to identify potential conservation opportunities.]

2.4 Relative Quality of Habitat Patches:
Required for all profiles. [Summarize the relative quality of KEY units mapped at the scale defined in section 2.1 in terms of their ability (or potential) to provide key ecological attributes of niches and habitats (e.g. availability of forage, nest sites, cover, diversity, and productivity). Describe KEY habitat patches in enough detail to identify where and what conservation actions need to take place under Element 4.]

2.5 Habitat Patch Protection Status:
[Summarize the relative protection status (e.g., fee, easement, other) of KEY units mapped at the scale defined in section 2.1 (e.g., ninety percent of mapped habitat patches in Wildlife Management Unit F are in fee-simple ownership by the state of New Hampshire, Division of Forests and Lands).]

2.6 Habitat Management Status:
[Summarize the relative efficacy of ongoing habitat management or restoration efforts with enough detail to identify habitat patches potentially requiring conservation action and to identify potential conservation opportunities.]

2.7 Sources of Information:
[Describe the process used (e.g., literature review, databases, meetings, expert review and consultation) to study the condition of species/habitat that were consulted during the planning process. Literature and other sources should be cited in text where applicable and included in the profile bibliography in Element 6.]

2.8 Extent and Quality of Data:

[Justify the level of detail provided by describing the extent and quality of existing data on the condition of species/habitat across the state. Clearly identify gaps in knowledge to adequately assess the condition of species/habitat.]

2.9 Condition Assessment Research:
[List high priority survey, monitoring, and research efforts needed to assess the current condition of species/habitat, including studies to develop measurable indicators of health and/or quality.]

Element 3: Species and Habitat Threat** Assessment

*** "THREAT" is used here synonymously with the term "Risk Factor", which is used throughout the WAP. "Risk Factor" was adopted after this template was drafted.*

NOTE: Complete and attach Form 1: Risk Exposure, Form 2: Risk Facto Ranking, and Form 4: Local Threat Weighting. Technical assistance will be provided. Form 4 can not be completed without a map.

3.1.X [Name of Direct Threat, Threat Category, Categorical Rank] *Complete this field only for high-ranking direct threats identified in the threat ranking procedure. Technical assistance will be provided.*

(A) Exposure Pathway: [Describe the chain of causality (exposure pathway) that leads from human activity (regardless of scale or origin, e.g., local, state, regional, national, international), to a direct threat to the focal species and/or habitat, to a response in the focal species and/or habitat. Following is an example for describing the exposure pathway for wintering bats. "Recreational spelunkers that enter caves during the winter may disturb hibernating bats. This could result in the bats expending energy at a time of year when energy conservation is imperative to survival. As a result, direct mortalities may occur."]

(B) Evidence: [Provide evidence to evaluate the severity, urgency, and underlying mechanisms of the direct threat for the species or habitat.]

3.2 Sources of Information:
[Describe the process used (e.g., literature review, databases, meetings, expert review and consultation) to study threats to species/habitat that were consulted during the planning process. Literature and other sources should be cited in text where applicable and included in the profile bibliography (Element 6).]

3.3 Extent and Quality of Data:
[Justify the level of detail provided by describing the extent and quality of existing data on the threats to the species/habitat across the state. Clearly identify gaps in knowledge about the threats to the species/habitat.]

3.4 Threat Assessment Research:
[List high priority survey, monitoring, and research efforts needed to identify threats that are adversely impacting the species and/or habitat, regardless of scale, including potential indicators of threats and evidence of their utility.]

Element 4: Conservation Actions

NOTE: Successful implementation of conservation actions rests on two assumptions: 1) that the conservation action will change the threat (i.e., conservation performance); 2) the targeted species/habitat will benefit by the change in the supposed threat (i.e., ecological response). Ideally, no action will be undertaken without reasonable evidence that the assumptions are true. However, there is no assurance that this will be the case. Because of this uncertainty, all actions that are undertaken need to be designed so that the assumptions can be evaluated. Doing so will allow practitioners to adapt conservation actions (if necessary) to focus on the correct problem or the correct implementation methods.

When there is insufficient information to elucidate whether a conservation action will clearly lead to a change in the threat (conservation performance) or that a change in the threat will lead to a change in the species or habitat (ecological response), then surveys, monitoring, or research should be indicated. The objectives of such research must focus on developing implementation methods to change the threat or evaluate whether or not the species/ habitat will respond beneficially to a proposed action.

