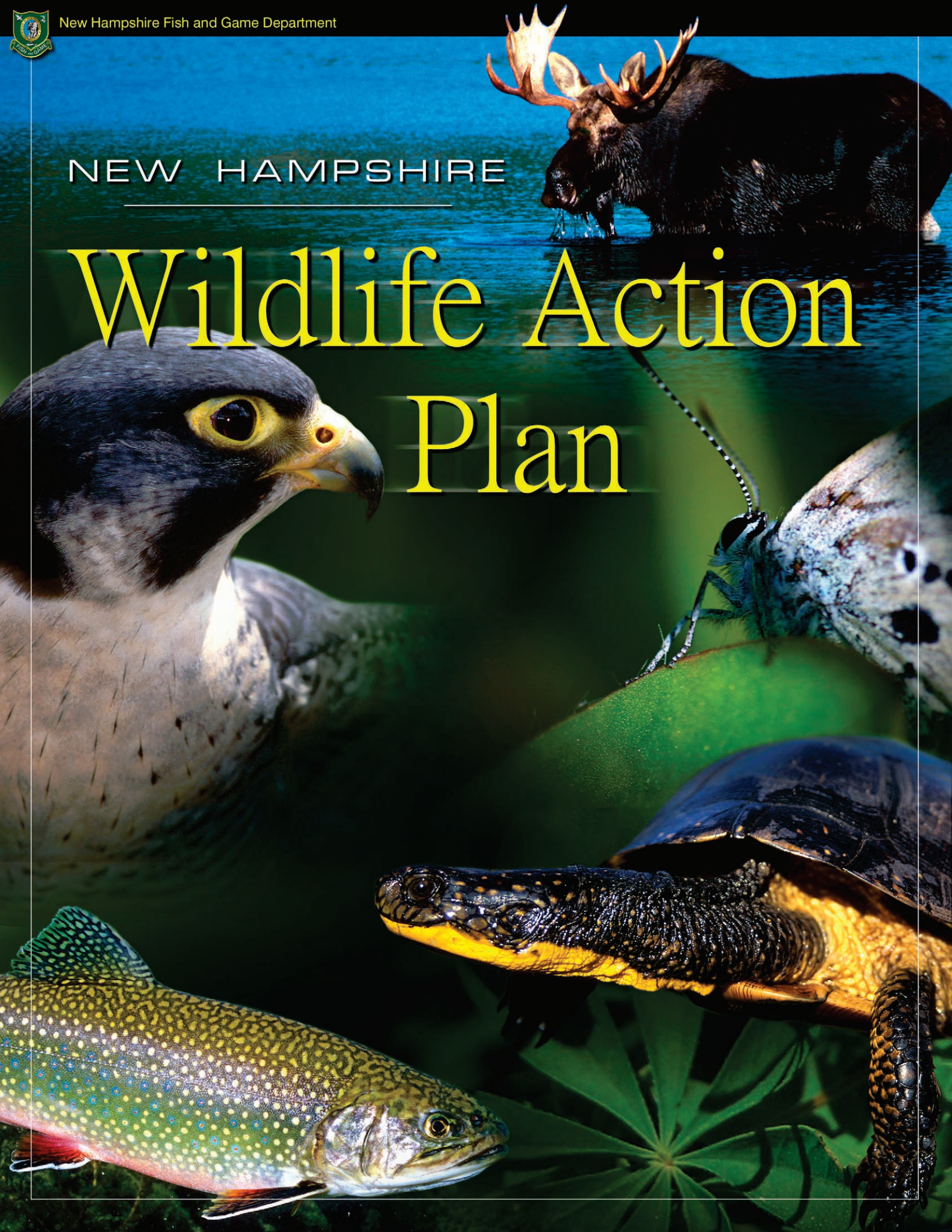
New Hampshire Fish and Game Department

NEW HAMPSHIRE

Wildlife Action Plan



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New Hampshire
Wildlife Action Plan

Submitted October 1, 2005

New Hampshire Fish and Game Department

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COMMONLY USED ACRONYMS

Many acronyms are used throughout the chapters and appendices. This list only includes the most commonly used acronyms. Those not listed here are spelled out the first time they are used in each chapter or appendix.

ACOE	United States Army Corps of Engineers
ATV	All Terrain Vehicle
DRED	Department of Resources and Economic Development
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
FLEP	Forestland Enhancement Program
GIS	Geographic Information System
GRANIT	Geographically Referenced Analysis and Information Transfer System
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
NAAT	National Advisory Acceptance Team
NHA	New Hampshire Audubon
NHBR	New Hampshire Bird Records
NHCP	New Hampshire Coastal Program
NHDES	New Hampshire Department of Environmental Services
NHDFL	New Hampshire Division of Forests and Lands
NHDOT	New Hampshire Department of Transportation
NHFG	New Hampshire Fish and Game
NHNHB	New Hampshire Natural Heritage Bureau
NHOSP	New Hampshire Office of State Planning
NRCS	Natural Resource Conservation Service
OHRV	Off Highway Recreational Vehicle
RAARP	Reptile and Amphibian Reporting Program
SPNHF	Society for the Protection of New Hampshire's Forests
TNC	The Nature Conservancy
UNH	University of New Hampshire
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geologic Survey
WAP	Wildlife Action Plan
WMNF	White Mountain National Forest

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STATE WILDLIFE GRANTS

"... No State, territory, or other jurisdiction shall receive a grant unless it has developed, or committed to develop by October 1, 2005, a comprehensive wildlife conservation plan, consistent with criteria established by the Secretary of the Interior, that considers the broad range of the State, territory, or other jurisdiction's wildlife and associated habitats, with appropriate priority placed on those species with the greatest conservation need and taking into consideration the relative level of funding available for the conservation of those species."

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Executive Summary

New Hampshire's Wildlife Action Plan (WAP) completion comes at a crucial time in the state's history. *New Hampshire's Changing Landscape 2005*, a recent report from the Society for the Protection of New Hampshire Forests (SPNHF), chronicles the increasing human footprint on the state's natural habitats, and documents the immediate need for improved habitat conservation. In 1983, the reforestation that followed farming and logging of the 19th and 20th centuries reached its peak, with 87 percent of the state's lands forested. By 1997, the U.S. Forest Service (USFS) estimated that the state's forest cover dropped three percent, to 84 percent. Unlike the 18th and 19th century conversion of forests to fields, today's land conversion to roads, housing, and businesses permanently alters natural habitats and degrades their value to native wildlife. The WAP points to where the most vulnerable species and habitats are in relation to these rapid changes to the natural landscape.

New Hampshire's WAP is the result of a mammoth effort by hundreds of people and organizations committed to ensuring the future welfare of wildlife in New Hampshire and providing opportunities for people to enjoy use of these resources. The WAP is the most comprehensive wildlife assessment ever completed in New Hampshire. Thirty-four wildlife experts from 10 conservation agencies, organizations, and academic institutions served as contributing authors.

In a parallel effort, a 33-person citizen advisory group shaped the management framework for New Hampshire's big game species. Working with the New Hampshire Fish and Game Department (NHFG) wildlife biologists and program administrators, management policies and population objectives were synthesized into a Big Game Management Plan (Appendix E). Big game management objectives were integrated into the WAP's Chapter 5, Conservation Strategies.

At New Hampshire's Wildlife Summit in March of 2004, 110 individuals representing conservation, recreation, business, and community interests identified priority conservation issues. Via a web survey, 1,256 individuals provided additional input. Preventing habitat loss from development, educating citizens about wildlife management, and improving land-use planning were survey respondents' top priorities. During May of 2005, a sub-group of Wildlife Summit participants identified tools that could effectively be used to implement WAP strategies in the political and social climate of New Hampshire.

Using all available data, a core team of biologists identified 123 species and 27 habitats in greatest need of conservation. More than a half-million dollars of State Wildlife Grant federal funds were provided to contract with experts at partnering organizations, agencies, and academic institutions to complete assessments of these species and habitats. Each partner brought significant resources to match federal funds.

To ensure consistency and comparability of information, a wildlife species and habitat template was provided to all contracted experts. Four major elements—distribution and habitat, species and habitat condition, species and habitat risk assessment, and conservation actions—were addressed. In total, 131 species and habitat profiles were completed for all habitats and nearly all priority wildlife, including several invertebrate and fish species (nineteen "at risk" species were not profiled, either because there was a lack of information for those species, or because the conservation concerns facing those species were best addressed at the habitat level).

Following the development of species and habitat profiles, technical analyses were conducted to assess the condition of habitats and risks to wildlife. The results of these technical assessments were incorporated into each profile and are summarized in this document.

During the condition assessment phase, we compiled data that tripled the number of records in our wildlife occurrence database, and we used sophisticated science to develop the first maps ever to predict the location and compare the current condition of all matrix forests, terrestrial, wetland, and aquatic habitats over the entire state. Mapping was also completed for a subset of well-studied species.

In the risk assessment, we called on wildlife experts to conduct a structured assessment for 62 priority wildlife species and 27 habitats. Preliminary results identified 16 wildlife species that are highly at risk of extirpation from New Hampshire. Included in this list are Karner blue butterflies, piping plovers, and roseate terns. Eleven of the 27 priority habitats assessed ranked in the highest conservation risk category. Examples include Appalachian Oak Pine Forests, Pine Barrens, Salt Marshes, Lowland Spruce-Fir Forests, and Vernal Pools. Further review and analysis of species and habitats that appear to be in most jeopardy will be a first step in implementation.

After completing analysis of individual species and habitats, we identified risks that were common among species and habitats and developed strategies to address these risks. Rapid urban development in many parts of the state was identified as the most potent risk to our wildlife, devastating the health of many terrestrial, wetland, and aquatic populations and irreversibly fragmenting their habitats. Urban development is outpacing land protection. We need to respond by helping communities integrate wildlife habitat conservation into decisions about development. To meet this goal, we will:

- Provide public and private entities at all levels in the urban development and planning communities with information and assistance, including conservation science, maps, and mitigation guidelines to encourage sustainable development in sensitive wildlife areas
- Consider proactive strategies such as landowner incentives and voluntary land protection

Regional air and water quality issues scored among the most threatening problems for wildlife, both in terms of broad cumulative degradation and intense localized impacts. In response, we will:

- Promote the inclusion of wildlife in structured risk assessments by agencies engaged in energy, transportation, and industrial development projects
- Promote regional and national policies and funding that improve air and water quality for New Hampshire's wildlife and people

Some habitats have been degraded to the point that wildlife species associated with them will be lost without human intervention. To maintain our biodiversity and landscape integrity, we will:

- Guide management and restoration of rare and declining plants, animals, habitats, and natural communities
- Address human and ecological issues that threaten New Hampshire's biodiversity with strategies such as population management, habitat management and, when necessary, regulatory protection

There is a critical need to obtain, store, and manage data on the status and condition of New Hampshire's wildlife. Current information is essential to providing the best conservation science and monitoring. We will:

- Compile, manage, and analyze information about New Hampshire's wildlife; assess risks; and prioritize conservation actions
- Develop a system to monitor ecological health and management performance
- Adapt to changing conditions

Introduction

From Mount Washington to our Atlantic coastline, New Hampshire supports a wealth of wildlife species and habitats. Through the 1700s and 1800s, a majority of the state's forests were cleared for fields, pastures, and timber. Rivers and streams, dammed and degraded, became largely impassable for migratory fish. During this period, many fish and wildlife—already beleaguered by deforestation and diminished water quality—were nearly extirpated by market hunting and fishing.

New Hampshire, like other states, reacted to this "era of exploitation" with efforts to conserve fish, wildlife, and land. In 1865, the New Hampshire Fisheries Commission was established to restore sea-run fish to the Merrimack and Connecticut rivers, and to introduce other species into lakes, ponds, and streams for their food and recreational value. Later, New Hampshire conservationists helped pass the 1911 Weeks Act, which in 1912 led to the purchase of 72,000 acres of land by the federal government and the creation of the White Mountain National Forest. Since then, people have flocked to New Hampshire each year to enjoy our forests, water, and wildlife.

In the early decades of the 20th century, concerned hunters and anglers demanded an end to the over-exploitation of the nation's fish and wildlife resources. In response, the reorganized and renamed New Hampshire Fish and Game Department (NHFG) took steps to conserve them by setting and enforcing bag limits; creating wildlife refuges and sanctuaries; paying for game damage; operating a game farm; and issuing hunting and fishing licenses. The revenue generated from fishing and hunting license sales enabled the agency to expand its restoration, education, and law enforcement programs.

Additional funding for wildlife restoration started coming to NHFG from the Federal government after the passage of the Pittman-Robertson Act in 1937. In 1950, the Dingell-Johnson Act was established to support the states' restoration of sport fish. With this infusion of funds and support and the efforts of the Department, dozens of fish and wildlife species like moose, black bears, beaver, white-tailed deer, and wood ducks were able to rebuild their populations' health and numbers.

Beyond Sport Fish and Game Restoration

In 1979, during an era of public outcry over polluted air and water, New Hampshire formally recognized the need to contribute to conserving endangered wildlife and passed the state Endangered Species Conservation Act. In partnership with the U.S. Fish & Wildlife Service (USFWS), U.S. Forest Service (USFS), and New Hampshire Audubon (NHA), NHFG staff initiated activities that would ultimately lead to the recovery of some of the high-profile species that were hit hardest by environmental contaminants—bald eagles, peregrine falcons, ospreys, and loons. The success of these efforts proved that management could benefit a broad range of wildlife.

Formally acknowledging the breadth of wildlife that are affected by environmental issues, and also recognizing the diversity of ecological roles and habitat values that are necessary to support wildlife, the Nongame Species Management Act was passed by the New Hampshire Legislature in 1988. The act expanded the mission of NHFG to include the full array of wildlife—not just game and endangered species. This was the genesis of the mechanism that allows the State to spend $50,000 out of the General Fund to match private contributions to New Hampshire's Nongame and Endangered Wildlife Program. Over the years, the Nongame Program has leveraged

these funds to gain additional grants; thousands of people have contributed to the program.

The conservation of aquatic species in New Hampshire has focused on anadromous fish restoration, through the Atlantic salmon, American shad, and river herring restoration programs; and sport fish management, through population assessments and state and federal regulations. Lesser-known species of fish and aquatic invertebrates have received little direct attention. Some species, such as the bridle shiner, have been identified as species of concern in nearby states, while the status of other whole groups of species, such as crayfish and snails, is virtually unknown. The WAP provides the opportunity to assess the status and develop conservation priorities for all aquatic species and habitats.

In the 1980s, the waterfowl stamp, a new state lands management collaborative, and the Land Conservation Investment Program fueled NHFG's ability to manage land for all wildlife. Today, NHFG owns dozens of parcels and easements on parcels, enabling staff to manage for wildlife and habitat values. In cooperation with the N.H. Department of Resources and Economic Development's Division of Forest and Lands, many state forests and parks are managed for habitats that support diverse wildlife.

A partnership of concerned citizens and conservation organizations has spearheaded land, water, and wildlife conservation efforts in the 1990s and 2000s. The Society for the Protection of New Hampshire Forests (SPNHF), NHA, The Nature Conservancy (TNC), individual towns and many others have worked on their own and in partnership with NHFG and local land trusts to protect hundreds of thousands of acres in the last decade.

Despite this long history of successful projects and partnerships, NHFG has never had the resources necessary to comprehensively address the challenges facing all the state's wildlife and habitats. Certainly, decades of efforts to improve conditions for sport fish and game animals benefited more than just the focal species; nonetheless, not until now have we been able to take stock of a comprehensive range of species and habitat conditions, synthesize and analyze the information to identify risks to wildlife, and specifically target strategies to alleviate them.

State Wildlife Grants and the Wildlife Action Plan

In 2002, the United States Congress passed a law appropriating $80 million in State Wildlife Grants, which would go to state wildlife agencies to address the "species in greatest need of conservation," including those species not hunted or fished. To be eligible for these funds, New Hampshire was required to develop a comprehensive wildlife conservation plan—the New Hampshire Wildlife Action Plan—to be submitted to Congress by October 1, 2005. Congress mandated that the Plan address eight elements:

1. Information on the distribution and abundance of species of wildlife, including low and declining populations as the State fish and wildlife agency deems appropriate, that are indicative of the diversity and health of the State's wildlife.
2. Descriptions of locations and relative condition of key habitats and community types essential to conservation of species identified in Element 1.
3. Descriptions of problems which may adversely affect species identified in Element 1 or their habitats, and priority research and survey efforts needed to identify factors which may assist in restoration and improved conservation of these species and habitats.
4. Descriptions of conservation actions necessary to conserve the identified species and habitats and priorities for implementing such actions.
5. Proposed plans for monitoring species identified in Element 1 and their habitats, for monitoring the effectiveness of the conservation actions proposed in Element 4, and for adapting these conservation actions to respond appropriately to new information or changing conditions.
6. Description of procedures to review the Plan at intervals not to exceed ten years.
7. Plans for coordinating, to the extent feasible, the development, implementation, review, and revision of the Plan Strategy with Federal, State, and local agencies and Indian tribes that manage significant land and water areas within the State or administer programs that significantly affect the conservation of identified species and habitats.
8. Plans for involving the Public in the development and implementation of Plan Strategies.

With the infusion of funds from the State Wildlife Grants and with the Congressional mandate, NHFG's Nongame and Endangered Wildlife Program has expanded over the last three years to cover more species and habitats in a broader context than ever before. Even with additional funding and staff, we continue to work closely with partners, recognizing that responsibility of protecting all wildlife and habitats is bigger than what we can accomplish on our own.

To assist in developing a comprehensive conservation plan, we called on broad expertise in the state to work as collaborators. Together, we developed an organizational structure (see Appendix F) and identified desirable outcomes to guide the development and future implementation of the Plan:

1. Citizens that are aware of New Hampshire's wildlife diversity and its contribution to the environmental, economic, and social fabric of the State and that actively support wildlife conservation.
2. An informed network of partners actively prepared to engage in implementing key conservation strategies and actions that protect the State's wildlife diversity.
3. A dynamic and adaptable GIS-based blueprint of New Hampshire's significant wildlife habitats that support species in greatest need for conservation and the full array of wildlife diversity.
4. A suite of conservation strategies that considers biological, social, and economic factors and opportunities to conserve the wildlife species in greatest need of conservation and all wildlife.
5. A dynamic and adaptable GIS-based wildlife data management system that contains all known wildlife occurrences and habitat polygons and that can be augmented continually with new data and queried by ecoregion, conservation land, habitat type, and species to monitor our progress in conserving wildlife.

The Planning Team developed the initial approach to completing the WAP. The Core Biologist Team served as a liaison between the biologists/researchers/writers and the Communications and Outreach Team, which worked on generating public input and releasing public information about the WAP. The three teams communicated frequently and most partner organizations were represented on more than one team, to keep technical/scientific and communications activities in sync.

Standards for the Wildlife Action Plan

In developing strategies to address challenging issues facing New Hampshire wildlife, we:

1. Identified Wildlife At Risk
2. Assessed Wildlife Habitat Conditions
3. Evaluated Risk Factors
4. Developed Strategies
5. Integrated Monitoring, Performance and Adaptive Management
6. Planned for Implementation

Throughout the process, we concentrated on developing a more systematic and transparent approach to wildlife planning. We invited public participation during plan development; efforts included the Northeastern Regional Survey, a Wildlife Summit, a Web Survey, Stakeholder Meetings, and a Strategy Forum.

Identifying Wildlife At Risk

In Chapter 2, we identify New Hampshire's low and declining wildlife populations and wildlife that are indicative of the diversity and health of the State's wildlife. This chapter corresponds primarily with the first of the Eight Required Elements, and builds on the many conservation initiatives that preceded the WAP in New Hampshire. Chapter 2 lays a foundation for Element 2 by describing the use of natural communities as surrogates for the diversity of poorly understood wildlife, the relationship between natural communities and wildlife habitats, and serves to organize both species and natural communities within the over-arching habitat types that occur in New Hampshire. These habitat types are the basis for our analyses and planning work described in later chapters.

Information Gathering (Data Templates)

One of the early and integral steps in the creation of this WAP was the development of an accurate, up-to-date, geographically referenced database system containing information on wildlife species. In cooperation with the New Hampshire Natural Heritage Bureau, we solicited data from experts on the highest

priority wildlife and improved the quality of existing records, tripling the initial amount of information. This database provides us with an efficient, web-based mechanism for reporting known fish and wildlife occurrences, and has been instrumental in determining distribution and abundance of species and habitats as required in the first and second of the Eight Required Elements.

Chapters 3-6 form the core of the WAP, with specific information about wildlife in New Hampshire, the problems they face, the solutions we propose, and how we will monitor them. To ensure that our work was comprehensive and based on the best available information, we developed standardized templates to gather technical information and data from contracted experts. All of the information collected on these forms is organized and linked in a database format, and has been applied throughout the document.

The first template, a Species and Habitat Profile Template (Appendix L), was completed for all wildlife and habitats. The fields in this template were designed to meet the first 5 of the Eight Required Elements, and their completion or lack thereof provide a clear indication of our knowledge gaps. Corresponding to each Profile Template, we completed a Risk Factor Ranking Form (Appendix M). Next, experts on each challenging issue evaluated ranks for the associated risk factors and summarized them in a Risk Assessment Template (Appendix N). This worked formed the body of Chapter 4.

To address all of the risks identified, we enlisted experts to complete a Strategy Template (Appendix O), with detailed information about implementation and feasibility for each objective. For each Strategy Template, a corresponding Feasibility Ranking Form (Appendix P) was completed. These data forms will help guide implementation.

Assessing Wildlife Habitat Condition

The location and relative condition of key wildlife habitats, the second of the Eight Required Elements, is the topic of Chapter 3. Describing the locations and condition of wildlife habitats is a complex process. In the predictive phase, we used computer analyses and GIS to predict where each kind of wildlife habitat is located. In the analytical phase, we compiled many different kinds of data about each location and used these data to analyze the local status of predicted habitats across the landscape. Information about local conditions will be compared and "filtered" to create maps showing areas of high potential and high risk for wildlife. A preliminary assessment of the condition of New Hampshire's wildlife habitats is reported in Chapter 3.

In New Hampshire, considerable public effort and money is being invested in the preservation of properties that may not be the most critical to wildlife. The goal of our investment in sophisticated mapping technology and conservation science is to provide tools for local and regional planners to ensure that time and money are spent in the most critical locations. Developing a complete map of wildlife habitats in New Hampshire and compiling information about them for the WAP was a major scientific undertaking. The coordinated work of all our partners will make conservation technology much more accessible to the entire planning community.

Evaluating Risk Factors

Although we were able to use quantitative data (Chapter 3) to gain insight about some of the challenging issues that threaten wildlife, for many issues, data are nonexistent. Chapter 4 addresses problems that may adversely affect wildlife and their habitats based on the expert opinions of wildlife professionals and the published literature. We used a structured process to organize and focus the attention of our science team on the most challenging issues.

From a scientific perspective, we recognize that all of the challenging issues, or "threats," that wildlife face can be viewed as having two aspects in common. First, each has certain "risk factors" that potentially have negative impacts on wildlife; and second, each has a series of events or an "exposure pathway" that brings a risk factor to fruition. A simplified description of the risk assessment process follows—this process was completed for all priority habitats and most priority wildlife species.

In the initial phase of the process, a panel of experts on a given species or habitat was supplied with a list of potentially challenging issues. The panel identified all of the risk factors associated with each issue and described the exposure pathway for their target species or habitat. During the ranking phase of the process, the panel completed a Risk Factor Ranking Form (Appendix M) to provide numeric ranks about

key aspects of each risk factor. To the extent that expertise and information were available, the values given for each risk factor were peer-reviewed and cross-referenced to scientific literature. A summary score was calculated for each risk factor, and the highest scoring ones were described in detail in the Species or Habitat Profile.

In the comparative phase of the process, all of the scores from all of the Risk Factor Ranking Forms were compiled in a database. The scores were grouped based on the list of general challenging issues that was originally provided to the species/habitat expert panels. Next, an expert on each issue screened the scores for all of the wildlife affected by it. The scores from the forms and descriptions from the Species/Habitat Profiles were written up in a Risk Assessment Template. Finally, scores were analyzed to compare the levels of risk among species/habitats and also among the broader issues. This approach enabled us to summarize challenging issues in a consistent, standardized format that will be used to help prioritize actions for implementation.

Developing an Action Plan

In response to the fourth of the Eight Required Elements, Chapter 5 describes actions necessary to conserve wildlife and provides information about prioritizing and implementing such actions. As part of the preceding chapters, we completed in-depth analyses to obtain a "diagnosis" of the issues that threaten New Hampshire's wildlife most. During the earlier steps in our planning process, we completed some preliminary work—the public participation process and the Species and Habitat Profiles—to prescribe actions to resolve the biggest issues. Based on this work, we generated an exhaustive list of potential actions. To ensure that the list properly assigned the right solutions to the right problems, we surveyed our expert team to help cross-reference wildlife, habitats, risks, and solutions in a linked database.

We utilized this cross-referenced information to analyze the breadth and depth of the actions necessary to conserve the full array of New Hampshire's wildlife. Within strategic program areas, wildlife management experts completed a ranking process to assess the operational feasibility of each action. For each strategy, experts gathered information about implementation potential and completed a detailed Strategy Template that far exceeds the scope of this document.

To simplify the WAP, we organized our strategies under four focus areas. The goal of the Regional Air and Water Quality Action Plan is to reduce harmful air and water pollutants by promoting sustainable energy, transportation, and industrial development practices. The Local Land and Water Conservation Action Plan contains approaches for promoting sustainable development and resource use to support wildlife health and diversity through a combination of coordinated working groups, technical assistance, and the production of targeted information and education materials. The actions under the Statewide Biodiversity Stewardship Program will help maintain New Hampshire's biodiversity and habitats by coordinating management, restoration, and land and regulatory protection. The Conservation Science and Information Management Action Plan will ensure that the best available science is used to adapt management and monitor those species and habitats of greatest conservation concern.

Integrating Monitoring, Performance, and Adaptive Management

To meet the fifth of the Eight Required Elements, Chapter 6 describes New Hampshire's plan for monitoring species identified in Element 1 and their habitats, for monitoring the effectiveness of the conservation actions proposed in Element 4, and for adapting these conservation actions to respond appropriately to new information or changing conditions. The three categories of variables we need to monitor are levels of risk factors, management effects, and ecological responses. Finding the right combination of measurements and variables within a reasonable budget—and still having the ability to respond to changes on the ground—is a critical challenge.

Our approach is to find the most efficient variables. By "efficient," we mean variables that fit into more than one of the categories described above and also represent many fish and wildlife species. Efficient also means that we can measure a variable and detect changes with minimal effort. When a variable meets these criteria, we consider it a useful "indicator" because it indicates changes that are happening for many variables. Our goal is to select useful indicators for each priority habitat and high priority species, and

to monitor them rigorously.

Guiding Implementation

In accordance with elements 6-8 of the Eight Required Elements, Chapter 7 describes our plans for coordinating, reviewing, and revising the WAP during the implementation phase in concert with our partners, stakeholders, and public. Several of the objectives described in Chapter 5 require immediate implementation and will serve as a transition between plan development and implementation. For example, information that we gathered about risks to wildlife and the feasibility of our objectives will be used to prioritize implementation of the WAP. We recognize that our priorities may differ from those of our partners, stakeholders, and the public, and therefore will provide guidance to match action items with the best organization for implementation.

Planning for the Future

Now, with the completion of the WAP, the process of funding and proceeding with its implementation begins. The benefits of investing in the WAP's strategies—or any wildlife conservation activities—go well beyond "saving" rare species. The economic benefits are clear. In a situation common to all states, wildlife associated recreation is a significant economic engine for New Hampshire. The U.S. Fish and Wildlife Service's 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation determined expenditures for these activities to be nearly $579 million in New Hampshire. Fishing brought in an estimated $165 million in 2001; hunting, $71 million; and wildlife watching, $343 million. Southwick Associates calculated that hunting and fishing alone provide more than 4,500 jobs in the state. Any downturn in participation in these activities would have a negative impact on the state's economy; whereas efforts to improve wildlife and habitat in New Hampshire would likely have the benefit of bringing more money into the system from hunters, anglers, and wildlife watchers.

The economic issue goes well beyond wildlife-associated recreation. New Hampshire's ecological framework is itself a hidden economy, untranslatable into dollars and cents. People live in and visit New Hampshire, and spend money in the state, in large part because it is a place of great natural beauty. The downside is this: New Hampshire's structures and services have boomed. When people move to New Hampshire from out of state, the amount of space developed per person has risen to more than two acres. Some 18,000 acres of land in New Hampshire are lost each year to development. This conversion of forest and other wildlife habitat into roads, houses, and businesses degrades the land's value to New Hampshire's wildlife. New Hampshire can support new people, and it can offer them places to live and drive and work and recreate; the WAP helps accomplish this by pointing to where the most vulnerable species and habitats are in relationship to the rapidly transforming landscape.

It starts with smart planning, which is at the heart of this Plan's strategies. When people are able to clearly see the connections between good wildlife management, clean air and water, sustainable economic growth, and our quality of life, wildlife habitat conservation actions will naturally be brought to the forefront of planning decisions.

Through existing and new partnerships, NHFG is moving forward with implementing the WAP. Prompt action is crucial—not only for the health and diversity of wildlife and habitats in the state, but also to ensure that future generations will have the opportunity to experience and enjoy the Wild New Hampshire we love and appreciate today.

Roadmap to Eight Required Elements

We used the eight required elements as the building blocks for New Hampshire's Wildlife Action Plan. Each element is an important piece of the wildlife puzzle. You will find these elements interwoven throughout the text, figures, and forms. We provide this guide to help you find the eight elements.

Element 1	Chapter and Appendix	Templates and Forms	Tables
Information on the distribution and abundance of species of wildlife, including low and declining populations as the State fish and wildlife agency deems appropriate, that are indicative of the diversity and health of the State's wildlife.	Chapter 2 Appendix A: Species Profiles	Species Profiles • 1.2 Justification • 1.4 Population and Habitat Distribution • 1.7 Sources of Information • 2.2 Relative Health of Populations	

Element 2	Chapter and Appendix	Templates and Forms	Tables
Descriptions of locations and relative condition of key habitats and community types essential to conservation of species identified in (1).	Chapter 3 Appendix B: Habitat Profiles	Habitat Profiles • 1.6 Habitat Map • 2.1 Scale • 2.2 Relative Health of Populations • 2.4 Relative Quality of Habitat Patches	Table 3-1 Table 3-2

Element 3	Chapter and Appendix	Templates and Forms	Tables
Descriptions of problems that may adversely affect species identified in (1) or their habitats, and **priority research and survey efforts** needed to identify factors which may assist in restoration and improved conservation of these species and habitats.	Chapter 4	Species and Habitat Profiles • 1.8 Extent and Quality of Data • 3.1 (A) Exposure Pathway • 3.1 (B) Evidence • 3.2 Sources of Information • 3.3 Extent and Quality of Data • 3.4 Threat Assessment Research Risk Exposure (Form 1) Risk Factor Assessment (Form 2)	Table 4-1 Table 4-2 Table 4-3

Element 4	Chapter and Appendix	Templates and Forms	Tables
Descriptions of conservation actions proposed to conserve the identified species and habitats and priorities for implementing such actions.	Chapter 5	Species and Habitat Profiles Existing Protection • 1.3 Protection and Regulatory Status • 2.3 Population Management Status Proposed Actions • 4.1 (A) Affected Threat • 4.1 (B) Justification • 4.1 (C) Conservation Performance Objective • 4.1 (D) Performance Monitoring • 4.1 (E) Ecological Response Objective • 4.1 (F) Response Monitoring • 4.1 (G) Implementation • 4.1 (H) Feasibility • Feasibility Ranking Form • 4.2 Conservation Action research Conservation Strategy Template	

Element 5	Chapter and Appendix	Templates and Forms	Tables
Proposed plans for monitoring species identified in (1) and their habitats, for monitoring the effectiveness of the conservation actions proposed in (4), and for adapting these conservation actions to respond appropriately to new information or changing conditions.	Chapter 6	Species Profiles • 1.9 Distribution Research • 4.1 (C) Conservation Performance Objective • 4.1 (F) Response Monitoring	Table 6.1

Element 6	Chapter and Appendix	Templates and Forms	Tables
Descriptions of procedures to review the strategy at intervals not to exceed ten years.	Chapter 7		

Element 7	Chapter and Appendix	Templates and Forms	Tables
Plans for coordinating the development, implementation, review, and revision of the plan with Federal, State, and local agencies and Indian tribes that manage significant land and water areas within the State or administer programs that significantly affect the conservation of identified species and habitats.	Chapter 7	Conservation Strategy Template (E): Organization	

Element 8	Chapter and Appendix	Templates and Forms	Tables
Broad public participation is an essential element of developing and implementing these plans, the projects that are carried out while these plans are developed, and the Species in Greatest Need of Conservation that Congress has indicated such programs and projects are intended to emphasize.	Chapter 1 Appendix H: Wildlife Summit results Appendix I: Web Survey Appendix K: Wildlife Strategy Forum results Appendix J: Public participation record		

CHAPTER ONE

Public Participation

Overview

This chapter addresses required Element 8 of the NAAT Guidelines, which calls for "broad public participation . . . [when] developing and implementing these plans." We formed the Communications and Outreach Team (COT) to develop the public participation component of the WAP. The COT met regularly from 2003-2005. They were responsible for developing and implementing a plan for gathering public input. Components included the following:

- A randomly distributed telephone survey of New Hampshire residents as part of a larger northeast regional survey (Fall 2003)
- A "Wildlife Summit" workshop of people who play (or could play) an active role in conserving New Hampshire wildlife (March 2004)
- A web survey based largely on priority issues that came out of the Wildlife Summit (August-November 2004)
- Stakeholder meetings to understand participants' perceptions of threats to our wildlife and habitats, and conservation strategies (various dates)
- A "Wildlife Conservation Strategy Forum" to gather input on some of the major strategies developed (May 2005)

Many conservation partners were included in the development, research, and writing of the WAP. Species and habitat profiles, threats assessments, and strategies were written in part or in whole by individuals from NHA, St. Anselm's College, UNH, University of Massachusetts-Amherst, USFS, USFWS, TNC, Loon Preservation Committee, Franklin Pierce College, North East Ecological Services, NHNHB, Biodrawversity, Ibis Wildlife Consulting, and BioDiversity Research Institute. Many conservation partners reviewed materials as they were being developed, including those mentioned above, the New Boston Air Force Base, and others.

Northeast Regional Survey

Responsive Management (a natural resources public opinion consulting company) collected information via a random telephone survey of 400 residents in each of 13 northeastern states. The Northeast Conservation Information and Education Association in conjunction with Responsive Management developed the survey questions, which were used to identify where communication, education, and marketing can improve reputation, credibility, and public support. This project was funded through a Multistate Conservation Grant from the USFWS using Federal Aid in Sport Fish and Wildlife Restoration Funds.

The results of the survey identified major issues to address, and were used especially as a basis for developing education and outreach strategies. Survey information about most commonly used media will help us determine which methods of delivery are most appropriate when implementing strategies. The New Hampshire survey results may be viewed on-line at http://www.responsivemanagement.com/download/reports/NCIEANH.pdf

TABLE 1-1. Agencies, organizations, businesses, and interests represented at the Wildlife Summit, March 25, 2004. Representatives of other groups and interests were invited but were unable to attend.

Agency/Organization/Entity	
Appalachian Mountain Club	New Hampshire House of Representatives
Audubon Society of New Hampshire	New Hampshire Lakes Association
Center for Land Conservation Assistance	New Hampshire landowners
Community conservation commissions	New Hampshire Natural Heritage Bureau
Connecticut River Joint Commission	New Hampshire naturalists
Ducks Unlimited	New Hampshire Office of Energy and Planning
Great Bay Protection Partnership	New Hampshire Snowmobile Association
Harris Center for Conservation	North Country Press
International Association of Fish and Wildlife Agencies	Pemi Valley Fish and Game Club
Jackson, Jackson and Wagner	Private conservation funders
Local Audubon Society of New Hampshire bird clubs	Private natural resource consultants
Loon Preservation Committee	Public Service of New Hampshire
Manchester Union Leader	Silvio O. Conte National Fish and Wildlife Refuge
Moose Mountains Regional Greenways	Society for the Protection of New Hampshire Forests
New England Reptile	Speaking for Animals in New Hampshire
New Hampshire Association of Conservation Commissions	Squam Lakes Science Center
New Hampshire Conservation Districts	Stephenson Strategic Communications
New Hampshire Coverts Project	The Balsams Grand Resort Hotel
New Hampshire Department of Agriculture	The Nature Conservancy
New Hampshire Department of Environmental Services	The Ruffed Grouse Society
New Hampshire Department of Resources and Economic Development, Division of Travel and Tourism	U.S. Army Corps of Engineers
New Hampshire Department of Resources and Economic Development, Parks and Recreation Division	U.S. Department of Agriculture Wildlife Services
New Hampshire Department of Transportation	U.S. Department of Agriculture, Natural Resources Conservation Service
New Hampshire Executive Council	U.S. Environmental Protection Agency
New Hampshire Farm Bureau	U.S. Fish and Wildlife Service
New Hampshire Fish and Game Commission	U.S. Senate (New Hampshire representative)
New Hampshire Fish and Game Department	University of New Hampshire Cooperative Extension
New Hampshire Governor's Office	University of New Hampshire Department of Natural Resources
New Hampshire Timberland Owners Association	University of New Hampshire Department of Zoology
New Hampshire Trappers Association	Vermont Fish and Wildlife Agency
New Hampshire Wildlife Federation	White Mountain National Forest
Normandeau Associates	Wildlife Management Institute
North Country Council	Wildlife Summit Representation

Wildlife Summit

The purposes of the Wildlife Summit were to:

- Develop public awareness of the comprehensive wildlife planning process
- Engage stakeholders in the planning process to encourage acceptance and increase plan implementation effectiveness
- Develop and enhance better communication among a diverse group of constituents

The Wildlife Summit public participation process was based on one previously used to develop the New Hampshire Statewide Comprehensive Outdoor Recreation Plan (SCORP). The lead facilitator and consultant for the Wildlife Summit and the Wildlife Conservation Strategy Forum—Charlie French, UNH Cooperative Extension Community Development Specialist—also acted in that role for the SCORP planning process.

One hundred twelve (112) people participated in the Wildlife Summit. Individuals represented a variety of agencies, organizations, businesses, and interests (Table 1-1). NHFG and UNH Cooperative Extension staff developed a framework of broad topic areas within which to discuss and prioritize issues at the Wildlife Summit. The results of the Wildlife Summit were used in the prioritization and development of our strategies and actions (see results under Appendix H, Wildlife Summit: Public Input on the Wildlife Action Plan).

Web Survey

A web survey, based largely on priority issues that were identified during the Wildlife Summit, was conducted in August-November 2004. The web survey consisted of twenty-seven questions, eighteen of which were related to the WAP and nine of which were demographic in nature (See Appendix I for a survey). The survey was developed and conducted by UNH Cooperative Extension with input from NHFG staff and members of the Communications and Outreach Team.

The survey was non-random, as individuals chose whether or not to complete the survey. A direct link to the survey was provided from the home page of the NHFG web site. People were directed to the survey via multiple methods. Public Service of New Hampshire (PSNH) sent an announcement of the survey to all their public utility customers (approximately 440,000), enclosed with their monthly bill. PSNH also placed a sponsor spot on New Hampshire Public Radio promoting completion of the survey. SPNHF and NHA did a one-minute segment on New Hampshire Public Radio, called "Something Wild," which discussed the WAP and encouraged listeners to complete the web survey. Additional promotion through email, meetings, and other partners' web sites was done to improve the number of survey respondents.

One thousand two hundred fifty-six (1256) surveys were completed. The table of survey results may be found on the NHFG web site. The results were used to inform the development of strategies for the WAP. The survey results will also be used to guide implementation of the strategies. Here are the top results for three of the questions:

Q1: "What do you feel are the most important issues affecting wildlife conservation in New Hampshire?" (Multiple responses possible)

Issue	Respondents
Development/sprawl	39%
Habitat loss (general)	38%
Pollution (general)	8%
Lack of funding	7%
Fragmentation	6%
Government (general)	6%

Q15: "What actions do you think we should take to conserve wildlife?" (Multiple responses possible)

Issue	Respondents
Protect/provide habitat	22%
Improve/manage habitat	9%
Smart growth/planned development	7%
More funding (general)	6%
Regulations (development)	6%

Q18: Of the following actions, which do you feel should be the top three priorities for wildlife conservation in New Hampshire? (Multiple responses possible)

Issue	Respondents
Prevent habitat loss	86%
Educate citizens about wildlife management	52%
Improve land use planning	40%
Encourage stewardship	36%

Stakeholder Meetings

NHFG and UNH Cooperative Extension held or attended meetings, workshops, and sessions around the state to inform and involve the public, understand participants' perceptions of threats to our wildlife and habitats, and seek their input on the development of conservation strategies. These stakeholder meetings are documented in a public participation record (see Appendix J). Meetings ranged from small meetings with 3 or 4 faculty at universities and colleges to larger groups of 30 to 50 people at statewide conferences. The public participation record documents the nature of each meeting.

Wildlife Conservation Strategy Forum

We invited attendees of the Wildlife Summit to participate in the Wildlife Conservation Strategy Forum. Twenty-four people participated. This was considered a continuation of their public participation work. As a part of the WAP, we developed some broad strategies and actions to address threats to our wildlife species and their habitats (see Appendix K, "Wildlife Conservation Strategy Forum"). The issues we focused on were habitat fragmentation, air and water quality, growth and development, and transportation. We sought input on the strategies, actions, and tools that would help us address these four issues. Results of the Wildlife Conservation Strategy Forum were used to inform the development of our strategies relative to these four major issues.

CHAPTER TWO

New Hampshire Wildlife and Habitats At Risk

Overview

This chapter and the associated species profiles address Element 1 of the NAAT Guidelines, "information on the distribution and abundance of species of wildlife." In this chapter we describe the process of selecting species in greatest need of conservation (SGNC) and selecting the WAP's focal habitats. We also present details on the development and plans for continued use of the conservation database, as well as wildlife projects conducted in support of the WAP.

Selecting species in Greatest Need of Conservation

The following information sources were used when selecting and prioritizing New Hampshire's species in greatest need of conservation.

A. All New Hampshire Species
Non-game species, game species, and fish were evaluated regardless of taxonomic group. Long-term datasets exist for some species, but little is known about many other species, especially invertebrates, fish, and some reptiles and amphibians. To update the SGNC list, these groups will require direct attention in the future.

B. Endangered and Threatened Species Lists
All species listed as endangered or threatened in New Hampshire under FIS 1000 (6/21/01) and those federally listed under the Endangered Species Act (1973) that are known to occur in New Hampshire were included. New Hampshire currently has 24 species listed as state endangered and 12 listed as threatened.

C. Natural Heritage Rank: Animal Tracking List
Species tracked by the NHNHB rare species database and listed in the Animal Tracking List (June 2003) were considered for inclusion in the SGNC. The rare species database was used to determine the number of known occurrences of each species in New Hampshire. Species with a state rank of S1 (critically imperiled because extreme rarity or some factor of its biology that makes it particularly vulnerable to extinction) or S2 (imperiled because rarity or other factors that demonstrably make it very vulnerable to extinction) were included in the SGNC. Invertebrates that were ranked as S1-S2 were incorporated in the list of SGNC if adequate knowledge of those species distribution and abundance was available.

D. Species of Regional Concern
Species identified by the Northeast Wildlife Diversity Technical Committee as a regional concern (Therres 1999) were also considered for the SGNC. This list did not include an assessment of invertebrates other than freshwater mussels and did not include those species already listed as endangered or threatened in the federal Endangered Species Act.