4.1.X [Specific Conservation Action, Category] *For "Category," list one of the following: Restoration and Management; Habitat Protection; Education and Outreach; Regulation and Policy. Specific conservation actions should correspond with "Category". Examples include captive rearing, fee-simple acquisition, educational video production, revised collection permitting process, respectively.*

(A) [List of Direct Threats Affected] *Must include at least one high-ranking threat described in section 3.1.*

(B) Justification:
Briefly provide reasoning that the following assumptions/criteria are satisfied:

1) [the conservation action will actually impact the relevant threats in a measurable way in specific locations.]
2) [impacting those threats will actually cause a beneficial and measurable ecological response in specific populations or habitat patches]
3) [the spatial scale of the action is appropriate for the spatial scale of the threat]
4) [the timeframe of the action is appropriate for the urgency of the threat and responsiveness of the specific populations or habitat patches]
5) [the conservation action can be adapted to new information about the performance of the action to achieve the desired ecological response.]

(C) Conservation Performance Objective:
[Performance describes the causal relationship between the conservation action and the problem or threat. Define the desired performance of the conservation action by identifying the scale-appropriate attribute of the human or ecological system that the action is intended to *directly change*, the direction of the change, the desired magnitude of the change, the desired time period for the change to occur, and an endpoint. Identify a measurable indicator of the performance of the conservation action that is directly linked to the intended change. For example, "The objective of captive breeding is to increase the captive population of translocated and captive reared butterflies to a minimum of 200 adults for each brood over a three-year period, and

maintain the population for five years. Successful captive breeding will be indicated by the annual number of adult butterflies released into the wild."]

(D) Performance Monitoring:
[Briefly describe methods for monitoring the performance indicator building on existing efforts and including specific objectives. Provide enough detail, including locations, justification for scale, and frequency of monitoring, to facilitate the development of more detailed methods at a later date. Describe how observed levels of performance indicators will influence management decisions.]

(E) Ecological Response Objective:
[Define the desired ecological response to the conservation action by identifying the scale-appropriate attribute of the ecological system that is expected to elicit a *beneficial response* to the change induced by the conservation action, the desired direction of the response, the desired magnitude of the response, the desired time period for the response to occur, and an endpoint. Identify a measurable indicator of the desired ecological response that is directly linked to the benefit intended for the ecological system. For example, " The desired ecological response to captive breeding is to maintain on average a positive growth rate in the wild population until the wild population is self-sustaining. Successful population restoration will be indicated by a positive growth rate in the wild population and achievement of federal viability criteria."]

(F) Response Monitoring:
[Briefly describe methods for monitoring the response indicator building on existing efforts and including specific objectives. Provide enough detail, including locations, justification for scale, and frequency of monitoring, to facilitate the development of more detailed methods at a later date. Describe how observed levels of response indicators will influence management decisions.]

(G) Implementation:
[Describe implementation of the conservation action sufficiently to guide the development and execution of specific projects and programs. Identify the frequency and intensity of the action, the time frame for initiating and completing the action, specific locations, and methodology. Describe the potential roles of state and federal agencies or local, regional, national, or international partners, and identify needs or opportunities to coordinate and collaborate with other states.

(H) Feasibility: [Categorical Rank]
[Discuss the feasibility of implementing the conservation action in sufficient detail to guide the prioritization of implementation and avoid potential roadblocks. Evaluate the preparedness and expertise of the agencies and partners with relevant roles, the funding requirements, personnel resources, and public and partner interest.] *Complete ranks on Form 5: Feasibility Ranking and Form 6: Local Feasibility Weighting (map and quantitative attributes required). Technical assistance will be provided.*

4.2 Conservation Action Research:

[When there is insufficient information to elucidate whether a conservation action will clearly lead to a change in the threat (conservation performance) or that a change in the threat will lead to a change in the species or habitat (ecological response), then surveys, monitoring, or research should be indicated. Provide enough detail to develop requests for proposals to implement research. Identify opportunities to build on existing programs.]