E. Living Legacy Project (Taylor et al. 1996) and New Hampshire Ecological Reserve System Project (1998) expert panels were formed to assess population conditions and vulnerability of species in New Hampshire. A list of critical wildlife habitats was developed based

TABLE 2-1. Species of greatest conservation concern. E = NH endangered (List revised 2001), T = NH threatened (List revised 2001), SC = NH species of special concern (List revised 2000), RC = Regional conservation concern (Therres 1999), FE = Federally endangered (current 8/05), FT = Federally threatened (current 8/05), BGP = Only included in the New Hampshire Big Game Management Plan (Appendix E)

Taxa
Invertebrates
Freshwater molluscs
Brook floater, E, RC
Dwarf wedgemussel, E, FE
Eastern pondmussel, RC
Insects
Barrens itame
Barrens xylotype
Broad-lined catopyrrha
Cobblestone tiger beetle, T
Cora moth
Frosted elfin butterfly, E
Karner blue butterfly, E, FE
Persius duskywing, E
Phyllira tiger moth
Pine barrens zanclognatha moth, T
Pine pinion moth, T
Puritan tiger beetle, FT
Ringed boghaunter, E
Sleepy duskywing
White Mountain arctic
White Mountain fritillary
Vertebrates
Fish
Alewife
American brook lamprey, RC
American eel
American shad
Atlantic salmon
Atlantic sturgeon, RC
Banded sunfish, RC
Blueback herrring
Bridle shiner, RC
Burbot
Eastern brook trout
Finescale dace
Lake trout
Lake whitefish
Northern redbelly dace
Rainbow smelt
Redfin pickerel
Round whitefish, RC
Sea lamprey
Shortnose sturgeon, E, FE
Slimy sculpin
Sunapee trout, E
Fish (continued)
Swamp darter
Tessellated darter
Amphibians
Blue-spotted salamander, RC
Fowler's toad, SC
Jefferson salamander, SC, RC
Marbled salamander, E
Mink frog
Northern leopard frog, SC, RC
Reptiles
Black racer
Blanding's turtle, SC, RC
Eastern box turtle, RC
Eastern hognose snake, T, RC
Ribbon snake, RC
Spotted turtle, SC, RC
Smooth green snake, SC
Timber rattlesnake, E, RC
Wood turtle, SC, RC
Birds
American bittern, RC
American black duck
American pipit, SC
American woodcock
Arctic tern, T
Bald eagle, E, FT
Bay-breasted warbler
Bicknell's thrush, SC, RC
Black guillemot, SC
Canada warbler[2], RC
Cerulean warbler, RC
Common loon, T
Common nighthawk, T
Common tern, E, RC
Cooper's hawk, T
Common moorhen
Eastern meadowlark
Eastern towhee
Golden eagle, E, RC
Golden-winged warbler, SC, RC
Grasshopper sparrow, T
Great blue heron
Horned lark
Least bittern, SC
Least tern, E, RC
Birds (continued)
Nelson's sharp-tailed sparrow, SC
Northern goshawk
Northern harrier, E, RC
Osprey, T
Palm warbler
Peregrine falcon, E
Pied-billed grebe, E, RC
Piping plover, E, FT
Purple finch
Purple martin, E
Purple sandpiper
Red shouldered hawk, SC
Roseate tern, E, FE
Ruffed grouse
Rusty blackbird, SC
Salt marsh sharp-tailed sparrow, SC, RC
Seaside sparrow, SC
Sedge wren, E, RC
Semipalmated sandpiper
Spruce grouse
Three-toed woodpecker, T
Turkey, BGP
Upland sandpiper, E, RC
Veery[2]
Vesper Sparrow
Whip-poor-will, SC, RC
Willet, SC
Wood thrush[2]
Mammals
American marten, T
Black bear, BGP
Bobcat, SC
Canada lynx, E, RC, FT
Eastern pipistrelle, SC
Eastern red bat, SC, RC
Eastern small-footed bat, E, RC
Hoary bat, SC, RC
Indiana bat, FE
Moose, BGP
New England cottontail, SC, RC
Northern bog lemming, SC, RC
Northern myotis
Silver-haired bat, SC, RC
White-tailed deer, BGP
Wolf, FT

[1]In addition to the above species of greatest conservation concern, a non-breeding birds profile was completed to assess concentrated wintering and migratory areas of New Hampshire.
[2]Canada warbler, veery, and wood thrush assessments were incorporated into matrix forest habitat profiles (See Appendix B).

on the habitat requirements of associated wildlife species of concern in the state.

F. Taxonomic Experts
Species were considered based on comments made by taxonomic experts. For example, ornithologists considered priority species listed in a variety of bird plans (e.g., Partners in Flight, United States Shorebird Conservation Plan, North American Waterfowl Management Plan, etc.). A team of invertebrate specialists was convened for the WAP, and this group determined that current knowledge of invertebrate distribution and abundance was inadequate to refine the list of invertebrates generated by items A-D above. Criteria used to determine a species' status in the state included the following:

- Distribution and abundance in New Hampshire and the Northeast
- The status and risk to the species or species' habitat in New Hampshire
- Species vulnerability due to life-history traits
- Statewide, regional, or global population trends

Identifying Key Wildlife Habitat

The New Hampshire Ecological Reserve System Project (renamed to the Living Legacy Project) used expert panels to assess population conditions and vulnerability of species in New Hampshire. A list of critical wildlife habitats was developed based on the habitat requirements of associated wildlife species of concern in the state. The list of associated wildlife species was developed by the Project's Scientific Advisory Group and modified by the Project's Wildlife Working Group. The habitat list was modified by biologists working on the WAP based on internal and external expert review. The wildlife habitat list was then cross-referenced with the NHNHB classification of 192 natural communities and 46 natural community systems to identify areas of correspondence and gaps (Appendix C).

Natural Communities as Surrogates for Biodiversity

Natural communities are recurring assemblages of plants and animals found in particular physical environments (Sperduto 2005); natural community systems are groups of natural communities that repeat in the landscape and are linked by a common setting or driving force (e.g., flooding or fire; Sperduto and Nichols 2004). Large-scale habitats were added, including matrix forests and aquatic watershed groupings. Other habitat-gaps (i.e., natural communities that did not correspond well with a habitat type) were addressed by considering the natural communities as embedded features within matrix forest systems

Large-scale ecosystem attributes allow conservationists to predict the distribution of taxa without exhaustive ground surveys. Thus, efficient conservation should start with a "coarse filter" approach, seeking to characterize broad natural community types that are correlated with particular species.

Rare, endemic, or wide-ranging species may be overlooked in a coarse-filter approach. Thus, conservation of natural communities should be coupled with species-based conservation; this is referred to as the "coarse filter - fine filter" strategy.

Integrating Habitats with Natural Communities and Systems

The wildlife habitats initially selected for inclusion in the WAP reflected habitats for priority wildlife species. We created a hierarchical data structure in which habitats form the largest scale or highest level, with natural community systems and natural communities forming subordinate smaller scale levels. Priority species may require multiple habitat types, and a habitat may provide a necessary component for more than one priority wildlife species (see Appendix D for Species and Habitat Associations).

In some cases, natural communities or ecological systems did not correspond with important wildlife habitats (e.g., grasslands and shrublands). In New Hampshire, shrublands and grasslands are maintained by management activities. Naturally occuring shrublands such as shrub wetlands or early seral stages of forests are included under other habitat types.

Conversely, other habitats correspond closely to a particular natural community system, such as the pine barrens habitat and the pitch pine sand plain system. Habitats with great ecological breadth (e.g., peatlands) or spatial extent (e.g., matrix forests and watershed groupings) were included to help address the full array of habitat diversity when planning for wildlife in New Hampshire.

TABLE 2-2. New Hampshire WAP habitat list.

Habitat Name
Large Scale Habitats
Matrix Forest Types
Appalachian Oak - Pine Forest
High-Elevation Spruce - Fir Forest
Lowland Spruce - Fir Forest
Northern Hardwood - Conifer Forest
Hemlock - Hardwood - Pine Forest
Watershed Groupings
Connecticut River Mainstem Watersheds
Southern Upland Watersheds
Northern Upland Watersheds
Montane Watersheds
Coastal Transitional Watersheds
Non-Tidal Coastal Watersheds
Tidal Coastal Watersheds
Open Ocean[1]
Medium and Small-Scale Habitats
Alpine
Shrublands
Grassland
Cliffs
Caves and Mines
Rocky Ridges[2]
Talus Slopes[2]
Pine Barrens
Marsh and Wet Meadows[3]
Shrub Wetlands[3]
Peatlands
Floodplain Forests
Vernal Pools
Salt Marshes
Coastal Islands
Dunes

[1] A habitat assessment was not completed for this habitat, nor was this considered in the watershed grouping analysis conducted by TNC. Relevant information, including a list of existing marine plans, was incorporated into the Tidal Coastal Watershed assessment.

[2] Rocky Ridges and Talus Slopes were combined for the threat ranking process and habitat Profile.

[3] Marsh and Wet Meadows and Shrub Wetlands were combined for the threat ranking process and habitat profiles as Marsh and Shrub Wetlands. These habitats were mapped together as one GIS data layer but can be queried separately.

As habitat models are refined and field verified they might be redefined to better reflect related natural communities and systems. Because these communities and systems may be more precisely correlated with particular species and ecological functions, they will be used to prioritize conservation efforts within habitats. For instance, unique systems within the "peatlands" habitat may prove more important, allowing greater precision in conservation.

Aquatic Classification

Unlike wetland and terrestrial habitats, an aquatic classification system for New Hampshire did not exist at the start of this planning effort. NHFG contracted TNC to initiate the development of an aquatic classification system based on a watershed and lake analytical stratification (Olivero and Bechtel 2005). This publication can be downloaded from the NHFG web site: visit www.nhfg.net, click on wildlife.

Watershed classification: The purpose of the watershed classification system was to help guide broad-scale conservation of aquatic ecosystems in New Hampshire. Conservation efforts that preserve the integrity of many types of watersheds provide greater opportunity to preserve unique, functional communities of organisms without having to identify each individual species and define its role in the community. Although this watershed classification system will need to be refined, it is a good step toward a comprehensive approach to aquatic ecosystem protection.

Lake classification: A lake classification system was developed for New Hampshire lakes to provide context for evaluating patterns in biological, water quality, and socioeconomic variables. The lake type classification used a physical environmental classification framework where local lake morphology characteristics define lake types within a larger environmental setting of elevation, geology, and landform patterns. The lakes classification is currently under review by NHFG biologists and will be incorporated into future conservation planning of aquatic systems.

Conservation Database

One of the early goals in the WAP process was to develop and maintain an accurate, up-to-date, geo-

referenced database containing information on New Hampshire's fauna. This process will continue, but several key steps have been completed including the development of a wildlife database website reporting mechanism, rare species database software upgrade to Biotics4, and incorporation of a tremendous amount of field-collected biological data into the database.

Development of a Framework for the Collection and Maintenance of Wildlife Data

A data collection tool, New Hampshire Wildlife Sightings (NHWS), was developed in cooperation with a number of government and nongovernment entities. NHWS employs a web site for collection of species occurrence data by qualified observers (http://nhwildlifesightings.sr.unh.edu) in a format that can easily be applied in distribution and habitat analyses. Currently, the pool of qualified observers is small as testing of the process continues.

Web hosting for NHWS is provided by the UNH Complex Systems Research Center. Raw observation data are downloaded from this web site by staff within the Wildlife Division at NHFG and imported into an in-house Access database to allow staff to perform quality control. After quality control is complete, data are forwarded to NHNHB within NHDRED to be incorporated into the rare wildlife, plant, and natural community database.

Software upgrade: BCD to Biotics4

In consultation with NatureServe, the NHFG, and NHNHB upgraded their Biological Conservation Database software to Biotics4 software. All previously entered wildlife, plant, and exemplary natural community data have been converted and stored in Biotics4. New exemplary wetland natural community records and a backlog of previously unprocessed wildlife records were incorporated into Biotics4. NHFG solicited new wildlife location data from experts around the state, which dramatically increased the number of rare species records.

Species and Habitat Assessments

The species and habitat profile template was designed to gather known information on the distribution, abundance, condition, threats, conservation actions, monitoring, and research for a particular species or habitat. Species and habitat assessments were completed by NHFG staff or were contracted to other taxonomic experts. To the extent that information is available, completed profile templates meet the required elements of the WAP. For most priority species (e.g., state-listed species) and habitats, an entire or nearly entire template was completed.

Through State Wildlife Grants, NHFG funded a number of projects to initiate research and compile data where information was lacking or insufficient to develop conservation strategies. The following list includes wildlife research completed or initiated during the WAP planning process:

- Pine Marten Restoration Project (University of Massachusetts, NHFG)
- Blanding's Turtle Nesting Study (NHFG)
- Vernal Pool Research: Amphibians as Indicators of Land and Water Habitat Quality (UNH)
- Salt marsh Bird Recovery (UNH and NHOEP)

Three Masters theses and associated peer-reviewed publications will result from these studies.

For some species, information was lacking and only a portion of the profile (e.g., element 1) was completed. For those species that had a close link to a habitat, detailed condition, threat, and conservation action assessments often were discussed in habitats profiles and referenced in appropriate species profiles.

The information in species and habitat assessments provided the basis for the development of New Hampshire's condition analysis (chapter 3), wildlife risk assessments (chapter 4) and statewide conservation strategies (chapter 5).

Distribution Maps

Distribution maps for species and habitats were compiled from various sources. Habitat distribution maps consisted largely of mapped known or predicted polygons completed as part of the WAP. Data for species distribution maps came from the Element Occurrence database maintained by NHNHB, Reptile and Amphibian Database, Wildlife Sightings Database, NHA Bird Records, museum records, and literature and expert reviews. Not all maps are complete or verified. Maps are constantly being updated based on new reports.

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CHAPTER THREE

New Hampshire's Wildlife Habitat Conditions

Overview

Element 2 of the NAAT Guidelines requires that each state provide, "descriptions of locations and relative conditions of key habitats and community types essential to conservation of species identified in element 1," which is the purpose of this chapter and the associated habitat profiles (Appendix B). Development of the wildlife conservation database to catalog the locations of wildlife observations (Chapter 2) was a preliminary step toward assessing the condition of wildlife habitats. In this chapter, a brief description of the methodology used to develop predictive habitat maps is provided. Complete descriptions are available under each species and habitat profile (Appendix A and B). Comprehensive data on local habitat conditions were organized in the GIS associated with each habitat map. Next, data were summarized within each habitat. The summary results of the condition of each habitat are presented under the headings Matrix Forests, Terrestrial Habitats, Wetland Habitats, and Watershed Groupings. Summary results for lakes are reported in Classification and Condition Assessment for New Hampshire's Lakes (Olivero and Bechtel 2005). Completion of predictive habitat maps and organizing pertinent data was a major undertaking that will benefit conservation, planning, and resource management organizations.

Step 1: Mapping wildlife habitats

The first step in assessing the condition of New Hampshire's wildlife habitats was to map their locations. We did not have complete data on the quantity and distribution of habitats, thus we used predictive models. Many different kinds of geographic data were organized and analyzed in GIS to generate predictive maps. Analytical methods and the resulting predictive maps were tailored to the ecological requirements and data available for each species and habitat. Generally, habitat maps were generated in one of four ways:

1. Correlate NHFG habitats with NHNHB systems or natural community classification and develop a model based on landscape features outlined in NHNHB descriptions
2. Identify common landscape features among known habitat locations and use those features to develop a model for the remainder of the state
3. Identify habitat components required by a specific species and generate a model based on those requirements
4. Grouping mapped lakes and watersheds based on similar habitat characteristics

A detailed description of the methods used is available under each species and habitat profile. Because of limited information and very limited predictability, maps were not created for Vernal Pools and Shrublands. The New Hampshire Habitat Landcover map (Figure 3-1) was compiled from the predicted matrix forests, terrestrial habitats, and wetland habitats (see Habitat Condition summaries). Maps were developed for a subset of priority wildlife species based on the availability of information and expertise and whether or not their specific habitat requirements were well

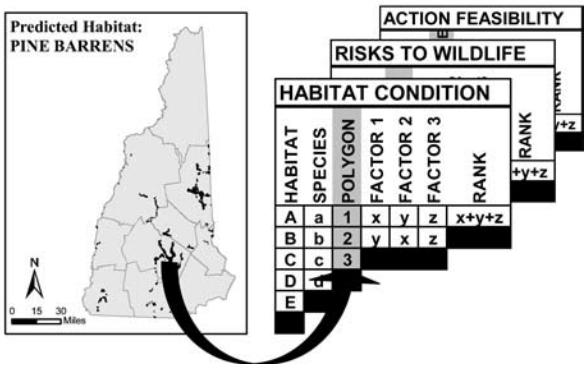


FIGURE 3-2. Mapping and Data Diagram. Data describing the condition of each habitat polygon were entered into a database for use in comparative analyses.

represented by the mapped habitat types. Species with completed predictive habitat maps include:

- Bald eagle
- Pied-billed grebe
- Grasshopper sparrow
- New England cottontail
- Bobcat
- Timber rattlesnake
- Canada lynx
- American marten
- Smooth green snake
- Black racer snake
- Eastern hognose snake
- Peregrine falcon
- Non-breeding birds
- Migratory birds

Aquatic habitats were analyzed at the watershed scale. A watershed classification system was developed to provide a tool to help guide broad conservation of aquatic ecosystems in New Hampshire. Conservation efforts that preserve the integrity of many types of watersheds provide greater opportunity to preserve unique, functional communities of organisms without having to identify each individual species and define its role in the community.

Major Watershed Groupings were chosen to represent large-scale aquatic habitats for further analysis in the WAP. Within these areas, multiple fine-scale habitat types, natural communities, and species can exist. Lakes were analyzed as a subcomponent of watersheds (Olivero and Bechtel 2005). Seven major Biological System Types (Very acidic ponds, Acidic ponds, Neutral ponds, Acidic shallow lake, Neutral shallow lake, Acidic deep lake, and Neutral deep lake) emerged as the dominant lake types.

A critical part of all predictive habitat-mapping efforts was to validate predictions about the type of habitat in a given location by checking whether or not a habitat type actually occurs in a subset of predicted locations. There are a number of different approaches to validating habitat maps, including:

- Check if predicted locations for a habitat correspond with locations that were mapped and confirmed by an unrelated process
- Select a subset of predicted locations for each habitat type and conduct a survey to confirm the actual habitat type on site

Model validation is not yet complete, but more detail about completing this task is provided in Chapter 5. Even though some habitat locations are already known, it is best to assume uncertainty for all locations until model validation has been completed.

Step 2: Measuring Condition Within Predicted Habitats

Every predicted location for each habitat is depicted in the GIS by a polygon delineating the spatial boundaries of the predicted area. Each predicted habitat polygon corresponds to dataset that describes the area within the polygon (Figure 3-2). Detailed information is not available for all of the habitat polygons, but we used the GIS to organize available information from many different sources. We gathered available information about the known risk factors, or threats, that influence wildlife health the most. This information provides quantitative data to augment the qualitative information developed during risk assessments (Chapter 4). Some information that was summarized for each habitat polygon is described in Table 3-1.

Landscape Context

Information about Landscape Context was calculated

FIGURE 3-1 (see insert). New Hampshire Habitat Landcover. Predictive habitat maps were developed for all WAP habitat types, and compiled to create a complete landcover. The New Hampshire Habitat Landcover will be used to conduct conservation planning analyses.

TABLE 3-1. Summary of preliminary terrestrial and wetland habitat condition analysis results. Not all results are reported here.

Habitat	Predicted Area (ac)	Predicted Area (ha)	% NH Area	% Unfragmented[1]	% Protected[2]	% Buildable[1]
Alpine	7717	3123	<1%	100%	100%	<1%
Grassland	232384	94043	4%	48%	8%	83%
Appalachian Oak-Pine Forest	424943	171969	7%	64%	13%	65%
Caves and Mines	n/a	n/a	<1%	n/a	11.1%[3]	<1%
Cliffs	5808	2350	<1%	98%	91%	<1%
Coastal Islands	820	332	<1%	47%	14%	<1%
Dunes	192	78	<1%	20%	67%	<1%
Floodplain Forest	112945	42950	2%	73%	27%	56%
Hemlock-Hardwood-Pine Forest	2688744	1088101	45%	72%	15%	n/a
High-Elevation Spruce-Fir Forest	243263	98446	4%	99%	87%	12%
Lowland Spruce-Fir Forest	770048	311629	13%	89%	32%	56%
Marsh & Shrub Wetlands	142073	57495	2%	45%	15%	68%
Northern Hardwood-Conifer Forest	1086765	439800	18%	93%	43%	55%
Peatlands	57698	23350	1%	75%	17%	68%
Pine Barrens	24682	9988	<1%	56%	19%	76%
Rocky Ridges & Talus Slopes	28049	11351	<1%	96%	61%	26%
Salt Marshes	5620	2274	<1%	82%	22%	<1%

[1]Based on NHFG Coarse Filter Wildlife Habitat Mapping Project, 2004.

[2] Complex Systems Research Center, 2005. Conservation/Public Lands Data.

[3] 2 of 18 sites

directly from the spatial geometry of individual habitat polygons and their relationships to one another. Variables that describe landscape context help describe predicted interactions among habitat polygons, such as the dispersal of wildlife and gross abundance of habitat in terms of area and neighboring resources. NHFG has contracted researchers at UNH to develop models to assess landscape connectivity for large carnivores. Some other landscape context variables that NHFG has analyzed include:

- Total area, land area [1], wetland area, total perimeter length
- Distance to and identity of nearest neighbor and other landscape features
- Shape index (measure of overall shape complexity)
- Elevation, aspect

Wildlife Diversity

Information about the diversity of plants and animals in a given location is very limited. Some monitoring programs provide data about certain groups of wildlife, and many rare wildlife are tracked by NHFG and NHNHB. NHNHB conducted analyses to assess information about tracked plants, animals, and natural communities (Table 3-2). One caveat pertaining to data summarizing tracked plant, animal, and exemplary natural community records is that it is difficult or impossible to know whether the absence of records in a given location is an indication that surveys yielded no observations or whether no surveys were conducted. In some cases, landscape features may serve as indicators of biodiversity. Some of the information that were used to assess wildlife diversity included:

TABLE 3-2. Summary of potential biodiversity indicators. Indicators should be interpreted cautiously. Recorded observations of rare plants, animals, and natural communities do not consistently represent structured surveys. Absence of survey information and null observations are both potential causes for low indicator levels, but no information is available to discern which is true.