Element 5: References
Personal communications should be cited in text using Journal of Wildlife Management *formatting guidelines.*

5.1 Literature: [Provide full citations in *Journal of Wildlife Management* format for all literature cited in text. Use Council of Biology Editors style when citing websites http://www.webwritingthatworks.com/DResourcesCITE06cbe.htm.]

5.2 Data Sources: [Use Council of Biology Editors style when citing databases http://www.webwritingthatworks.com/DResourcesCITE06cbe.htm.]

Element 6: List of Figures [Provide a list of figures with caption. If appropriate, include a statement of credit at the end of the caption (e.g., "Photo by R. Dolbeer.", "Photo courtesy of United States Fish and Wildlife Service.")]

Appendix M

Directions for Identifying and Ranking Risks Using Forms 1 & 2

PURPOSE OF IDENTIFYING AND RANKING RISKS

1. Describe risks in a consistent, standardized format to facilitate planning decisions.
2. Provide a tool that will allow NHFG to objectively prioritize actions within and among levels of the ecological hierarchy (e.g., within species, within habitat, and among species and habitats).
3. Provide a source of data that can be queried to obtain a comprehensive overview of risks.

FORM 1: RISK EXPOSURE

Complete Form 1 or provide comments on a completed draft of Form 1 using the following guidelines, and return it to NHFG:

a. SPATIAL SCALE: Identify all possible risks, regardless of spatial scale, for each conservation target (i.e., species or habitat). The scale of the risk should be commensurate with the scale of the target. Broad scale, pervasive risks like global climate change, acid rain, and heavy metal contamination should be assessed if exposure can be linked to a stress in the conservation target, even though it may be difficult to identify specific points on the exposure pathway for a given target. It is recognized that ultimately it will be impractical to plan for such large-scale issues within the context of a particular species or habitat; therefore major statewide risks will be compiled and explicitly addressed in a section of the Comprehensive Wildlife Strategy (CWS) specifically dedicated to statewide risks. As such, no conservation actions should be provided for statewide risks within a species or habitat profile.

b. TEMPORAL SCALE: Identify all possible risks that wildlife are currently or potentially exposed to. Limit potential risks to those with underlying causes that currently exist and are likely to increase with current human population patterns. The 'timing' field could also be interpreted as a rough indicator of the CWS planning horizon. The upper bar for strategy development is 15 years. Some broad scale, long-range issues (e.g., climate change, acid deposition) will receive attention elsewhere in the plan.

c. ECOLOGICAL SCALE: Risks that cause stress to individual species should be evaluated at the species level. For habitats, address risks that stress entire groups of species, such as small mammals, large mammals, birds, reptiles, amphibians, invertebrates, natural communities, or habitat structure/composition.

d. RISK CATEGORIES: Consider all categories of risk identified in **TABLE 2 "Generic Threats in Different Biome Types"**, but only list risks that actually or potentially cause stress to the target.

e. CAUSALITY: Definitions of the terms used to describe exposure pathways are given in **TABLE 1.** The pathways of risk exposure are continuous chains of causality

that lead from human action (usually) to impacts on a conservation target. There are an infinite number of discrete points along the exposure pathway, so it is expected that there will be variation in the underlying causes, direct risks, stresses, and targets that individuals identify for any given pathway. The ability to plan conservation actions effectively is limited by knowledge of the causes of ecological stress and effects on targets. It will be most useful to identify the underlying causes and direct risks for which it is most practical to develop and implement actions to abate the risk. Likewise, it will be most useful to identify stresses or aspects of the conservation target that can be easily monitored to observe a response to changes in the risk.

f. EVIDENCE: As much as possible, cite evidence in support of your assessment of each risk that has been identified.

1. Completed forms and comments will be compiled and condensed by NHFG or the profile writer to screen for redundancy and collate underlying causes, direct risks, and stresses under the most appropriate categories.

FORM 2: RISK FACTOR RANKING FORM

1. Transfer the list of direct risks from the final FORM 1 to FORM 2 (this may have been done already by NHFG or the profile writer).

2. Fill in scores for the factors described below. The factors are rarely constant over time. Onset of loss of function in the target will be used as an ecological constant across all assessments of risks for all species and habitats. Loss of function may be defined as an adverse change (stress) in the trend of a critical process in the life history of an organism (e.g., reduced survival, reproduction, or foraging, etc.) or ecology of a habitat (e.g., shifting composition, structure, or productivity, etc.). Onset occurs at the inflection point for the changing trend. To truly signify onset, such a change would have to be sustained and exceed the normal range of variation. If onset has already occurred, TIMING should receive the score for 'current' (4), and scores for all other factors should be based on their current values. Otherwise, TIMING should be scored based on the projected time of onset, and all other factor scores based on their projected values at the timing of onset.

   In some instances quantitative statewide risk data are available to assist with scoring the factors. Currently, for example, quantitative data are available to assess risks caused by air and water pollution, road impacts, wind energy, climate change, development, and population growth. However, little reliable quantitative data exists beyond these issues. As such, expert opinion will be used to augment quantitative data to assist with making conservation planning decisions.

3. MAGNITUDE FACTORS

   a. SCOPE: A measure of the percent (%) of the statewide distribution of the target that may be exposed to the risk or number affected relative to the total

area or number). A risk that is very localized, therefore not impacting a large percentage of the affected target, should score lowest, whereas a pervasive broad scale risk should score high. Consider whether outside factors like land protection influences the potential scope of the risk.

b. SEVERITY: A measure of the intensity of the stress impacting the proportion of the target exposed (as defined by SCOPE) to the risk. Severity is expressed as the percent (%) of the exposed population/habitat that will realize loss of function as defined above (e.g., mortality, loss of viability, failed dispersal, starvation, competitive exclusion, community succession, etc.). A stress inducing a very low rate of lost function in the exposed population should be assigned a low score while a stress inducing a high loss of function should be assigned a high score.

4. URGENCY FACTORS
   a. TIMING: Time until the target begins to lose function (loss of function is defined above). If a risk already has caused a loss of function in the target, it should be considered current, and score highest. If a risk is expected to cause a loss of function more than 15 years from now, it should score lowest.
   b. LIKELIHOOD: The probability that the risk will actually be manifested as defined above (e.g., at the levels projected for scope, severity, and timing). The likelihood score increases as probability increases.
   c. INFORMATION: A measure of the quality and reliability of evidence that the risk will be manifested as defined above (e.g., at the levels projected for scope, severity, and timing). The information score increases as the quality and reliability of evidence increases.

5. OVERALL RISK RANK: Ranked factors will be applied to a formula that calculates the overall RISK RANK (this will be done automatically if using the available Excel spreadsheets). The factors used to measure risks are reduced to magnitude (scope, severity) and urgency (timing, likelihood, information), by taking their means, and are then given a multiplicative relationship and scaled to 4 to retain the original scoring scale:

   RISK RANK= (((a+b)/2)/4)((c+d+e)/3)

   where a=SCOPE score, b=SEVERITY score, c=TIMING score, d=LIKELIHOOD score, and e=INFORMATION score.

6. INTERPRETING RISK RANK: In the published literature, there are many examples of arithmetic and rule-based approaches that summarize the factors influencing risks. Most of these conservation-planning tools use a combination of weights, means, and additive or multiplicative interaction of factors. The resultant ordering varies according to how the summary algorithm or formula is defined. It is acknowledged that the summary rank is a planning and decision-making tool, not a true quantitative measure. Therefore, precise ordering is not the intended outcome. The purpose of the ranking process is to provide a consistent basis for comparing risks across all species and habitats, and for placing those risks into categories of appropriate conservation action.

7. CATEGORICAL CLASSES: For this planning effort, the RISK RANK score will be used to assign the risk to a categorical class and decide which risks to plan to address in the current planning period with focused conservation strategies. When a score for a given risk falls near the threshold for two classes, careful scrutiny of the ranks given for each factor is warranted to ensure that the potency of the risk is being ranked appropriately relative to the other risks being ranked. When evaluating your scores, consider risks in the following context:

    a. Without action, CATASTROPHIC risks (3.25-4.00) will in the near future almost certainly result in the widespread complete loss of populations/habitat patches, with statewide extirpation already looming on the horizon. Immediate action is necessary to secure the conservation target, and there is not enough time to wait for better information.

    b. Without action, CRITICAL risks (2.50-3.24) will in the near future almost certainly result in widespread degradation of populations/habitats, resulting in an increasing risk of statewide extirpation. Action is necessary to control the risk, but initiating research to improve the efficacy of actions is, in some cases, justifiable over immediately initiating abatement.

    c. Without action, SERIOUS risks (1.75-2.49) may in the near future degrade some populations/habitats, with a very low risk of statewide extirpation. The risk may need to be controlled at the local level in the short term, but it is advisable to first conduct research to obtain more accurate information about the risk or wait until changes in the level of the risk can be measured statewide.

    d. Without action, CHRONIC risks (0-1.74) may degrade some populations/habitats at a level that is currently sustainable. The risk may need to be controlled in the long term, but currently it is reasonable to plan to re-evaluate the risk later.