Habitat	Average Information Diversity for Rare Animals[1]	Average Information Diversity for Rare Plants[2]	Average Richness of Natural Communities[3]	Average Proportion Rare or Exemplary Natural Community in Habitat[4]
Alpine	1.1	1.5	5.5	47.6
Grassland	1.7	0.1	1.0	0.2
Appalachian Oak-Pine Forest	n/a	n/a	n/a	n/a
Caves and Mines	n/a	n/a	n/a	n/a
Cliffs	1.4	0.2	2.0	17.1
Coastal Islands	1.9	0.2	0.6	2.3
Dunes	1.8	1.0	8.0	30.0
Floodplain Forests	1.7	0.3	1.7	5.9
Hemlock-Hardwood-Pine Forest	n/a	n/a	n/a	n/a
High-Elevation Spruce-Fir Forest	1.4	0.0	1.5	2.6
Lowland Spruce-Fir Forest	1.4	0.0	0.0	0.5
Marsh & Shrub Wetlands	1.7	0.0	0.0	1.1
Northern Hardwood-Conifer Forest	n/a	n/a	n/a	n/a
Peatlands	1.7	0.0	0.5	3.7
Pine Barrens	2.4	0.3	5.9	7.7
Rocky Ridges and Talus Slopes	1.6	0.1	2.0	24.5
Salt Marshes	n/a	n/a	n/a	n/a

[1] Shannon diversity index calculated within their dispersal distances from each habitat polygon.

[2] Shannon diversity index calculated based on number of rare plant source features within 1 kilometer of each habitat polygon.

[3] Richness calculated based on number of natural communities within 1 kilometer of each habitat polygon.

[4] Area mapped as rare or exemplary natural communities/total area of a habitat polygon, averaged across all polygons.

- Presence, absence, or status of tracked wildlife
- Total number of observations, richness, and diversity of tracked rare animals, plants, and exemplary natural communities observed within their (NHNHB standard) dispersal or buffered distance and within predicted habitat polygons[21]
- Average qualitative rank and distribution of recorded observations of tracked animals and rare plants within 1 km of a predicted habitat polygon[21]
- Average condition rank of recorded observations of tracked rare and exemplary natural communities within 1 km of a mapped habitat polygon[21]
- Shellfish resources (clam/oyster beds) [3]
- Migratory and wintering bird sites [6]
- Richness of Ecological Land Units (TNC) [19]
- Diversity of Habitat (Figure 3-3)

Recreational Factors

Recreational influences on wildlife are difficult to assess. It is especially difficult to measure animal responses via GIS. Although trails are often well marked on the land and new technology makes it

FIGURE 3-3 (see insert). Habitat Diversity by Town. Total number (richness) of WAP habitat types within town boundary. Habitat diversity may be used as an indicator of wildlife diversity.

easy to map them, most trails remain undocumented. For many popular recreational activities, it is possible to measure indicators of the level of the activity or proximity to wildlife resources. Such indicators may help focus attention on areas of conflict:

- Geocache sites visited by GPS users
- Mine shaft type, an indicator of spelunking
- Golf courses
- Rock-climbing routes (based on guide books)
- Boat access sites, marinas, and sport fishing areas[3]
- Hiking trails
- Snowmobile and other OHRV trails

Development and Land Use Factors

Human development and infrastructures may affect wildlife, including reduced landscape connectivity, introduction of invasive species, contaminants, and modified local climate. To evaluate edge effects associated with fragmenting features on the landscape, such as the spread of contaminants from roads, noise, invasive plants, and changes in microclimate, NHFG and TNC developed a computer model. Figure 3-4 shows a preliminary product generated from this model. When complete, this model will help to identify pristine and unfragmented blocks of habitat. Important development and land use factors include:

- Area in Conservation/fee ownership (Figure 3-5)[4]
- Influence of fragmenting features[20]
- Designated prime wetland [5]
- Wetland and forestry permits [7]
- Buildable area (hectares, from generalized statewide buildout analysis, NHFG) [12]
- Population growth [22]
- Agriculture and other landuses [22]
- Wind power areas and communication towers [13, 14]
- Dams and transmission lines [17, 22]
- Airports, roads, railroads

FIGURE 3-4 (see insert). Preliminary Integrated Fragmentation Effects Surface. Preliminary results showing predicted edge effects for 'human' landcover types. Fragmentation effects may be used as an indicator of ecological integrity.

FIGURE 3-5 (see insert). Conservation Lands by Town.

Air and Water Quality Factors

Broad patterns of air and water quality influence the quality of wildlife habitats, even if they are protected from local influences such as development. Many aspects of broad environmental quality issues are beyond the scope of the WAP. For some issues, air and water quality indicators may have relevance for wildlife. For example, DES monitors stream invertebrate populations to measure contaminant levels and the Biodiversity Research Institute measures levels of mercury in many wildlife species. Data sources include:

- Oil spill response staging area[3]
- Shoreline sensitivity (environmental sensitivity index) [3]
- Contamination sources, outfalls, PORTFS [8, 9, 22]
- Impoundments, drawdowns, and water withdrawals [10, 11, 22]
- Forested headwaters, surface waters, free flowing water [22]
- Exotic aquatic plant infestation sites [22]
- Mercury levels from wildlife specimens [23]
- Predicted acid rain sensitivity and mercury deposition rates [23]

Step 3: Comparing Conditions Across the Landscape

Patterns of biodiversity form on the landscape at many different scales. For example, forest trees form patterns of diversity across great ranges in altitude, while aquatic insects form patterns of diversity across stream riffles that span several meters. Therefore, in order to address the full range of biodiversity, the condition of the natural landscape needs to be assessed at more than one scale.

The most relevant indicators listed above will be used to generate a relative condition index for each habitat type by habitat polygon and unit. Such an index will allow a comparison among polygons and units within a habitat type to identify those in the best relative condition to target for protection and those that are most threatened and in need of restoration or other remediation activities. See Jones et al. (1997) for one example of calculating a relative condition index based on condition indicators.

The result of habitat condition analyses will be

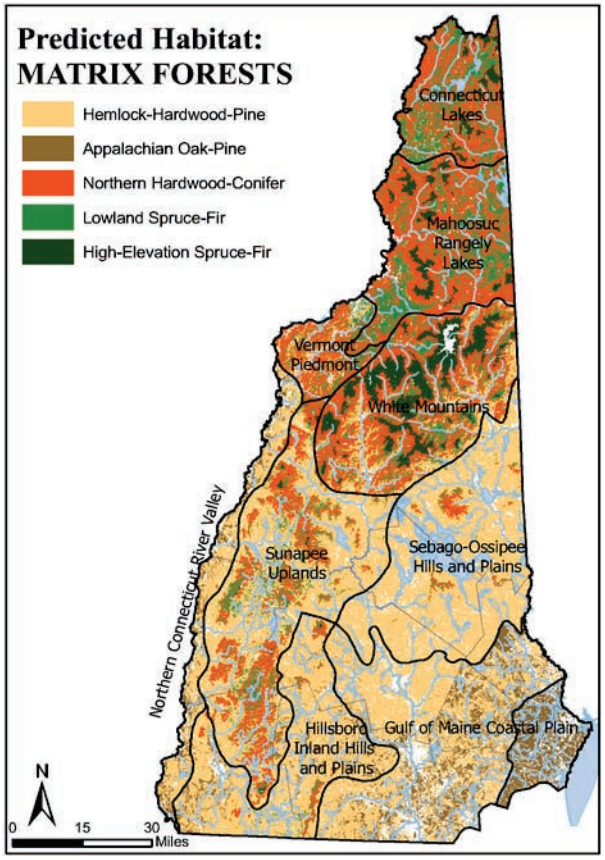


FIGURE 3-7. Predicted Matrix Forests. Matrix Forest maps were created collaboratively by NHFG, TNC, NHB, and NRCS. Map validation is a priority WAP objective.

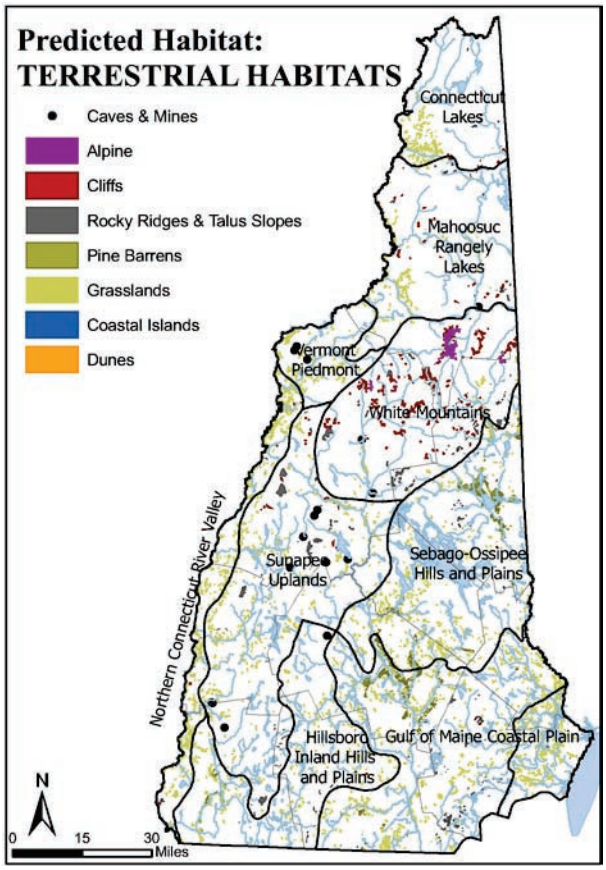


FIGURE 3-8. Predicted Terrestrial Habitats. Terrestrial Habitat maps were created by NHFG and NHB. Map validation is a priority WAP objective.

that implemented strategies will address the entire breadth of biodiversity contained within the state, from large-ranging forest mammals to the smallest-ranging stream invertebrates. At each of three levels of ecological scale, analyses will be conducted to 'filter' out pieces of the landscape that have the greatest biodiversity and highest value for wildlife (Figure 3-6). At the largest ecological scale, we will identify very large unfragmented forest blocks that harbor diverse mosaics of habitat and support many natural communities, wildlife, and plant populations. In the landscape that surrounds the largest unfragmented forest blocks, analyses conducted on medium- to large-scale habitats will distinguish a diverse array of high quality habitats from areas that have lower value for wildlife.

FIGURE 3-6 (see insert). Town Scale Habitat Summary Map. New Hampshire Habitat landcover shown at the town scale. Condition analyses are underway for small, medium, and large-scale habitat types.

Finally, optimal habitats for at-risk plants, animals, and natural communities will be identified in the context of supporting neighboring habitats and large unfragmented forest areas.

Unfragmented Forest Blocks

Unfragmented forest blocks are the largest scale at which condition will be assessed. At this scale, the diversity of different habitat types in close proximity to one another is one of the key considerations. Once preliminary fragmentation modeling is complete, unfragmented forest blocks will be broken up into 3 or 4 different size classes. Each block within a size class will be analyzed to determine the abundance and diversity of smaller scale elements of biodiversity (natural community, plant and wildlife element occurrences or predicted wildlife habitats), medium scale (alpine, cliffs, floodplain forest, etc.), and large-scale habitats (matrix forest types) contained within it. Each block

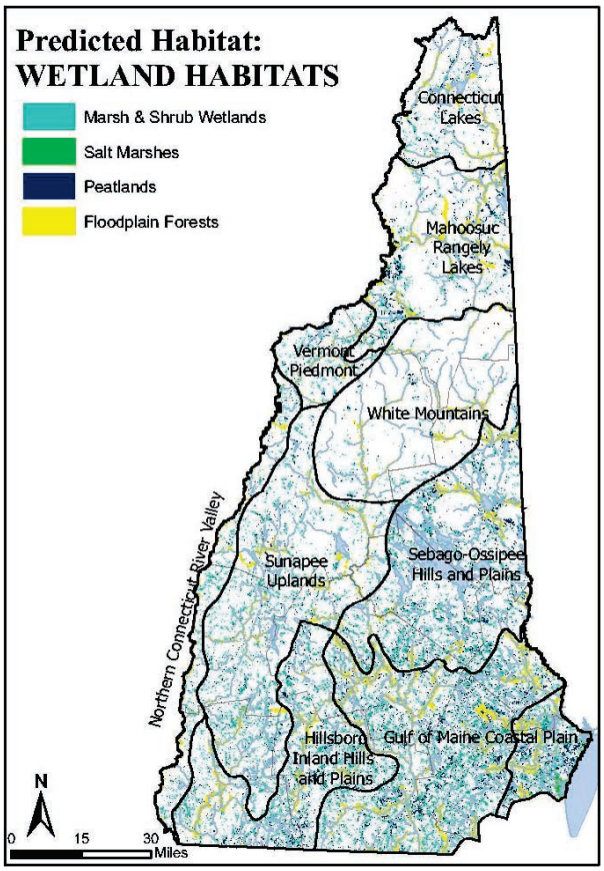


FIGURE 3-9. Predicted Wetland Habitats. Wetland Habitat maps were created collaboratively by NHFG and NHB. Map validation is a priority WAP objective.

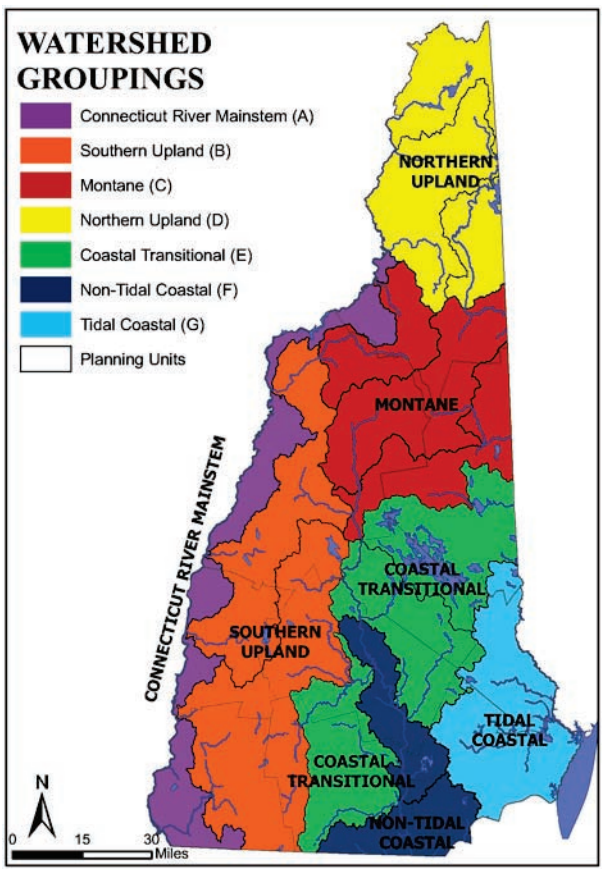


FIGURE 3-10. Watershed Groupings. Watershed Groupings were created by TNC. Validation of watershed classifications is a priority WAP objective.

will also be evaluated to assess the relative level of risk factors based on the data described above (e.g., from transportation, development, recreation, etc.) associated with it.

The results of this assessment will help identify the largest and intact portions of New Hampshire's natural landscape. Diverse assemblages of wildlife habitats, natural communities, wildlife, and plant populations will be contained within these areas. Information about the known risks to wildlife will be summarized for each unfragmented focal area.

Large and Medium-Scale Habitats

Matrix forest types (Figure 3-7) and Watershed Groupings (Figure 3-10) comprise the large-scale habitats addressed in the WAP. Terrestrial habitats (Figure 3.8) and wetland habitats (Figure 3.9) are the medium-scale unit addressed in the WAP. Like the unfragmented blocks, matrix forests and habitats will be assessed to determine the abundance and diversity of natural communities, plants, and wildlife populations. Each block will then be evaluated to assess the relative level of risk factors based on the data described above (e.g., from transportation, development, recreation, etc.) associated with it. Preliminary analyses are complete at this level, and are summarized below.

Natural Communities, Lakes, and Wildlife Populations

Habitat maps developed for bald eagle, timber rattlesnake and others are comparable in spatial scale to some of the habitats described above. However, each represents a very limited component of New Hampshire's biodiversity, and has very specific requirements. Natural communities represent more biodiversity than wildlife populations, but less than medium and large-scale habitats or unfragmented blocks. TNC analyzed the relative condition of lakes (Figure 3-11,

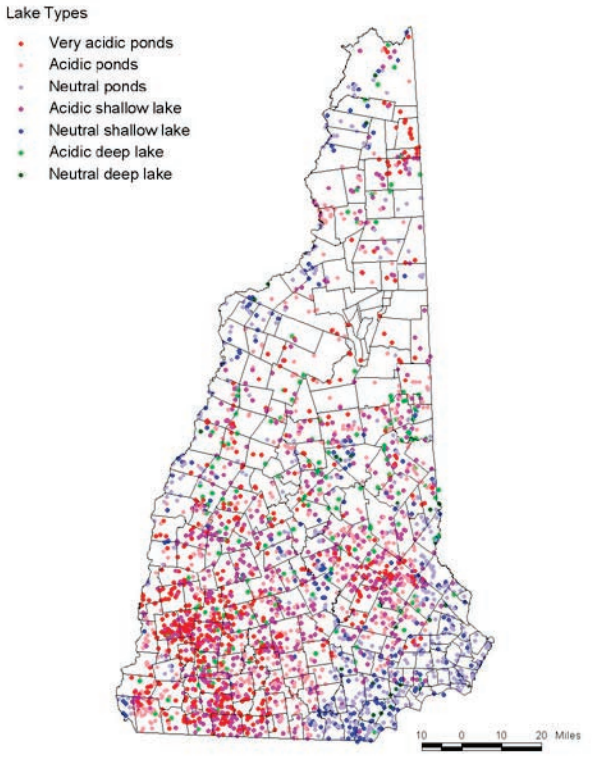


FIGURE 3-11. Lake Types. Lake Types were created by TNC. Validation of Lake Types is a high priority WAP objective.

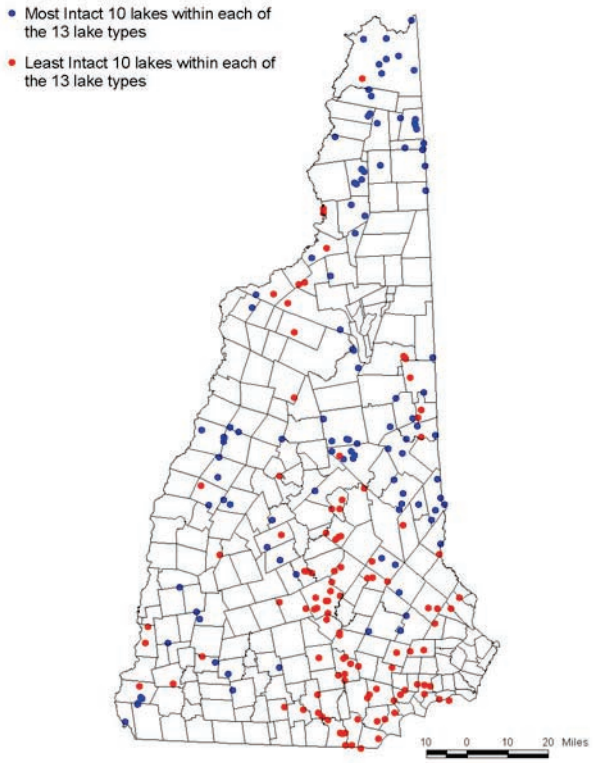


FIGURE 3-12. Lake Condition Summary. The condition of NH lakes was analyzed by TNC (Appendix).

Figure 3.12). Small-scale natural communities, wildlife, and plant populations are represented by element occurrences (EO) tracked by NHNHB. The condition of EOs can be assessed by evaluating the number of individuals recorded in a population, proximity to other EOs of the same species or natural community, etc. In some cases, qualitative indicators of condition are available within the EO database. Threats such as distance to nearest road, presence of invasive plants, and others can also be assessed to ascertain relative EO quality.