Conservation actions should only be generated for risks ranked as "CATSTROPHIC" or "CRITICAL." However, if you find that you have no serious or critical risks, then address those higher ranked "moderate" ones.

8. Where data are available, quantitative analyses will be conducted to check results. As an additional check, risks assessments are nested within all species, habitats, and landscapes. It would be very difficult for a significant risk to a conservation target to be missed at each of these hierarchical filters. For example, on a hypothetical landscape scale, lack of concrete information limits our ability to develop a strategy to address climate change or even project the magnitude of stress induced by it, which may result in climate change receiving a "seriou" rather than a "critical" overall rank. Effort to address such a landscape risk would be allocated to informing regional, national, and global planners of our findings and by supporting regional monitoring and planning efforts. However, in some instances, climate change may be well documented in a specific location, with a fairly predictable pattern of high magnitude

stress for a well-known species. In such cases a resulting risk rank of "critical" would be justified. In these cases, effort may be allocated to the critical species risk by immediately initiating research on rates of habitat change and evaluating preservation of the species in zoos before it becomes extinct.

Completed risk ranking forms will be compiled and condensed by NHFG or the profile writer. Scores from individuals will be averaged….

Thank you for taking the time to contribute to NH's Comprehensive Wildlife Conservation Strategy!

Table 1. Definitions (from Salefsky et al, 2003).

- **Threats** – Any human activity or process that has caused, is causing or may cause the destruction, degradation and/or impairment of biodiversity and natural processes. There is often a fine line between a naturally occurring event such as a fire set by lightning and a human-caused threat such as a fire set by a match or even increased intensity of fires due to forest management practices. In general, we would regard the latter two as threats whereas the former is not. In systems that depend on human actions to maintain biodiversity such as the use of prescribed burns, the removal or alteration of these management activities may also constitute a threat. Includes both *direct threats* and *underlying causes*. Synonymous with *pressures*.

- **Direct Threats** – Factors that immediately cause stress to conservation targets by physically causing their destruction or degrading their integrity.

- **Underlying Causes** – A condition or environment, usually social, economic, political, institutional, or cultural in nature, that enables or otherwise contributes to the occurrence and/or persistence of a direct threat. There is typically a chain of underlying causes behind any given direct threat. In a situation analysis, underlying causes can be subdivided into *indirect threats* (factors with a negative effect) and *opportunities* (factors with a positive effect). Synonymous with *drivers*.

- **Targets** – The biological entities (species, communities, or ecosystems) that the project is trying to conserve. Synonymous with *conservation targets, biodiversity targets,* and *focal targets*.

- **Stress** – The impairment or degradation to a key ecological attribute of a conservation target that results in reduced integrity of the target. As shown in the diagram, a stress is not a threat in and of itself, but rather a condition of the target. In many situations, defining specific stresses leads to an unnecessary level of detail, especially when the project is operating at a coarse scale. In these cases, it is better to just have the stress be implicit in the arrow leading from the threat to the target. For example, if a threat to a forest in a National Park is illegal clearcut logging, then the project team members will want to act to keep the loggers out of the forest. They don't need to worry about stresses. In some situations, however, it is important to detail the specific mechanisms by which a threat affects a target. For example, the threat to a forest in a managed timber area is legal selective logging, then the team may not be able to completely eliminate the loggers. Instead, the project may wish to ameliorate specific problems caused by the logging such as soil erosion into streams and secondary damage to trees caused by felling practices. In this case, the team members may wish to expand the arrow linking the logging threat to the forest target to show specific mechanisms or stresses.

Table 2. Threat Categories (from Salefsky et al, 2003).

	GENERIC THREATS IN DIFFERENT BIOME TYPES				
THREAT CATEGORY	**Forests**	**Grasslands / Savannah**	**Desert**	**Freshwater**	**Marine**
Habitat conversion	Housing Industrial development Farms Plantations Ski areas	Housing Industrial development Farms Dam construction Golf courses	Housing Industrial development Farms Golf courses	Docks Farms (e.g., rice) Channelization Dam construction Ship yards	Aquaculture Destructive fishing
Transportation infrastructure	Utility lines Roads Railroads	Utility lines Roads Railroads	Utility lines Roads Railroads	Levees & dikes Dredging	Dredging Shipping lanes
Abiotic resource use	Mining Oil & gas drilling Geothermal energy Water withdrawal	Mining Oil & gas drilling Geothermal energy Water withdrawal Wind farms	Mining Oil & gas drilling Geothermal energy Water withdrawal Wind farms	Mining Oil & gas drilling Water withdrawal	Mining Oil & gas drilling Coral mining Desalizanation plants Wind farms
Consumptive biological resource use	Hunting / NTFP collect Grazing Logging	Grazing Hunting / gathering	Grazing	Fishing	Fishing Trawling
Non-consumptive biological resource use	ATVs / snowmobiles Hiking / biking Scientific research Military maneuvers	ATVs Hiking / biking Scientific research Military maneuvers	ATVs Hiking / biking Scientific research Military maneuvers	Jet skis Boating Scientific research Military maneuvers	Jet skis Boating Scuba / snorkeling Scientific research
Pollution	Acid rain Solid waste Toxins Radio active fallout	Solid waste Toxins Radio active fallout Agricultural runoff	Salizanation Toxins Solid waste	Municipal waste Solid Waste Toxins Agricultural runoff Thermal pollution	Solid Waste Toxins Agricultural Runoff Municipal waste Sonic pollution
Invasive species (alien and native)	Plants Animals Disease & pathogens	Plants Animals Disease & pathogens	Plants Animals Disease & pathogens	Plants Animals Disease & pathogens	Plants Animals Disease & pathogens
Modification of natural processes / ecological drivers / disturbance regimes *	Climate change Loss of key predators Grazing patterns Fire regime	Climate change Desertification Grazing patterns Fire regime	Climate change Grazing patterns	Climate change Sea-level rise Sedimentation Salinity Loss of key predators Flow regimes (dams) Shoreline stabilization	Climate change Sea-level rise Coral bleaching Loss of key predators

* Items in this row could be categorized as "stresses" rather than as "threats" but are important for practitioners to consider.

Appendix N
Risk Factor Ranking Template

RISK CATEGORY: [Name of category or challenging issue]
AUTHOR: [Name]

1. Definition: [120 word maximum]
[State the problem in general terms, broadly covering underlying causes and typical direct risks to wildlife included under this risk category.]

2. Expert Opinion: [100 word maximum]
[In terms that are consistent with the categorical values of ranked factors, use the provided risk ranking summary table to textually summarize scope, severity, timing, likelihood, information and overall ranks provided by experts for affected species and habitats. *According to expert opinion, [insert name of risk][insert scope descriptor, i.e. extensively, somewhat extensively, somewhat locally, locally] affects species and habitats of conservation concern in NH. Impacts will [insert likelihood descriptor, i.e. certainly, likely, possibly, unlikely] be [insert severity descriptor, i.e. catastrophic, severe, moderate, mild] for [insert names of highest ranking HABITATS] in the [insert timeframe, i.e. immediately, short-term, near-term, long-term]. [insert Names of highest ranking HABITATS] impacts are [insert information field descriptor, i.e. well documented, somewhat documented, weakly documented, undocumented].*

3. Known Wildlife Exposure Pathways: [min=2 pathways, max=5 pathways, not to exceed 600 words total]

a) [Describe the exposure pathway and supporting evidence for the risk as described in Element 3 of profiles for the best-documented and highest-ranking habitat and related habitats or species. Be sure to synthesize similar pathways, even if they have different target species and habitats.]
b) [Describe the exposure pathway and supporting evidence for the risk as described in Element 3 of profiles for the best-documented and highest-ranking habitat and related habitats or species. Be sure to synthesize similar pathways, even if they have different target species and habitats.]
c) [Describe the exposure pathway and supporting evidence for the risk as described in Element 3 of profiles for the best-documented and highest-ranking habitat and related habitats or species. Be sure to synthesize similar pathways, even if they have different target species and habitats.]