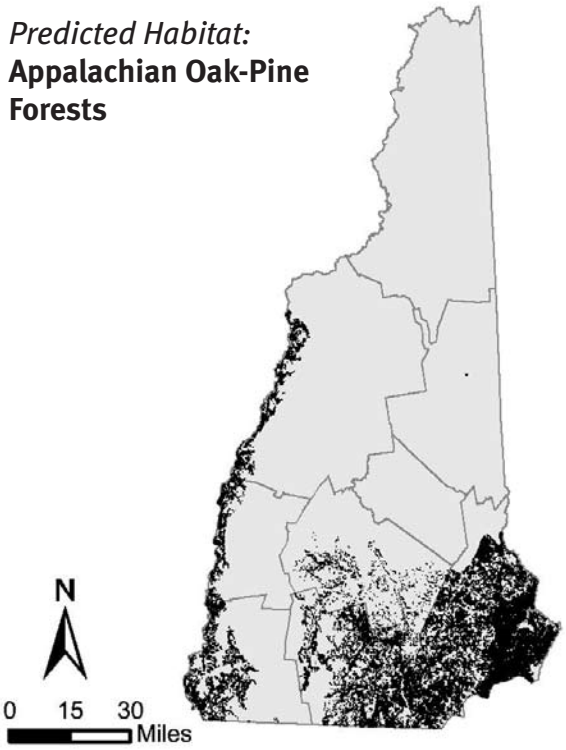
MATRIX FOREST HABITAT:

Appalachian Oak-Pine Forests

Important Wildlife: American woodcock, bald eagle, black bear, black racer, Blanding's turtle, blue-spotted salamander, bobcat, Canada warbler, cerulean warbler, common nighthawk, Cooper's hawk, Eastern box turtle, Eastern hognose snake, Eastern pipistrelle, Eastern red bat, Eastern towhee, Fowler's toad, Jefferson salamander, marbled salamander, moose*, New England cottontail, Northern goshawk, Northern myotis, ribbon snake, ruffed grouse, silver-haired bat, smooth green snake, spotted turtle, timber rattlesnake, wild turkey*, veery, whip-poor-will, white-tailed deer*, wood thrush, migrating/wintering birds, wood turtle

**Big game species addressed in Big Game Plan Management Plan*

Natural Communities: Appalachian oak - mountain laurel forest, Chestnut oak forest/woodland, Dry Appalachian oak - hickory forest, Dry river bluff, Mesic Appalachian oak - hickory forest, Pitch pine - Appalachian oak - heath forest, Semi-rich Appalachian oak - sugar maple forest, Red maple - sensitive fern swamp, Red maple - black ash - swamp saxifrage swamp, Red maple - lake sedge swamp, Circumneutral seepage swamp, Highbush blueberry - winterberry shrub thicket, Hemlock - cinnamon fern forest, Red maple - red oak - cinnamon fern forest, Red maple - Sphagnum basin swamp, Red maple - elm - lady fern silt forest, Seasonally flooded red maple swamp, Subacid forest seep, Acidic Sphagnum forest seep, Circumneutral hardwood forest, Rich mesic forest, Semi-rich mesic sugar maple forest, Rich sugar maple - oak - hickory terrace forest, Semi-rich Appalachian oak - sugar maple forest



- Predicted Appalachian oak-pine forests in New Hampshire cover a total of 171,969 ha, approximately 7.2% of New Hampshire's area.
- Approximately 90% of New Hampshire's predicted Appalachian oak-pine forest is located in Cheshire, Hillsborough, Rockingham, and Strafford counties.
- Approximately 12.6% of New Hampshire's predicted Appalachian oak-pine forest area has some level of protection.
- New Hampshire's most extensive Appalachian oak-pine forest blocks are located in Rockingham county.
- Appalachian oak-pine forests are one of New Hampshire's most at-risk habitats. The most challenging issues facing Appalachian oak-pine forests are human development and transportation infrastructure and altered natural disturbance.
- Approximately 109,737 ha or 64% of the land area in Appalachian oak-pine forests is more than 400 feet from roads and other forms of urban development.

MATRIX FOREST HABITAT:

Hemlock-Hardwood-Pine Forests

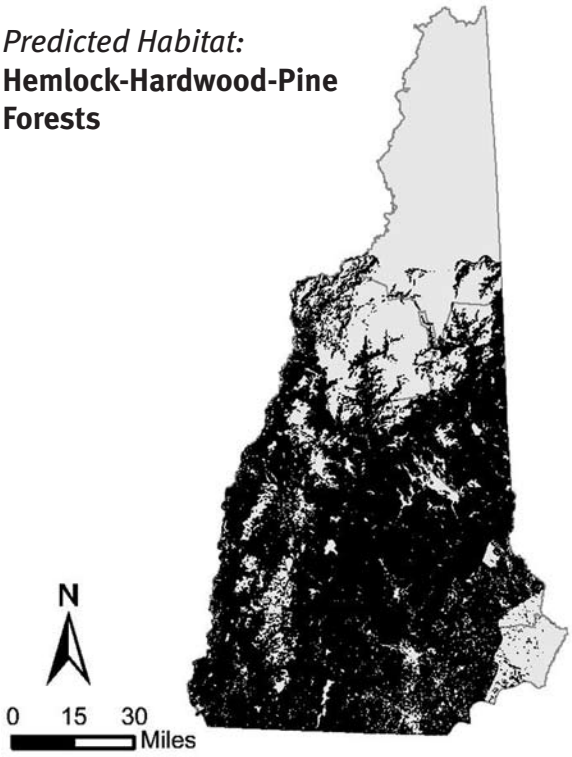
Important Wildlife: American woodcock, bald eagle, black bear*, black racer, Blue-spotted salamander, bobcat, Canada warbler, cerulean warbler, Cooper's hawk, Eastern box turtle, Eastern hognose snake, Eastern pipistrelle, Eastern red bat, Eastern small-footed bat, Eastern towhee, Fowler's toad, Jefferson salamander, marbled salamander, moose*, New England cottontail, Northern goshawk, Northern myotis, purple finch, red shouldered hawk, ribbon snake, ruffed grouse, silver-haired bat, smooth green snake, spotted turtle, timber rattlesnake, wild turkey*, veery, whip-poor-will, white-tailed deer*, wood thrush, wood turtle, Blanding's turtle, migrating/wintering birds

**Big game species addressed in Big Game Plan Management Plan*

Natural Communities: Red maple - sensitive fern swamp, Red maple - black ash - swamp saxifrage swamp, Red maple - lake sedge swamp, Circumneutral seepage swamp, Highbush blueberry - winterberry shrub thicket, Hemlock - cinnamon fern forest, Red maple - red oak - cinnamon fern forest, Red maple - Sphagnum basin swamp, Red maple - elm - lady fern silt forest, Seasonally flooded red maple swamp, Subacid forest seep, Acidic Sphagnum forest seep, Circumneutral hardwood forest, Northern hardwood seepage forest, Rich mesic forest, Semi-rich mesic sugar maple forest, Rich sugar maple - oak - hickory terrace forest, Semi-rich Appalachian oak - sugar maple forest, Beech forest, Dry red oak - white pine forest, Hemlock - beech - northern hardwood forest, Hemlock - beech - oak - pine forest, Hemlock - white pine forest, Hemlock forest, Semi-rich mesic sugar maple forest

- Predicted hemlock-hardwood-pine forest in New Hampshire covers a total of 1,088,101 ha, approximately 45.3 % of New Hampshire's area.
- Approximately 73% of New Hampshire's predicted hemlock-hardwood-pine forest is located in Carroll, Cheshire, Grafton, Hillsborough, and Merrimack counties.

Predicted Habitat:
Hemlock-Hardwood-Pine Forests



- Approximately 15% of New Hampshire's predicted hemlock-hardwood-pine forest has some level of protection.
- New Hampshire's most extensive hemlock-hardwood-pine forest blocks are located in Belknap and Merrimack counties.
- Hemlock-hardwood-pine forests are one of New Hampshire's most at-risk habitats. The most challenging issues facing hemlock-hardwood-pine forests are human development, introduced species and altered natural disturbance.
- Approximately 786,542 ha or 72% of the land area in hemlock-hardwood-pine forests is more than 400 feet from roads and other forms of urban development.

MATRIX FOREST HABITAT:

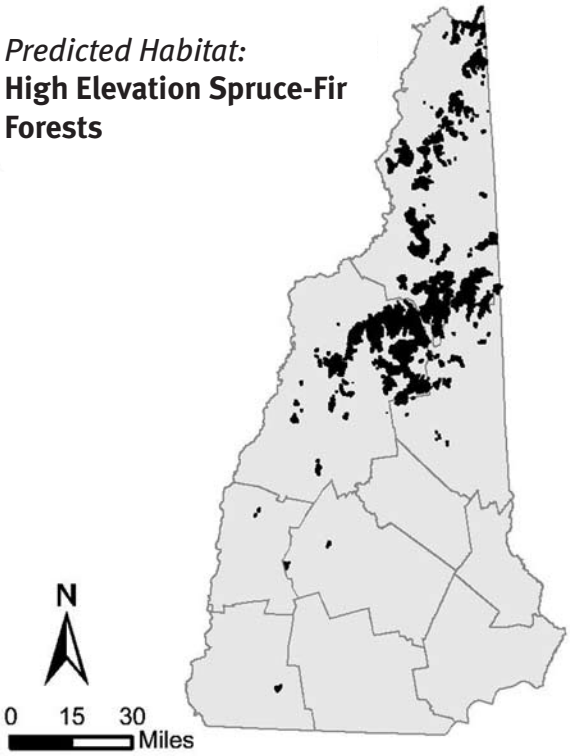
High Elevation Spruce-Fir Forests

Important Wildlife: American marten, American pipit, bay-breasted warbler, Bicknell's thrush, Canada lynx, moose*, spruce grouse, three-toed woodpecker, migrating/wintering birds

**Big game species addressed in Big Game Plan Management Plan*

Natural Communities: High-elevation balsam fir forest, High-elevation spruce - fir forest, Montane landslide, Northern hardwood - spruce - fir forest, Subacid forest seep, Acidic Sphagnum forest seep

- Predicted high elevation spruce-fir forest covers a total of 98,365 ha, approximately 4.3% of New Hampshire's area.
- Nearly 80% of New Hampshire's predicted high elevation spruce-fir forest is located in Coos and Grafton counties.
- Approximately 87% of New Hampshire's predicted high elevation spruce-fir forest is protected by conservation ownership or easement.
- New Hampshire's most extensive high elevation spruce-fir forests are located in the White Mountain National Forest.
- The most challenging issue that faces high elevation spruce-fir forests is acid deposition.
- Approximately 98,199 ha or 99% of the land area in high elevation spruce-fir forests are more than 400 feet from roads and other forms of urban development.



MATRIX FOREST HABITAT:

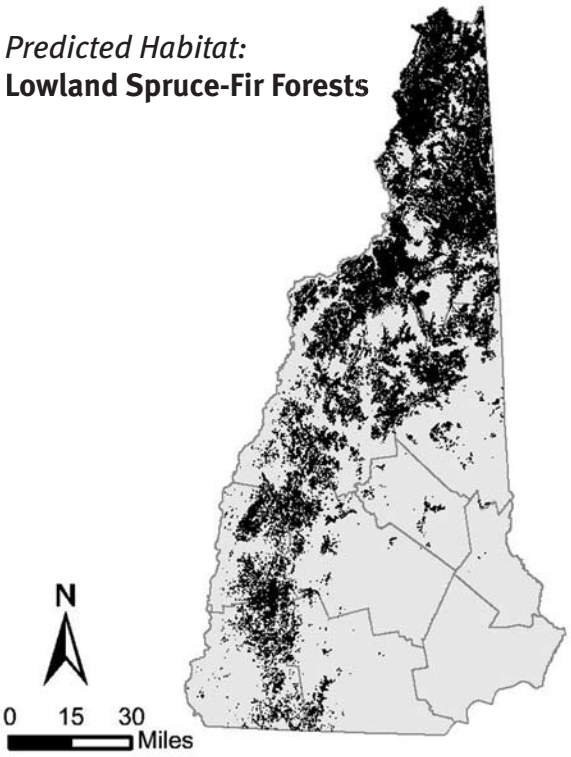
Lowland Spruce-Fir Forests

Important Wildlife: American marten, bald eagle, bay-breasted warbler, black bear, Canada lynx, Cooper's hawk, hoary bat, mink frog, Northern bog lemming, Northern goshawk, palm warbler, purple finch, rusty blackbird, spruce grouse, three-toed woodpecker, white-tailed deer*, wolf, wood turtle, migrating/wintering birds, moose*

**Big game species addressed in Big Game Plan Management Plan*

Natural Communities: Red spruce swamp, Lowland spruce - fir forest, Montane black spruce - red spruce forest, Northern hardwood - black ash - conifer swamp, Seasonally flooded boreal swamp, Speckled alder wooded fen, Subacid forest seep, Acidic Sphagnum forest seep, Circumneutral hardwood forest, Northern hardwood seepage forest

- Predicted lowland spruce-fir forest covers a total of 311,390 ha, approximately 13.5% of New Hampshire's area.
- Nearly 80% of New Hampshire's predicted lowland spruce-fir forest is located in Coos and Grafton counties.
- Approximately 33% of New Hampshire's predicted lowland spruce-fir forest is protected by conservation ownership or easement.
- New Hampshire's most extensive predicted lowland spruce-fir forest is located in the Success flats, Coos county.
- The most challenging issues that face lowland spruce-fir forests are development, timber harvest, non-point source pollutants and altered natural disturbance regimes.
- Approximately 276,462 ha or 89% of the land area in lowland spruce-fir forests are more than 400 feet from roads and other forms of urban development.



MATRIX FOREST HABITAT:

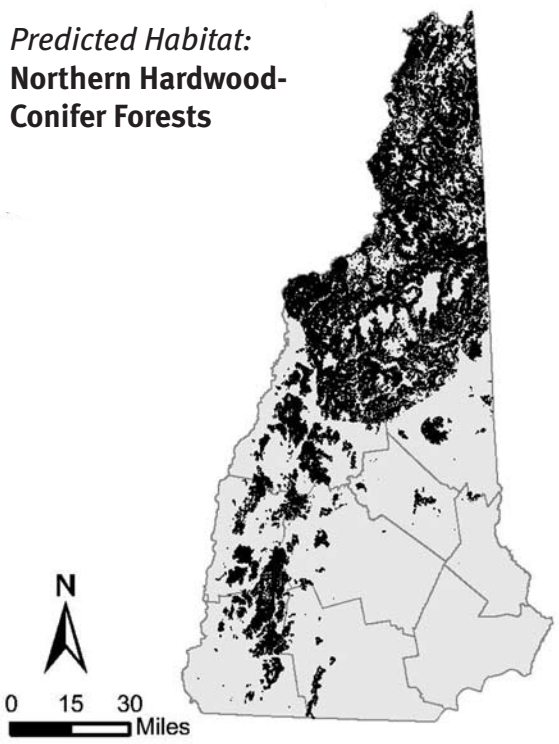
Northern Hardwood-Conifer Forests

Important Wildlife: American woodcock, bald eagle, black bear*, blue-spotted salamander, bobcat, Canada lynx, Canada warbler, Cooper's hawk, Eastern pipistrelle, Eastern red bat, Eastern small-footed bat, hoary bat, Indiana bat, Jefferson salamander, marbled salamander, mink frog, Northern goshawk, Northern myotis, purple finch, ribbon snake, ruffed grouse, silver-haired bat, smooth green snake, spotted turtle, timber rattlesnake, wild turkey*, veery, white-tailed deer*, wolf, wood thrush, wood turtle, migrating/wintering birds, moose*

**Big game species addressed in Big Game Plan Management Plan*

Natural Communities: Beech forest, Hemlock - beech - northern hardwood forest, Hemlock - spruce - northern hardwood forest, Hemlock forest, Northern hardwood - spruce - fir forest, Semi-rich mesic sugar maple forest, Sugar maple - beech - yellow birch forest Northern hardwood - black ash - conifer swamp, Seasonally flooded boreal swamp, Speckled alder wooded fen, Subacid forest seep, Acidic Sphagnum forest seep, Circumneutral hardwood forest, Northern hardwood seepage forest, Rich mesic forest, Semi-rich mesic sugar maple forest, Rich sugar maple - oak - hickory terrace forest, Semi-rich Appalachian oak - sugar maple forest

- Predicted northern hardwood-conifer forest in New Hampshire covers a total of 439,573 ha, approximately 19 % of New Hampshire's area.
- Approximately 78% of New Hampshire's predicted northern hardwood-conifer forest is located in Coos and Grafton counties.
- Approximately 44 % of New Hampshire's predicted northern hardwood-conifer forest has some level of protection.
- New Hampshire's most extensive northern hardwood-conifer forests are located in Coos county.
- The most challenging issues facing northern hardwood-conifer forests are development and acid deposition.
- Approximately 407,537 ha or 93% of the land area in northern hardwood-conifer forests is more than 400 feet from roads and other forms of urban development.



TERRESTRIAL HABITAT:

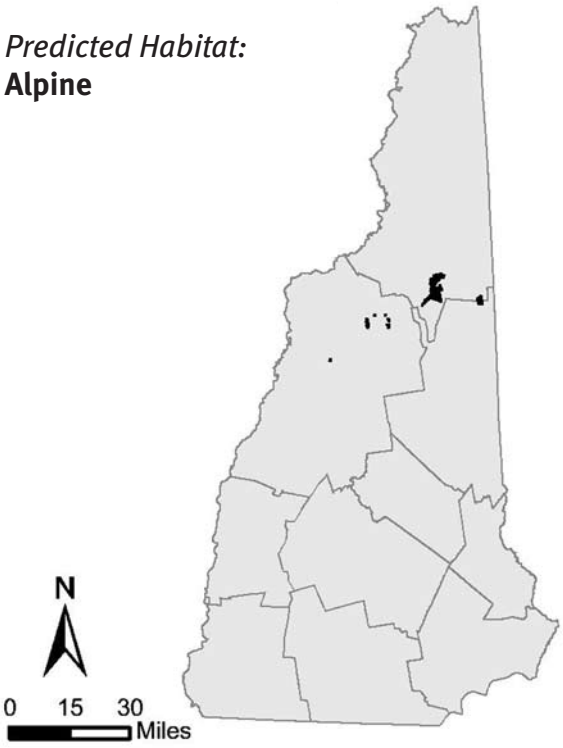
Alpine

Important Wildlife: American pipit, White Mountain arctic, White Mountain fritillary

Natural Communities: Alpine cliff, Alpine heath snowbank, Alpine herbaceous snowbank/rill, Alpine ravine shrub thicket, Bigelow's sedge meadow, Black spruce/balsam fir krummholz, Diapensia shrubland, Dwarf shrub - bilberry - rush barren, Felsenmeer, Labrador tea heath - krummholz, Moist alpine herb - heath meadow, Montane heath woodland, Montane landslide, Red spruce - heath - cinquefoil rocky ridge, Sedge - rush - heath meadow, Sheep laurel - Labrador tea heath - krummholz, Subalpine cold-air talus barren, Subalpine rocky bald, Subalpine sliding fen

- Predicted alpine habitat in New Hampshire covers a total of 3,125 ha, <1% of New Hampshire's area, and occurs exclusively in Carroll, Coos, and Grafton counties.
- Alpine habitat within the WMNF is protected by the USFS National Wilderness Preservation System and Standards and also Guidelines for Management Area 8.1 - Alpine Zone.
- New Hampshire's most extensive and ecologically diverse area of alpine habitat (2,807 ha) occurs in the Presidential Range. Other sizeable areas exist on Franconia Ridge (153 ha) and Baldface (100 ha).
- The most challenging issues facing alpine habitat are climate change and acid deposition.
- Approximately 3,123 ha or 100% of the land area in alpine habitat is more than 400 feet from roads and other forms of urban development.

Predicted Habitat:
Alpine



TERRESTRIAL HABITAT:

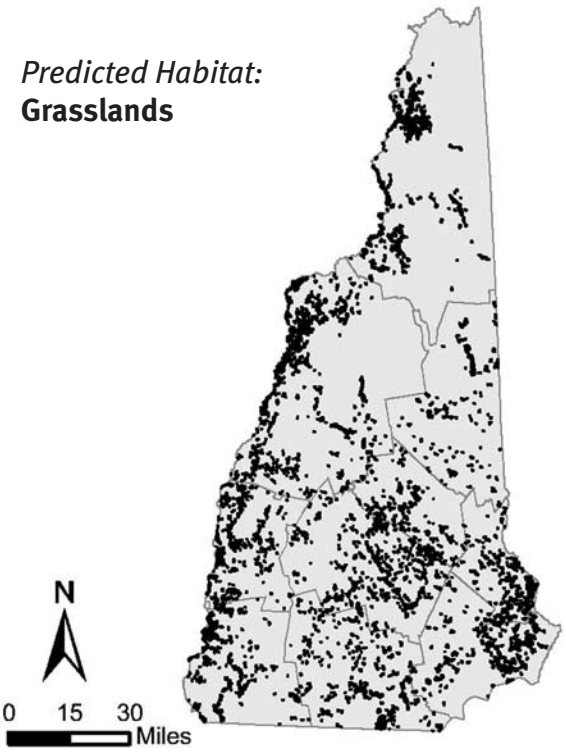
Grasslands

Important Wildlife: American bittern, American woodcock, Blanding's turtle, Eastern hognose snake, Eastern meadowlark, grasshopper sparrow, horned lark, migrating/wintering birds, Northern harrier, Northern leopard frog, purple martin, smooth green snake, upland sandpiper, vesper sparrow, whip-poor-will, white-tailed deer*, wood turtle, black racer

**Big game species addressed in Big Game Plan Management Plan*

Natural Communities: Grasslands are created, managed, and maintained by human actions. They are not described in the NHNHB natural communities classification.

- Predicted grassland habitat in New Hampshire includes 94,043 ha (3.9% of New Hampshire area) of grassland complexes at least 10 hectares in size. Grasslands exceeding 10 ha are located in all New Hampshire counties.
- The largest proportions of grasslands occur in Grafton (20%), Merrimack (13%), and Coos (12%) counties.
- Only 8% percent of New Hampshire grasslands exceeding > 10 hectares are under conservation easement or ownership. The percentage of conserved grasslands by county ranges from 4 – 11% with the most area conserved in Merrimack and Strafford counties (11% each) and the least in Belknap county (4%).
- New Hampshire's airports provide some of the most extensive and highest quality grassland habitat
- The most challenging issues facing grasslands and species that use this habitat for breeding are development and certain agricultural practices, such as mowing during breeding seasons.
- UNH Complex Systems Research Center documented a 50% decline in active agricultural land from 1962 to 1998 in Rockingham and Strafford County; farm abandonment leads to loss of grassland either due to development or natural succession



- Approximately 44,720 ha or 48% of the land area in grasslands is more than 400 feet from roads and other forms of urban development.

TERRESTRIAL HABITAT:

Shrublands

Important Wildlife: American bittern, American woodcock, black bear*, bobcat, Canada lynx, Eastern box turtle, Eastern hognose snake, Eastern towhee, golden-winged warbler, moose*, New England cottontail, migrating/wintering birds, Northern harrier, purple finch, ruffed grouse, smooth green snake, timber rattlesnake, whip-poor-will, white-tailed deer*, wood turtle, black racer

**Big game species addressed in Big Game Plan Management Plan*

Natural Communities: Most shrublands are created, managed, and maintained by human actions. They are not described in the NHNHB natural communities classification..

- Since 1960, the distribution and abundance of shrubland-dependant New England cottontails has declined to such an extent that they are being considered for listing under the federal Endangered Species Act.
- According to USFS surveys, the amount of area in seedling/sapling forest (used here as a surrogate) declined 63% from 1973-2002. Seven counties experienced a 70 - 100% decline. Coos County experienced only a 12% decline.
- New Hampshire has lost more than 6,885 ha of open space to development each year in the past five years. Shrublands are often on good soils or near roads and hence highly desirable for development.
- The most challenging issues facing shrublands are vegetative succession and urban development.

TERRESTRIAL HABITAT:

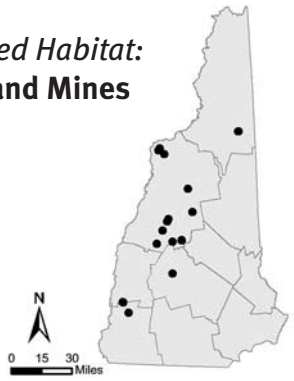
Caves and Mines

Important Wildlife: Eastern pipistrelle, Indiana bat, Northern myotis, Eastern small-footed bat

Natural Communities: Not Applicable.

- New Hampshire has 7 mines known to serve as bat hibernacula in Coos, Grafton, and Merrimack counties.
- Two New Hampshire mines supporting hibernacula are on lands managed by the New Hampshire Department of Resources and Economic Development. The remaining 5 hibernacula are on private lands and lack protective status.
- Mines providing the best bat hibernaculum habitat, as evidenced by bat numbers, include one each in Coos, Grafton, and Merrimack counties.

Predicted Habitat:
Caves and Mines



- The most challenging issues facing the habitat that caves and mines provide are recreational activities such as spelunking and geocaching.

TERRESTRIAL HABITAT:

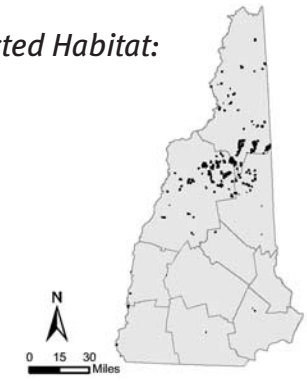
Cliffs

Important Wildlife: golden eagle, peregrine falcon, Eastern small-footed bat

Natural Communities: Alpine cliff, Appalachian oak - pine rocky ridge, Circumneutral rocky ridge, Cliff seep, Lowland acidic cliff, Lowland circumneutral cliff, Montane acidic cliff, Montane circumneutral cliff, Red spruce - heath - cinquefoil rocky ridge

- Predicted cliff habitat in New Hampshire includes 316 sites and covers 2,350 ha (<1%) of New Hampshire's area, primarily in Carroll, Coos, and Grafton counties.
- The majority of New Hampshire's cliffs are protected from some human activities by public ownership (66% U.S. Forest Service, 23% New Hampshire Division of Parks and Recreation).
- The best habitat for cliff-nesting raptors, as evidenced by Peregrine Falcon use during the past 25 years, includes 5 sites in Carroll County, 4 sites in Coos County, and 7 sites in Grafton County.
- The most challenging issues facing cliff habitat for nesting birds and plant communities are recreational activities such as hiking and rock climbing.
- Approximately 2,301 ha or 98% of the land area in Cliff habitat is more than 400 feet from roads and other forms of urban development.

Predicted Habitat:
Cliffs



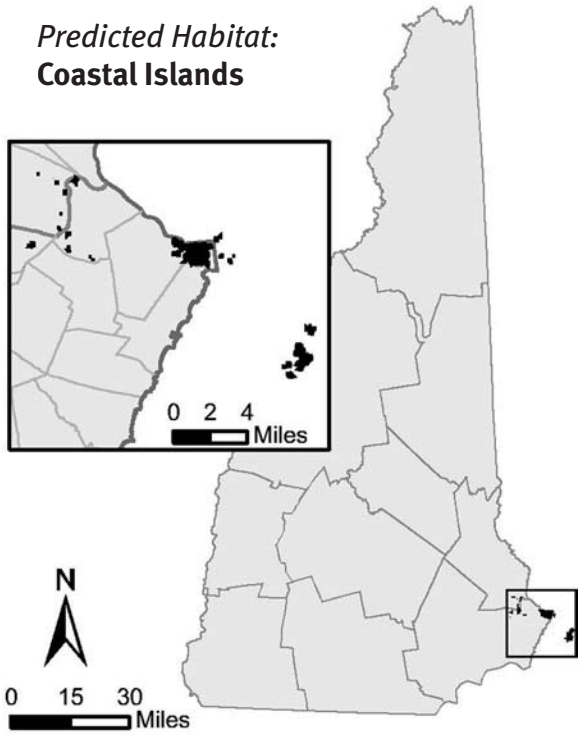
TERRESTRIAL HABITAT:

Coastal Islands

Important Wildlife: Arctic tern, black guillemot, common tern, least tern, purple sandpiper, roseate tern, migrating/wintering birds

Natural Communities: Coastal rocky headland, Coastal shoreline strand/swale, Highbush blueberry - winterberry shrub thicket, Maritime intertidal rocky shore, Maritime rocky barren, Maritime shrub thicket, Short graminoid - forb emergent marsh/mud flat

- New Hampshire's coastal islands include 4 of the 9 offshore Isles of Shoals and several small islands in Portsmouth Harbor, the Piscatqua River, and Great and Little bays, totaling 332 ha (<1%) of New Hampshire's land area.
- Two of the New Hampshire Isles of Shoals (White and Seavey) are owned by the New Hampshire Division of Parks. Seavey Island is managed by NHFG, in partnership with DRED and NHA, as an endangered species nesting area and is protected under both state and federal endangered species laws. In Great Bay, Hen Island is owned by the Town of Newington, Goat Island is owned by NHFG and Fox Island is within the Great Bay National Wildlife Refuge.
- Some of New Hampshire's most pristine coastal island habitat exists on the Isles of Shoals, particularly on Seavey Island, which is being managed as endangered species nesting habitat.
- The most challenging issues facing coastal island habitat and seabird communities are over-populated and introduced predators.
- Approximately 156 ha or 47% of the coastal island land area is more than 400 feet from roads and other forms of urban development.



TERRESTRIAL HABITAT:

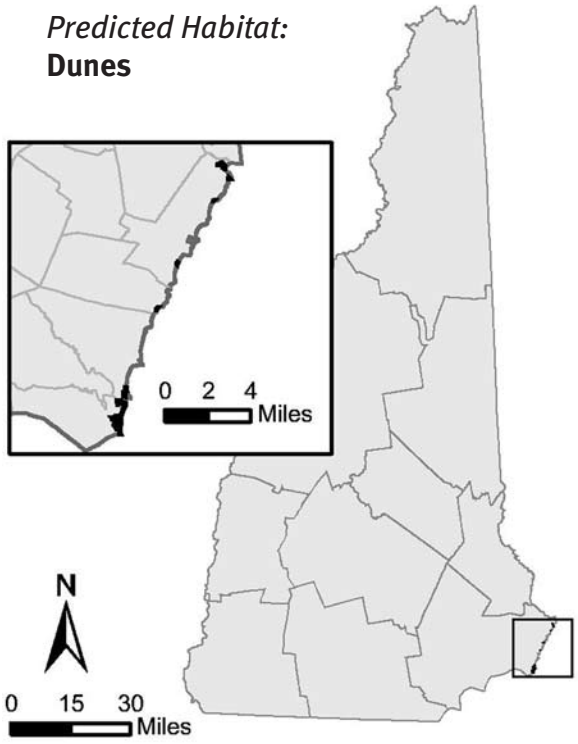
Dunes

Important Wildlife: horned lark, least tern, piping plover, semipalmated sandpiper, migrating/wintering birds

Natural Communities: Bayberry - beach plum maritime shrubland, Beach grass grassland, Coastal interdunal marsh/swale, Coastal shoreline strand/swale, Maritime wooded dune

- Coastal dunes now cover slightly more than 69 ha in New Hampshire, <1% of New Hampshire's area. Coastal dunes are located entirely in Rockingham County, in Hampton, Rye, and Seabrook.
- New Hampshire's remaining coastal dunes are protected from some human activities by various federal and state regulations and by public ownership (state and municipal).
- The best remaining coastal dunes are located at the Seabrook Town Beach (48 ha) and Hampton Beach State Park (13 ha).
- The most challenging issues facing dune habitat are recreational activities, oil spills, and rising sea level resulting from climate change. Dunes are one of the most at-risk habitats in New Hampshire.
- Approximately 16 ha or 20% of the Dune land area is more than 400 feet from roads and other forms of urban development.

Predicted Habitat:
Dunes



TERRESTRIAL HABITAT:

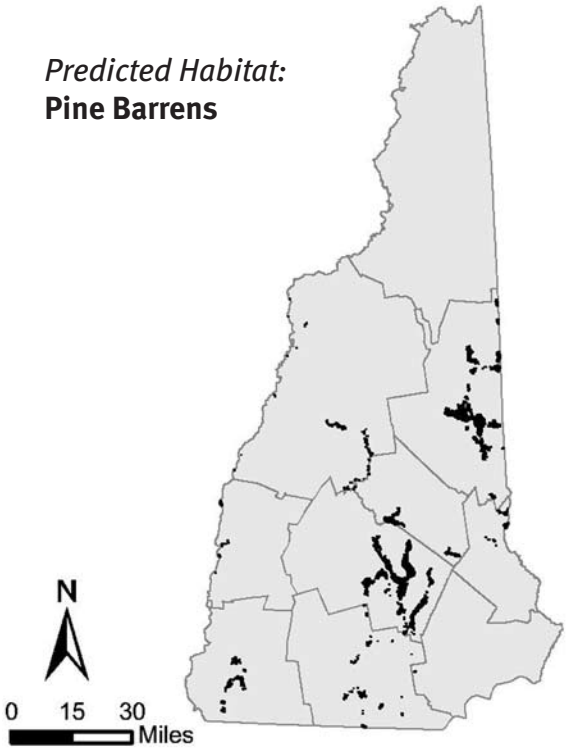
Pine Barrens

Important Wildlife: barrens xylotype, black racer, broad-lined catopyrrha, common nighthawk, cora moth, Eastern box turtle, Eastern hognose snake, Eastern towhee, Fowler's toad, frosted elfin butterfly, Karner blue butterfly, New England cottontail, persius duskywing, phyllira tiger moth, pine barrens zanclognatha moth, pine pinion moth, sleepy duskywing, smooth green snake, whip-poor-will, white-tailed deer*, barrens itame

**Big game species addressed in Big Game Plan Management Plan*

Natural Communities: Dry Appalachian oak - hickory forest, Dry red oak - white pine forest, Dry river bluff, Mixed pine - red oak woodland, Pitch pine - Appalachian oak - heath forest, Pitch pine - scrub oak woodland, Red pine - white pine - balsam fir forest

- Predicted pine barrens habitat in New Hampshire covers 9,988 (<1%) of New Hampshire's area, located primarily in Carroll and Merrimack counties.
- Approximately 227 ha (560 ac) of the remnant Concord pine barrens is protected through the Concord Municipal Airport Development and Conservation Management Agreement (2000). Approximately 30% of the remaining Ossipee pine barrens are in conservation ownership.
- Concord pine barrens have the highest known density of rare plants and animals, Ossipee pine barrens are least fragmented and most extensive.
- Approximately 5,583 ha or 56% of pine barrens habitat are more than 400 feet from roads and other forms of urban development.



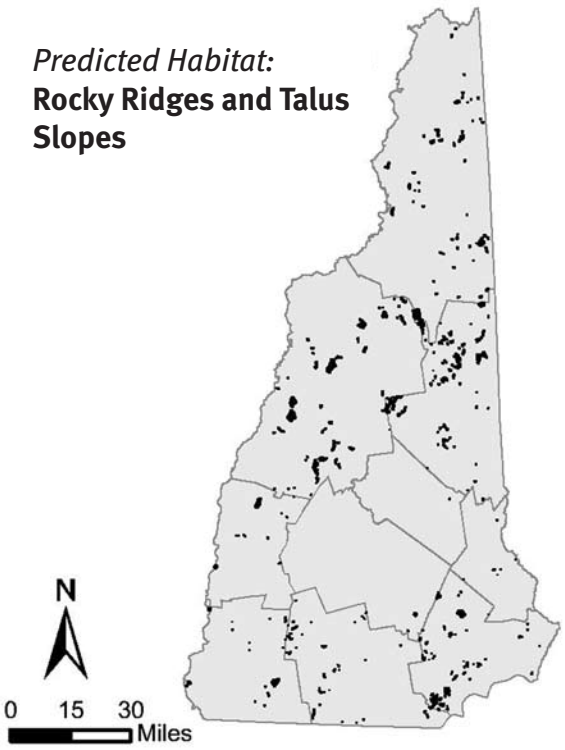
TERRESTRIAL HABITAT:

Rocky Ridges and Talus Slopes

Important Wildlife: black bear*, black racer, bobcat, common nighthawk, timber rattlesnake

**Big game species addressed in Big Game Plan Management Plan*

Natural Communities: Appalachian oak - pine rocky ridge, Chestnut oak forest/woodland, Dry Appalachian oak - hickory forest, Jack pine rocky ridge woodland, Montane acidic cliff, Montane heath woodland, Red oak - ironwood - Pennsylvania sedge woodland, Red pine rocky ridge, Red spruce - heath - cinquefoil rocky ridge, Alpine/subalpine pond, Chestnut oak forest/woodland, Montane landslide, Montane lichen talus barren, Red oak - black birch wooded talus, Red oak - hickory wooded talus, Red oak - hickory wooded talus, Red oak - ironwood - Pennsylvania sedge woodland, Rich Appalachian oak rocky woods, Rich mesic forest, Rich red oak rocky woods, Semi-rich Appalachian oak - sugar maple forest, Semi-rich mesic sugar maple forest, Spruce - birch - mountain maple wooded talus, Subalpine cold-air talus barren, Temperate lichen talus barren



- Predicted rocky ridge and talus slope habitat in New Hampshire includes 11,351 ha (0.5%) of New Hampshire's area primarily in Carroll, Coos, and Grafton counties.
- Much (57%) of New Hampshire's mapped rocky ridge and talus slope habitat occurs on conservation lands, including the White Mountain National Forest and private lands under conservation easements.
- Extensive talus slopes occur on Cannon Mountain and in Zealand Notch in Grafton County and on Magalloway Mountain in Coos County. Exemplary rocky ridges occur in Conway in Carroll County and in Benton, Grantham, and Rumney in Grafton County.
- The most challenging issues facing rocky ridges and talus slopes are hiking and climbing.
- Approximately 10,871 ha or 96% of the rocky ridge and talus slope habitat are more than 400 feet from roads and other forms of urban development.

WETLAND HABITAT:

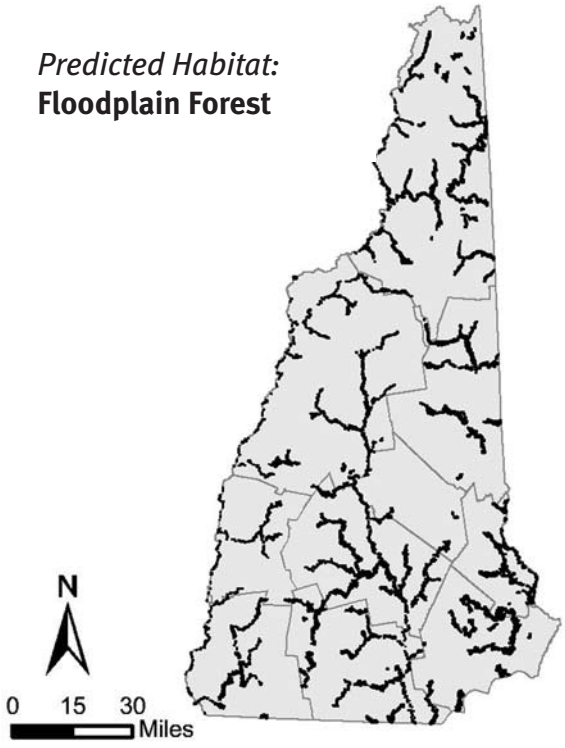
Floodplain Forest

Important Wildlife: American woodcock, Blanding's turtle, cerulean warbler, Cooper's hawk, Eastern red bat, Jefferson salamander, mink frog, migrating/wintering birds, Northern leopard frog, red shouldered hawk, ribbon snake, silver-haired bat, spotted turtle, veery, white-tailed deer*, wood thrush, wood turtle, Canada warbler

**Big game species addressed in Big Game Plan Management Plan*

Natural Communities: Alder - dogwood - arrowwood alluvial thicket, Alder alluvial shrubland, Alluvial mixed shrub thicket, Aquatic bed, Balsam fir floodplain/silt plain, Basswood - white ash - black maple floodplain forest, Blue-joint - goldenrod - virgin's bower riverbank/floodplain, Herbaceous riverbank/floodplain, Herbaceous/wooded riverbank/floodplain, Meadowsweet alluvial thicket, Oxbow buttonbush swamp, Oxbow marsh, Red maple floodplain forest, Riverbank/floodplain fern glade, Silver maple - false nettle - sensitive fern floodplain forest, Silver maple - wood nettle - ostrich fern floodplain forest, Sugar maple - ironwood - short husk floodplain forest, Sugar maple - silver maple - white ash floodplain forest, Swamp white oak floodplain forest, Sycamore floodplain forest

- New Hampshire's predicted floodplain forests cover approximately 42,950 ha (1.9%) of New Hampshire's land area, and are distributed widely across the state in association with larger rivers.
- Approximately 11.6% of New Hampshire's floodplain area is under some form of protection.
- The most extensive montane/near-boreal floodplain occurs in Coos County in the Upper Ammonoosuc River drainage; the most extensive major river silver maple floodplain occurs in Coos County in the Middle Androscoggin River watershed; and the most extensive temperate minor river floodplain occurs in Strafford County in the Lamprey River watershed.



- The most challenging issue facing floodplain forests are human development and transportation infrastructure.
- Approximately 33,191 ha or 73% of floodplain forests are more than 400 feet from roads and other forms of urban development.

WETLAND HABITAT:

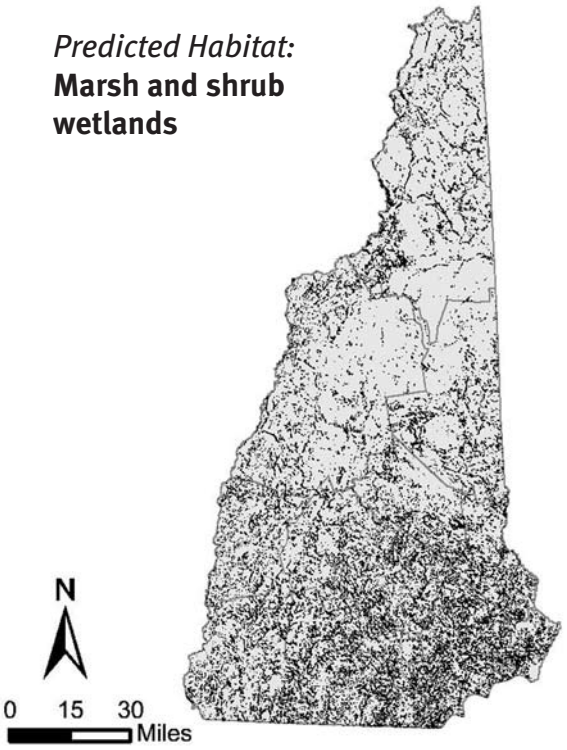
Marsh and Shrub Wetlands

Important Wildlife: American bittern, American black duck, American woodcock, banded sunfish, blue-spotted salamander, common moorhen, Eastern red bat, Fowler's toad, golden-winged warbler, great blue heron, Jefferson salamander, least bittern, mink frog, moose*, New England cottontail, migrating/wintering birds, Northern harrier, Northern leopard frog, osprey, pied-billed grebe, red shouldered hawk, ribbon snake, ringed boghaunter, rusty blackbird, sedge wren, silver-haired bat, smooth green snake, spotted turtle, Blanding's turtle

**Big game species addressed in Big Game Plan Management Plan*

Natural Communities: Alder - dogwood - arrow-wood alluvial thicket, Alder alluvial shrubland, Alluvial mixed shrub thicket, Aquatic bed, Bulblet umbrella-sedge open sandy pond shore, Buttonbush basin swamp, Cattail marsh, Deep emergent marsh - aquatic bed, Herbaceous seepage marsh, Highbush blueberry - winterberry shrub thicket, Hudsonia inland beach strand, Meadow beauty sand plain marsh, Meadowsweet - robust graminoid sand plain marsh, Meadowsweet alluvial thicket, Medium-depth emergent marsh, Mixed tall graminoid - scrub-shrub marsh, Montane sandy basin marsh, Northern medium sedge meadow marsh, Peaty marsh, Pitch pine - heath swamp, Red maple - Sphagnum basin swamp, Seasonally flooded boreal swamp, Seasonally flooded red maple swamp, Sharp-flowered manna-grass shallow peat marsh, Short graminoid - forb emergent marsh/mud flat, Spike-rush - floating-leaved aquatic mud flat, Swamp white oak basin swamp, Sweet gale - speckled alder shrub thicket, Tall graminoid emergent marsh, Three-way sedge - manna-grass mud flat marsh, Twig-rush sandy turf pond shore, Water lobelia aquatic sandy pond shore

- Predicted marsh and shrub wetlands in New Hampshire cover 57,495 ha (2.4%) of New Hampshire's area (unbuffered), and are broadly distributed.