4. Strategies: [To be provided by NHFG]

5. Research Needs: [min=2 items, max=5 items, not to exceed 200 words total]
a) [List the highest priority research item identified in field 3.4 of affected species and habitat profiles.]

b) [List the NEXT highest priority research item identified in field 3.4 of affected species and habitat profiles.]
c) [List the NEXT highest priority research item identified in field 3.4 of affected species and habitat profiles.]

7. Rank Frequency By Class: [To be provided by NHFG]

8. Summary of Ranks: [To be provided by NHFG]

9. Literature Cited: [JWM format, not to exceed 20 citations]

Appendix O
Strategy Template

[STRATEGY CODE][STRATEGY HEADING]
AUTHOR: [Name]

DESCRIPTION: [Describe the general logistics, scope, and variety of activities encompassed by this strategy.] [150 WORDS]

GOAL: [Describe the broad purpose or legacy of the strategy. Include broad patterns of ecological, social, or political response that represent a long-term statewide benefit to wildlife.] [150 WORDS]

[CODE] OBJECTIVE:
[Describe a specific action that will in the short term directly change an ecological, social, or political factor that drives the condition of an aspect of wildlife health in NH.] [100 WORDS]
[CODE] (A) EXPECTED BENEFITS:
[Explain how wildlife or wildlife habitats will directly or indirectly benefit over time as a result of the action. List species and habitats identified in the provided Strategy Summary Table that will benefit most from the action.] [100 WORDS]
[CODE] (B) AFFECTED RISKS:
[List the most problematic risks identified in the provided Strategy Summary Table that will be affected by the action.] [100 WORDS]
[CODE] (C) EXISTING RESOURCES:
[List resources already in place to implement the objective, including funding sources, personnel, training, facilities, equipment, and communications media. State whether existing resources are more than adequate, adequate, or limiting.] [100 WORDS]
[CODE] (D) CRITICAL INPUTS:
[List additional inputs, including funding, personnel, training, facilities, equipment, and communications media, necessary to achieve the objective and improve limiting factors identified above.] [100 WORDS]
[CODE] (E) ORGANIZATION:
[Describe the current and/or potential roles of state and federal agencies or local, regional, national, or international partners, and identify needs or opportunities to coordinate and collaborate with other states. Clearly identify legislation, rules, formal agreements, and programs necessary to organize supporting partnerships or clarify authority.] [200 WORDS]
[CODE] (F) FEASIBILITY: [Insert the score from the feasibility ranking form.]
[CODE] (G) INITIATION: [Immediate, 1 year, <2 years, <5 years, >5 years]
[CODE] (H) DURATION: [1 year, <2 years, <5 years, <10 years, >10 years]

FEASIBILITY RANKING **STRATEGY: [CODE][STRATEGIC HEADING]** **COMPLETED BY: [NAME]**

OBJECTIVE	EFFICACY[1]	RESOURCES[2]	ORGANIZATION[3]	EXPERTISE[4]	MOTIVATION[5]	INFORMATION[6]	Summary Rank
	4=Certain 3=Likely 2=Somewhat. 1=Unlikely	4=<$50,000 3=$50,000- 2=$250,000- 1=>$1,250,000	4=Very Functional 3=Functional 2=Somewhat 1=Non-functional	4=Highly 3=Accessible 2=Somewhat 1=Inaccessible	4=Support >> 3=Support >= 2=Support <= 1=Support <<	4=Well Documented 3=Somewhat 2=Weakly 1=Undocumented	
[code][Restore/Maintain Natural Flow Regimes]	3	4	4	3	3	4	**3.06**

[1] Expected success of the proposed action in abating the targeted risk or improving wildlife health
[2] Estimated cost of implementing actions to achieve the objective
[3] Experience and efficiency of existing or developing organizational structures poised to implement the action
[4] Availability of skills and knowledge necessary to see implementation through
[5] Anticipated level of buy-in of all involved public and private interests
[6] Quality or reliability of the evidence, experience, or factual knowledge supporting the scores provided
[7] Summary rank= ((a+b/2)/4)((c+d+e+f)/4), where a=efficacy score, b=resources score, c=organization score, d=expertise score, e=motivation, f=information