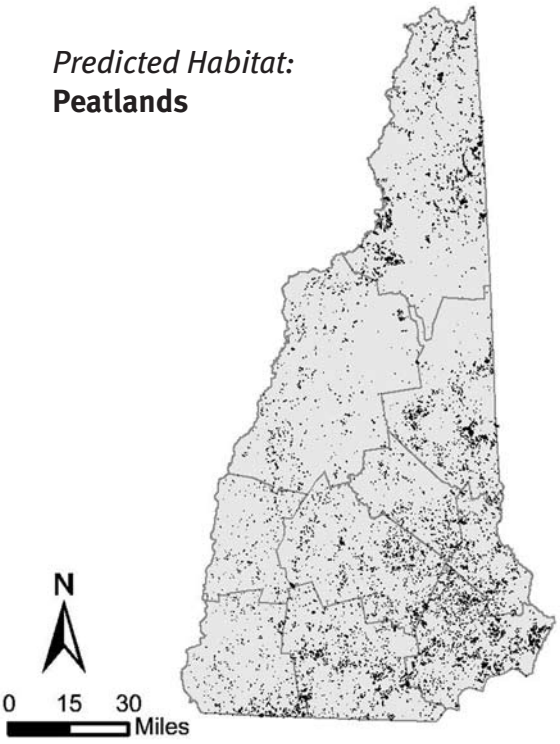
- Of land within 250 m of mapped marsh and shrub wetlands, 10% is in conservation ownership and 3% is under conservation easement.
- Some of New Hampshire's most extensive marsh and shrub wetland complexes are located in southern New Hampshire, including Belknap and Rockingham counties.
- The most challenging issues facing many wildlife species that depend on marsh and shrub wetlands are fragmentation, transportation infrastructure, development of surrounding uplands and invasive species.
- Approximately 375,779 ha or 45% of buffered (250 m) marsh and shrub wetlands are more than 400 feet from by roads and other forms of urban development.

WETLAND HABITAT:

Peatlands

Important Wildlife: Blanding's turtle, Eastern towhee, mink frog, Northern bog lemming, palm warbler, ribbon snake, ringed boghaunter, rusty blackbird, spotted turtle, spruce grouse

Natural Communities: Acidic northern white cedar swamp, Atlantic white cedar - giant rhododendron swamp, Atlantic white cedar - yellow birch - pepperbush swamp, Atlantic white cedar swamp, Black gum - red maple basin swamp, Black spruce - larch swamp, Calcareous sedge - moss fen, Hemlock - cinnamon fern forest, Highbush blueberry - mountain holly wooded fen, Highbush blueberry - winterberry shrub thicket, Inland Atlantic white cedar swamp, Northern hardwood - black ash - conifer swamp, Northern white cedar - balsam fir swamp, Northern white cedar - hemlock swamp, Northern white cedar swamp, Pitch pine - heath swamp, Red maple - red oak - cinnamon fern forest, Red maple - sensitive fern swamp, Red maple - Sphagnum basin swamp, Red maple - Sphagnum basin swamp, Red spruce swamp, Seasonally flooded Atlantic white cedar swamp, Seasonally flooded red maple swamp, Speckled alder wooded fen, Swamp white oak basin swamp, Sweet pepperbush wooded fen, Winterberry - cinnamon fern wooded fen, Bog rosemary - sweet gale - sedge fen, Calcareous sedge - moss fen, Circumneutral - calcareous flark, Floating marshy peat mat, Hairy-fruited sedge - sweet gale fen, Highbush blueberry - sweet gale - meadowsweet shrub thicket, Large cranberry - short sedge moss lawn, Leather-leaf - black spruce bog, Leather-leaf - sheep laurel dwarf shrub bog, Liverwort/horned bladderwort mud-bottom, Marshy moat, Montane alder - heath shrub thicket, Montane heath woodland, Montane sloping fen, Northern white cedar circumneutral string, Speckled alder - lake sedge intermediate fen, Speckled alder wooded fen, Sphagnum rubellum - small cranberry moss carpet, Subalpine sliding fen, Sweet gale - meadowsweet - tussock sedge fen, Sweet pepperbush wooded fen, Water willow - Sphagnum lagg, Water willow - Sphagnum lagg, Wet alpine/subalpine bog, Winterberry - cinnamon fern wooded fen, Wooded subalpine bog/heath snowbank



- Predicted peatlands cover 23,350 ha (1%) of New Hampshire's total land area (unbuffered), and clusters are widely distributed across the state.
- Of land within 250 m of predicted peatlands, 16% is under some form of protection.
- New Hampshire's largest peatland complexes occur in Carroll county.
- The most challenging issues facing peatlands habitat are development, altered hydrology, non-point source pollutants, and unsustainable forest harvesting.
- Approximately 206,556 ha or 75% of buffered (250 m) peatlands are more than 400 feet from roads and other forms of urban development.

WETLAND HABITAT:

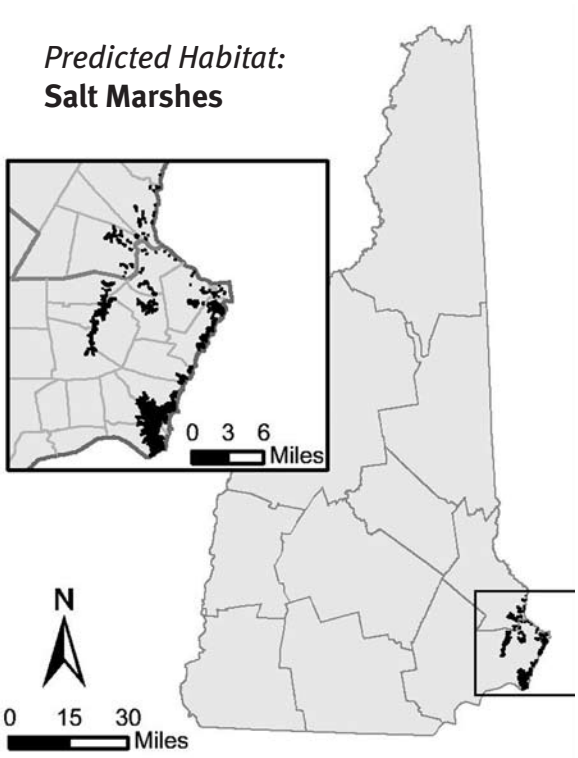
Salt Marshes

Important Wildlife: American black duck, common tern, great blue heron, Nelson's sharp-tailed sparrow, Northern harrier, salt marsh sharp-tailed sparrow, seaside sparrow, semipalmated sandpiper, white-tailed deer*, willet, migrating/wintering birds

**Big game species addressed in Big Game Plan Management Plan*

Natural Communities: Brackish marsh, Coastal salt pond marsh, Coastal shoreline strand/swale, High brackish tidal riverbank marsh, High salt marsh, Intertidal rocky shore, Low brackish tidal riverbank marsh, Low salt marsh, Saline/brackish intertidal flat, Salt pannes and pools

- New Hampshire's remaining salt marsh habitat includes approximately 2,274 ha, approximately (<0.1%) of New Hampshire's area, and 50-70% of the state's original salt marsh. All New Hampshire's salt marshes are located in Rockingham County.
- All New Hampshire salt marshes are protected from many human activities by Department of Environmental Services regulations. Some marshes, as well as some areas of the Hampton Marsh complex, are further protected through conservation easements.
- The best and most extensive salt marsh habitat in the state occurs in the Hampton Marsh complex, located in Hampton, Seabrook, and North Hampton.
- The most challenging issues facing salt marshes are human development and altered hydrology.
- Approximately 1858 ha or 82% of the land area in salt marsh habitat are more than 400 feet from roads and other forms of urban development.



WETLAND HABITAT:

Vernal Pools

Important Wildlife: Blanding's turtle, blue-spotted salamander, Jefferson salamander, marbled salamander, ribbon snake, spotted turtle

Natural Communities: Vernal floodplain pool, Vernal woodland pool , Meadow beauty sand plain marsh, Meadowsweet - robust graminoid sand plain marsh, Montane sandy basin marsh, Sharp-flowered manna-grass shallow peat marsh, Spike-rush - floating-leaved aquatic mud flat, Three-way sedge - manna-grass mud flat marsh, Highbush blueberry - winterberry shrub thicket

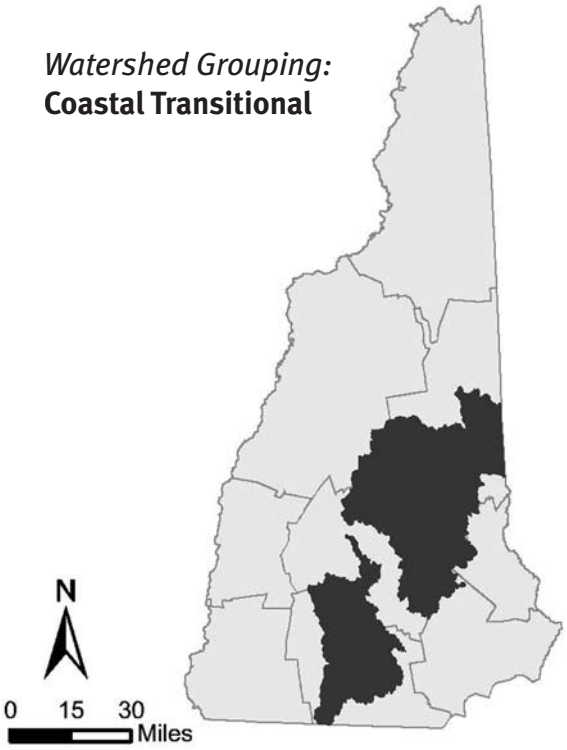
- Vernal pools occur at scattered locations throughout New Hampshire.
- The proportion of New Hampshire's vernal pools in conservation ownership is unknown.
- Many of the rare species that depend on vernal pools are restricted to southern New Hampshire.
- The most important wildlife values of vernal pools are provision of critical foraging and breeding habitat for a number of reptiles, amphibians, and invertebrates.
- The most challenging issues facing vernal pool habitats are human development and transportation infrastructure, wetland filling, altered hydrology, and loss or degradation of surrounding upland habitats.

WATERSHED GROUPING:

Coastal Transitional Watersheds

Important Wildlife: American eel, Atlantic salmon, bald eagle, banded sunfish, Blanding's turtle, bridle shiner, brook floater, burbot, common loon, Eastern brook trout, lake trout, lake whitefish, Northern leopard frog, rainbow smelt, round whitefish, sea lamprey, slimy sculpin, spotted turtle, Sunapee trout, swamp darter, tessellated darter, wood turtle, migrating/wintering birds, osprey

Natural Communities: Acidic riverbank outcrop, Acidic riverside seep, Alder - dogwood - arrowwood alluvial thicket, Alder alluvial shrubland, Alluvial mixed shrub thicket, Aquatic bed, Blue-joint - goldenrod - virgin's bower riverbank/floodplain, Boulder - cobble river channel, Calcareous riverside seep, Cattail marsh, Circumneutral riverbank outcrop, Cobble - sand river channel, Deep emergent marsh - aquatic bed, Dwarf cherry river channel, Herbaceous low riverbank, Herbaceous riverbank/floodplain, Herbaceous sandy river channel, Herbaceous/wooded riverbank/floodplain, Hudsonia - silverling river channel, Meadowsweet alluvial thicket, Medium-depth emergent marsh, Riverbank/floodplain fern glade, Short graminoid - forb emergent marsh/mud flat, Twisted sedge low riverbank, Willow low riverbank, Eelgrass bed, Oyster bed, Saline/brackish subtidal channel/bay bottom, Tidal creek bottom



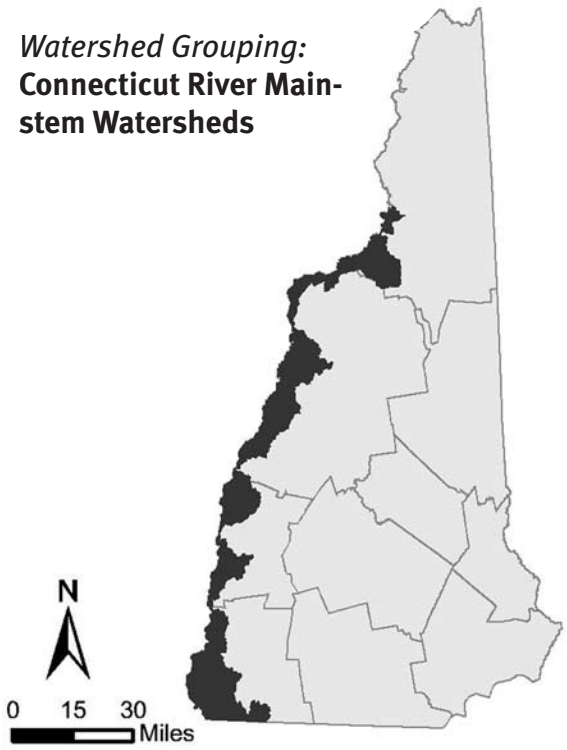
- Coastal Transitional Watersheds comprise approximately 470,617 ha or 19.6% of New Hampshire's total area and 38,675 ha or 42.8% of New Hampshire's surface waters primarily in Hillsboro, Merrimack, Belknap, Carroll counties.
- Approximately 59,359 ha or 13.7% the land area in Coastal Transitional Watersheds is under some form of protection.
- The most challenging issue facing Coastal Transitional Watersheds is introduced species.
- Approximately 300,358 ha or 69.5% of the land area in Coastal Transitional Watersheds are more than 400 feet from roads and other forms of development.

WATERSHED GROUPING:

Connecticut River Mainstem Watersheds

Important Wildlife: American eel, American shad, Atlantic salmon, bald eagle, blueback herrring, burbot, common loon, dwarf wedgemussel, Eastern brook trout, Eastern pond mussel, Northern leopard frog, osprey, sea lamprey, slimy sculpin, tessellated darter, wood turtle, migrating/wintering birds, cobblestone tiger beetle

Natural Communities: Acidic riverbank outcrop, Acidic riverside seep, Alder - dogwood - arrowwood alluvial thicket, Alder alluvial shrubland, Alluvial mixed shrub thicket, Aquatic bed, Blue-joint - goldenrod - virgin's bower riverbank/floodplain, Boulder - cobble river channel, Calcareous riverside seep, Cattail marsh, Circumneutral riverbank outcrop, Cobble - sand river channel, Deep emergent marsh - aquatic bed, Dwarf cherry river channel, Herbaceous low riverbank, Herbaceous riverbank/floodplain, Herbaceous sandy river channel, Herbaceous/wooded riverbank/floodplain, Hudsonia - silverling river channel, Meadowsweet alluvial thicket, Medium-depth emergent marsh, Riverbank/floodplain fern glade, Short graminoid - forb emergent marsh/mud flat, Twisted sedge low riverbank, Willow low riverbank, Eelgrass bed, Oyster bed, Saline/brackish subtidal channel/bay bottom, Tidal creek bottom



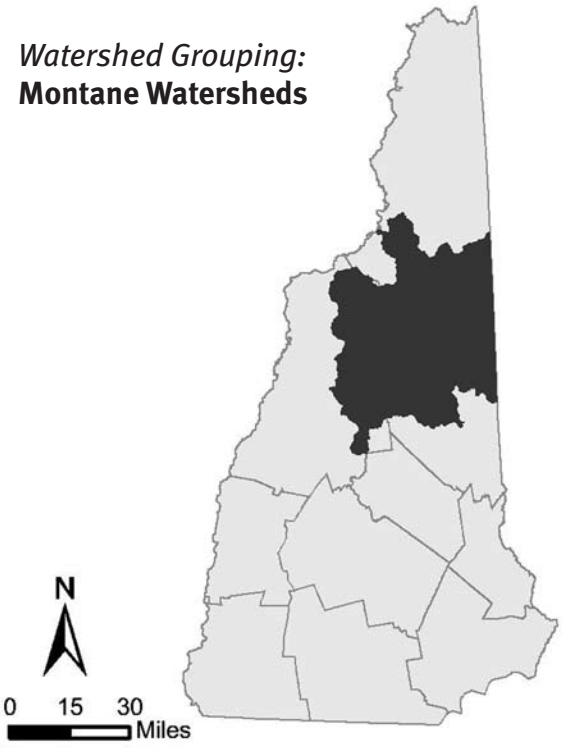
- Connecticut River mainstem watersheds comprise approximately 217,618 ha or 9.0% of New Hampshire's total area and 7,573 ha or 8.4% of New Hampshire's surface waters primarily in Coos, Grafton, Sullivan, Cheshire counties.
- Approximately 32,698 ha or 15.6% the land area in Connecticut River mainstem watersheds is under some form of protection.
- The most challenging issues facing the Connecticut River mainstem watersheds are non-point source pollution and agriculture.
- Approximately 166,556 ha or 79.3% of the land area in Connecticut River mainstem watersheds are more than 400 feet from roads and other forms of urban development.

WATERSHED GROUPING:

Montane Watersheds

Important Wildlife: Atlantic salmon, burbot, Eastern brook trout, mink frog, migrating/wintering birds, Northern leopard frog, slimy sculpin, wood turtle, rainbow smelt

Natural Communities: Acidic riverbank outcrop, Acidic riverside seep, Alder - dogwood - arrowwood alluvial thicket, Alder alluvial shrubland, Alluvial mixed shrub thicket, Aquatic bed, Blue-joint - goldenrod - virgin's bower riverbank/floodplain, Boulder - cobble river channel, Calcareous riverside seep, Cattail marsh, Circumneutral riverbank outcrop, Cobble - sand river channel, Deep emergent marsh - aquatic bed, Dwarf cherry river channel, Herbaceous low riverbank, Herbaceous riverbank/floodplain, Herbaceous sandy river channel, Herbaceous/wooded riverbank/floodplain, Hudsonia - silverling river channel, Meadowsweet alluvial thicket, Medium-depth emergent marsh, Riverbank/floodplain fern glade, Short graminoid - forb emergent marsh/mud flat, Twisted sedge low riverbank, Willow low riverbank, Eelgrass bed, Oyster bed, Saline/brackish subtidal channel/bay bottom, Tidal creek bottom



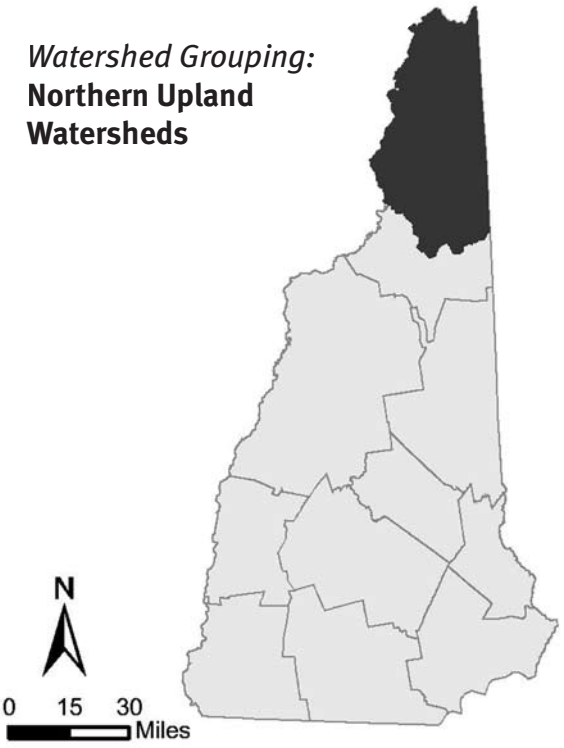
- Montane Watersheds comprise approximately 423,615 ha or 17.6% of New Hampshire's total area and 3,415 ha or 3.8% of New Hampshire's surface waters primarily in Coos, Grafton, Carroll counties.
- Approximately 273,325 ha or 65.0% the land area in Montane Watersheds is under some form of protection.
- No critical threats to Montane Watersheds have been identified. However, acid deposition and non-point source pollution are serious and likely to become more problematic over time.
- Approximately 372,010 ha or 88.5% of the land area in Montane Watersheds are more than 400 feet from roads and other forms of urban development.

WATERSHED GROUPING:

Northern Upland Watersheds

Important Wildlife: American eel, Atlantic salmon, bald eagle, burbot, common loon, dwarf wedgemussel, Eastern brook trout, finescale dace, lake trout, lake whitefish, mink frog, Northern leopard frog, Northern redbelly dace, osprey, round whitefish, slimy sculpin, tessellated darter, wood turtle, migrating/wintering birds, rainbow smelt

Natural Communities: Acidic riverbank outcrop, Acidic riverside seep, Alder - dogwood - arrowwood alluvial thicket, Alder alluvial shrubland, Alluvial mixed shrub thicket, Aquatic bed, Blue-joint - goldenrod - virgin's bower riverbank/floodplain, Boulder - cobble river channel, Calcareous riverside seep, Cattail marsh, Circumneutral riverbank outcrop, Cobble - sand river channel, Deep emergent marsh - aquatic bed, Dwarf cherry river channel, Herbaceous low riverbank, Herbaceous riverbank/floodplain, Herbaceous sandy river channel, Herbaceous/wooded riverbank/floodplain, Hudsonia - silverling river channel, Meadowsweet alluvial thicket, Medium-depth emergent marsh, Riverbank/floodplain fern glade, Short graminoid - forb emergent marsh/mud flat, Twisted sedge low riverbank, Willow low riverbank, Eelgrass bed, Oyster bed, Saline/brackish subtidal channel/bay bottom, Tidal creek bottom



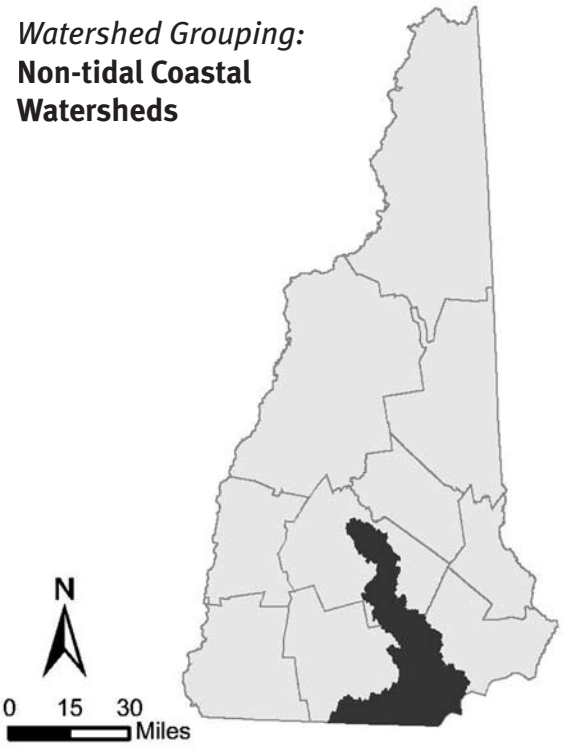
- Northern Upland Watersheds comprise approximately 332,247 ha or 13.8% of New Hampshire's total area and 8,159 ha or 9.0% of New Hampshire's surface waters primarily in Coos County.
- Approximately 73,373 ha or 22.6% the land area in Northern Upland Watersheds is under some form of protection.
- No critical threats to Northern Upland Watersheds have been identified. However, development and altered hydrology are likely to become more problematic over time.
- Approximately 304,191 ha or 93.9% of the land area in Northern Upland Watersheds are more than 400 feet from roads and other forms of urban development.

WATERSHED GROUPING:

Non-tidal Coastal Watersheds

Important Wildlife: alewife, American brook lamprey, American eel, American shad, Atlantic salmon, Atlantic sturgeon, bald eagle, banded sunfish, Blanding's turtle, blueback herrring, bridle shiner, brook floater, burbot, common loon, Eastern brook trout, Eastern pond mussel, rainbow smelt, redfin pickerel, sea lamprey, shortnose sturgeon, slimy sculpin, spotted turtle, swamp darter, tessellated darter, wood turtle, migrating/wintering birds, osprey

Natural Communities: Acidic riverbank outcrop, Acidic riverside seep, Alder - dogwood - arrowwood alluvial thicket, Alder alluvial shrubland, Alluvial mixed shrub thicket, Aquatic bed, Blue-joint - goldenrod - virgin's bower riverbank/floodplain, Boulder - cobble river channel, Calcareous riverside seep, Cattail marsh, Circumneutral riverbank outcrop, Cobble - sand river channel, Deep emergent marsh - aquatic bed, Dwarf cherry river channel, Herbaceous low riverbank, Herbaceous riverbank/floodplain, Herbaceous sandy river channel, Herbaceous/wooded riverbank/floodplain, Hudsonia - silverling river channel, Meadowsweet alluvial thicket, Medium-depth emergent marsh, Riverbank/floodplain fern glade, Riverbank/floodplain fern glade, Short graminoid - forb emergent marsh/mud flat, Twisted sedge low riverbank, Willow low riverbank, Eelgrass bed, Oyster bed, Saline/brackish subtidal channel/bay bottom, Tidal creek bottom



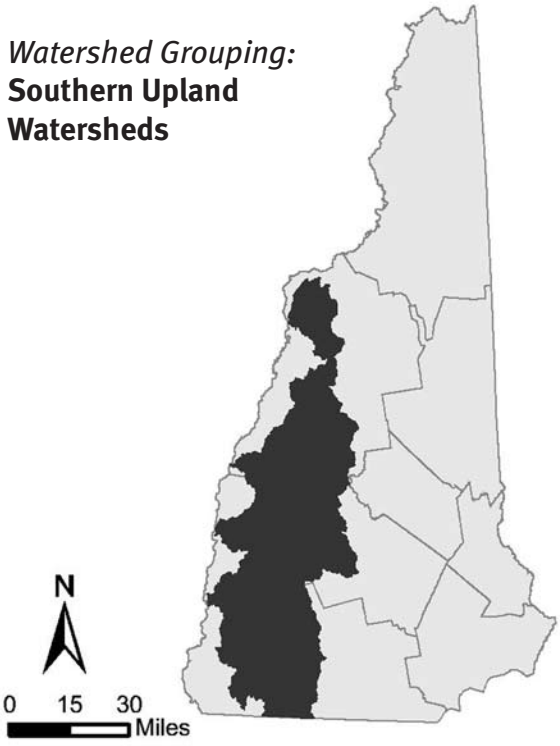
- Non-Tidal Coastal Watersheds comprise approximately 176,078 ha or 7.3% of New Hampshire's total area and 5,940 ha or 6.6% of New Hampshire's surface waters primarily in Hillsboro, Merrimack, Rockingham counties.
- Approximately 18,769 ha or 11.0% the land area in Non-Tidal Coastal Watersheds is under some form of protection.
- The most challenging issues facing non-tidal coastal watersheds are development and non-point source pollution.
- Approximately 91,575 ha or 53.8% of the land area in Non-Tidal Coastal Watersheds are more than 400 feet from roads and urban development.

WATERSHED GROUPING:

Southern Upland Watersheds

Important Wildlife: Atlantic salmon, bald eagle, banded sunfish, brook floater, burbot, common loon, dwarf wedgemussel, Eastern brook trout, Eastern pond mussel, lake trout, Northern redbelly dace, osprey, round whitefish, slimy sculpin, spotted turtle, Sunapee trout, tessellated darter, wood turtle, migrating/wintering birds, rainbow smelt

Natural Communities: Acidic riverbank outcrop, Acidic riverside seep, Alder - dogwood - arrowwood alluvial thicket, Alder alluvial shrubland, Alluvial mixed shrub thicket, Aquatic bed, Blue-joint - goldenrod - virgin's bower riverbank/floodplain, Boulder - cobble river channel, Calcareous riverside seep, Cattail marsh, Circumneutral riverbank outcrop, Cobble - sand river channel, Deep emergent marsh - aquatic bed, Dwarf cherry river channel, Herbaceous low riverbank, Herbaceous riverbank/floodplain, Herbaceous sandy river channel, Herbaceous/wooded riverbank/floodplain, Hudsonia - silverling river channel, Meadowsweet alluvial thicket, Medium-depth emergent marsh, Riverbank/floodplain fern glade, Short graminoid - forb emergent marsh/mud flat, Twisted sedge low riverbank, Willow low riverbank, Eelgrass bed, Oyster bed, Saline/brackish subtidal channel/bay bottom, Tidal creek bottom



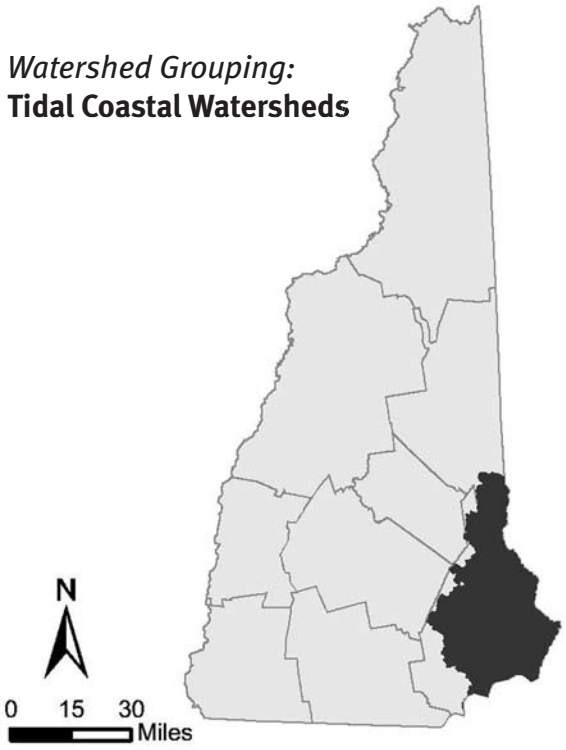
- Southern Upland Watersheds comprise approximately 552,062 ha or 23.0% of New Hampshire's total area and 16,295 ha or 18.0% of New Hampshire's surface waters primarily in Cheshire, Hillsboro, Sullivan, Merrimack, Grafton counties.
- Approximately 98,583 ha or 18.4% the land area in Southern Upland Watersheds is under some form of protection.
- No critical threats to Southern Upland Watersheds have been identified. However, acid deposition and non-point source pollution are likely to become more problematic over time.
- Approximately 417,284 ha or 77.9% of the land area in Southern Upland Watersheds are more than 400 feet from roads and other forms of development.

WATERSHED GROUPING:

Tidal Coastal Watersheds

Important Wildlife: alewife, American brook lamprey, American eel, American shad, Atlantic salmon, Atlantic sturgeon, bald eagle, banded sunfish, Blanding's turtle, blueback herrring, bridle shiner, brook floater, burbot, common loon, Eastern brook trout, Eastern pond mussel, Northern leopard frog, rainbow smelt, redfin pickerel, sea lamprey, shortnose sturgeon, spotted turtle, swamp darter, wood turtle, migrating/wintering birds, osprey

Natural Communities: Acidic riverbank outcrop, Acidic riverside seep, Alder - dogwood - arrowwood alluvial thicket, Alder alluvial shrubland, Alluvial mixed shrub thicket, Aquatic bed, Blue-joint - goldenrod - virgin's bower riverbank/floodplain, Boulder - cobble river channel, Boulder - cobble river channel, Calcareous riverside seep, Cattail marsh, Circumneutral riverbank outcrop, Cobble - sand river channel, Deep emergent marsh - aquatic bed, Dwarf cherry river channel, Herbaceous low riverbank, Herbaceous riverbank/floodplain, Herbaceous sandy river channel, Herbaceous/wooded riverbank/floodplain, Hudsonia - silverling river channel, Meadowsweet alluvial thicket, Medium-depth emergent marsh, Riverbank/floodplain fern glade, Short graminoid - forb emergent marsh/mud flat, Twisted sedge low riverbank, Willow low riverbank, Eelgrass bed, Oyster bed, Saline/brackish subtidal channel/bay bottom, Tidal creek bottom



- Tidal coastal watersheds comprise approximately 233,496 ha or 9.7% of New Hampshire's total area and 10,360 ha or 11.5% of New Hampshire's surface waters primarily in Rockingham, Strafford, Carroll counties.
- Approximately 21,916 ha or 9.8% the land area in tidal coastal watersheds is protected.
- The most challenging issue facing tidal coastal watersheds is development (urbanization, habitat loss and conversion, non-point source pollution, etc.)
- Approximately 143,939 ha or 64.5% of the land area in tidal coastal watersheds are more than 400 feet from roads and other forms of urban development.

References

[1] Complex Systems Research Center, University of New Hampshire, Nov. 2004 1:24,000 water bodies, from U.S. Geological Survey digital line graph data

[2] NH Department of Transportation: SmartMap road inventory database, Dec. 2004

[3] NOAA: Environmental Sensitivity Index maps prepared in cooperation with NH Dept. of Environmental Services for oil spill response planning, Dec. 2004
Applicable only to coastal islands and dune habitat.

[4] CSRC: Conservation/Public Lands, Feb. 2005

[5] NH Dept. of Environmental Services: designated prime wetlands, Feb. 2005
Applicable only to marsh, peatland, floodplain forest

[6] NH Audubon: non-breeding bird areas, Feb. 2005
Applicable only to marsh, peatland, floodplain forest

[7] NHDES: wetlands alteration permit sites 2000-2004, Feb. 2005
Applicable only to marsh, peatland, floodplain forest

[8] NHDES: groundwater hazard inventory (project type is known threat), Nov. 2004
Applicable only to coastal islands, dunes, marsh, peatland, floodplain forest

[9] NHDES: groundwater hazard inventory (project type is potential threat), above ground storage tanks, underground storage tanks, RCRA hazardous waste generators, auto salvage yards, local source water hazard inventory, nonpoint potential pollution, NPDES outfalls, Nov. 2004
Applicable only to coastal islands, dunes, marsh, peatland, floodplain forest

[10] NHDES: lake drawdown schedule, Fall 2004
Applicable to marsh, peatland, floodplain forest

[11] NHDES: registered water users and community water supplies, Nov. 2004
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[12] NH Fish & Game Dept: statewide generalized buildout analysis, March 2005

[13] Massachusetts Technology Collaborative: wind power raster data finalized June 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, Massachusetts Technology Collaborative, and Northeast Utilities System.

[14] NH Office of Energy and Planning: NH Personal Wireless Service Facilities, 2004

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[19] Eastern Resource Office of The Nature Conservancy: ecological land units, July 2003

[20] NH Chapter of The Nature Conservancy: Integrated Fragmentation Surface for the State of New Hampshire, DRAFT July 2005

[21] NH Chapter of The Nature Conservancy/NH Natural Heritage Bureau, July 2005

[22] NHDES Watershed approach, March 2005

[23] Biodiversity Research Institute, March 2005

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Disclaimer

Most data represent stock data sets obtained from NH GRANIT, at Complex Systems Research Center, UNH. CSRC, under contract to the NH Office of Energy and Planning (OEP), and in consultation with cooperating agencies, maintains a continuing program to identify and correct errors in these data. NHOEP, CSRC, NHFG and the cooperating agencies make no claim as to the validity or reliability or to any implied uses of these data.

CHAPTER FOUR

Wildlife Risk Assessment

Overview

This chapter addresses Element 3 of the NAAT Guidelines, which requires, "descriptions of problems that may adversely affect species identified in Element 1 or their habitats, and priority research and survey efforts needed to identify factors which may assist in restoration and improved conservation of these species and habitats." New Hampshire's habitats and wildlife are affected by many challenging issues, ranging from broad-scale threats such as climate change to local-scale threats such as cessation of grassland mowing. Conservation and management programs depend on an objective assessment of the degree of risks posed to species and habitats of greatest concern.

Generally, quantitative data on factors that influence New Hampshire wildlife are lacking. The factors for which data are available are evaluated in chapter 3. This chapter is based on the results of a structured qualitative assessment of factors that influence wildlife and their habitats. Using expert opinion of regional scientists and managers, and scientific literature, New Hampshire sought to meet the following objectives:

- Describe risk factors in a consistent format
- Objectively prioritize conservation actions within and among species and habitats
- Compile an overview of challenging issues

For all habitat assessments, wildlife were assumed to be an integral part of the habitat. Therefore, in this chapter, risks to broad groups of wildlife are considered risks to the habitat at large. Thorough peer-reviewed qualitative assessments were completed for wetland and terrestrial habitats, but assessments are preliminary for aquatic habitats, since the current classification of aquatic habitats is incomplete. Peer-review was somewhat limited for many wildlife species assessments due to the limited availability of taxonomic expertise. Rather than assess threats to individual fish species with poorly known distributions, the assumption was made that these and other aquatic species are similarly influenced by threats to aquatic habitats, which were assessed by watershed group. This approach was intended to shift from a species-specific approach to a more inclusive assessment of aquatic ecosystems in New Hampshire. However, because of the volume of information available and recent initiatives to restore the Atlantic salmon and assess native eastern brook trout populations, we included an analysis of threats to these two fish species.

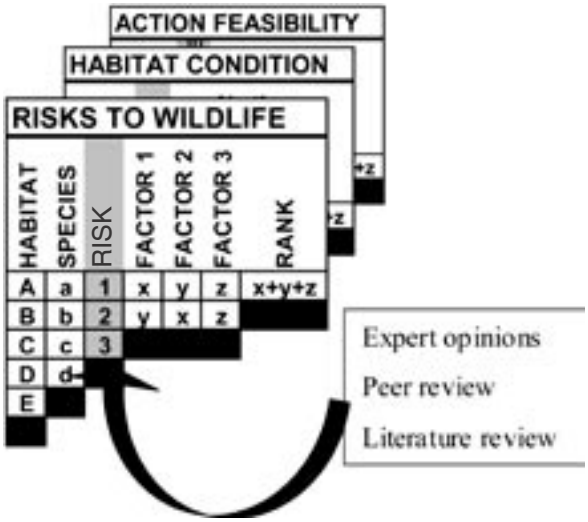

FIGURE 4-1. Risk factor ranking process. Wildlife experts identified risks to wildlife, and scored each risk based on their experience, published literature, and peer review.

Risk Assessment Results

Wildlife habitats and populations are exposed to enormous pressure from human population growth and recreational activities. Urban development is the most challenging issue for most of New Hampshire's wildlife and habitats. Many habitats are rapidly disappearing or are fragmented by roads and dams, and many ecosystems are disrupted by human activities.

Even if all the land necessary to support New Hampshire's critical populations and habitats could be protected from development, without improving air and water quality, the long-term viability of New Hampshire's wildlife will not be sustained. Runoff polluted with agrochemicals and urban waste is toxic for many species, and atmospheric pollution causes broad degradation to all habitats.

Acid deposition leaches nutrients from forest soils, and forests across the Northeast are showing signs of distress, such as compositional shifts and reduced forage quality. Unfortunately, nutrients that are being lost, like calcium, come primarily from bedrock and cannot be replaced. Acid deposition can also aggravate other environmental problems, contributing to widespread ecological damage; mercury accumulates more rapidly in wildlife under acidic conditions, even in remote and relatively unpolluted waterbodies. Mercury can migrate over the land and through forests via insects and their predators. If mercury sources can be cutrailed promptly, wildlife may recover before populations are permanently damaged.

Likewise, if climate change is not addressed, New Hampshire's wildlife and natural resources will be altered, particularly those in geographic extremes, such as mountaintops, northern lakes, and coastal islands. To prevent ultraviolet radiation, warmer temperatures, and the many attendant effects of ozone depletion, emissions must be addressed.

Risk Factor Ranking Process

All of the challenges that wildlife face can be viewed as having two aspects in common. First, each has certain "risk factors" that potentially have negative impacts on wildlife, and second, each has a series of events or an "exposure pathway" that brings a risk factor to fruition for wildlife. It is more difficult and expensive to repair the damage once it is done than it is to address risk and avoid exposure in the first place.

Addressing underlying causes or factors that pose a risk to wildlife, rather than waiting to manipulate dwindling populations or habitats after the fact, is a powerful and pre-emptive long-term solution. In chapter 2, we identified some of the wildlife and habitats that showed symptoms of declining health. We developed a structured approach to understand the most prevalent risk factors for these declines and to work toward their recovery.

Patterns of cause and effect were organized systematically to diagnose the main exposure pathways for factors that threaten wildlife. Next, species and habitat experts completed scoring forms that ranked five variables (scope, severity, timing, likelihood, and information) for each known threat. The scores given were based on strict criteria, and were subject to a peer-review process. Evidence to support or refute scores was carefully evaluated by NHFG biologists. Finally, scores were cross tabulated and summarized to clarify which sources pose the greatest risk to species and habitats, and which species and habitats are at greatest risk. The process allowed biologists to critically analyze the range of expert opinions and focus on critical problems.

For the purposes of the WAP, NHFG created a list of 18 challenging issues that are most relevant to its habitats and species of conservation concern, and conducted a risk assessment for each one. NHFG developed a two-step process to determine the applicability and severity of different risk factors within each challenging issue, using a numeric scoring system to determine rank and class for comparative purposes. Government, NGO, and academic scientists were contracted to complete the ranking process and write summaries for their species or habitat of expertise, drawing on professional experience and a review of published and unpublished sources.

The summary rank is a planning and decision-making tool, not a true quantitative measure. The purpose of the ranking process was to provide a consistent basis for comparing risk factors across all species and habitats, and for placing those factors into categories of appropriate conservation action. The ranking process formed the basis for the risk assessment summaries presented in this chapter. Although the ranking process can be somewhat subjective, each step of the process was clearly described and fully transparent, allowing NHFG to assess and revise ranks as new information emerges.

RISK FACTOR RANKING PROCESS

Step One: Risk Exposure Form

Working from a list of challenging issues provided by NHFG, experts and expert panels compiled a list of all the associated risk factors relevant to each species and habitat. The experts carefully evaluated the series of events, or exposure pathway, that may cause each factor to become a problem for wildlife.

Step Two: Rank

Risk factors from form 1 were scored and ranked, using categorical criteria to assign numeric scores (1, 2, 3, or 4) (form 2). Each risk factor received five scores for magnitude (scope and severity) and urgency (timing, likelihood, and information). These are described briefly here and more fully in Appendix M.

- Scope: Percent (%) of the statewide distribution of the species/habitat that may be exposed to the risk factor
- Severity: Degree of loss of function in the exposed population/habitat (e.g., due to stressed survival, reproduction, foraging, etc.)
- Timing: Time until exposed population begins to lose function
- Likelihood: Probability that the scope, severity, and timing of the risk factor will be realized
- Information: Quality or reliability of the evidence, experience, or factual knowledge supporting the scores provided

An overall rank was computed for each risk factor, using a formula that gave equal weight to magnitude and urgency and scaled the result to 4. Scores could range from 0.25 (if all factors were ranked as 1.0) to 4.0 (if all factors ranked as 4.0). Scores were then categorized from 1-4, with 4 indicating highest possible risk.

Step 3: Summarizing Risk to Species and Habitats

Qualitative scores and ranks were compiled in a database, collated by broad categories ("challenging issues"), submitted to wildlife biologists for final review, and edited for internal consistency. The frequency of ranked exposure pathway scores that fell into the four risk categories were tabulated by categories, following the 'maximum effects' rule as described below. Next, the average 'maximum effect' was calculated within categories. Only maximum values for affected species and habitats were included in this average, so it provides a reasonable index of the 'Intensity' of a given risk factor. Finally, the cumulative effect of all the exposure pathways scored was summed within each category, and divided by the total number of all the species/habitats that were assessed to provide an index of the 'Cumulative' effect of the category. Results are shown in table 4-1 and table 4-2. To avoid misinterpretation, ranks are not shown. Summaries of the major exposure pathways were written up in detail and grouped under broad categories for analysis.

Step 4: Summarizing Challenging Issues

Ranks and score were summarized to provide an index of relative risk to species and habitats. First, the frequency of ranked exposure pathway scores that fell into the four risk categories were tabulated by species and habitat. For any issue, only the 'maximum effects' to species and habitats were tallied. Next, the average value of the top scoring exposure pathways was recorded for each species (top 3 exposure pathways) and habitat (top 6). Only the top values were used because the number of exposure pathways varied across species and habitats. Finally, the cumulative effect of all the exposure pathways was summed for each species and habitat. Results are shown in table 4-3.

TABLE 4-1. Preliminary habitat risk groups. Habitats were placed into risk groups based on information provided on risk assessment forms.

4	3	2
Grasslands	Alpine	Montane Watersheds
Appalachian Oak Pine Forest	Shrublands	Northern Upland Watersheds
Coastal Islands	Caves and Mines	Peatlands
Dunes	Cliffs	Southern Upland Watersheds
Hemlock-Hardwood-Pine Forest	Coastal Transitional Watersheds	
Lowland Spruce-Fir Forest	Connecticut River Mainstem Watersheds	
Non-Tidal Coastal Watersheds	Floodplain Forests	
Pine Barrens	High Elevation Spruce-Fir Forest	
Salt Marshes	Marsh and Shrub Wetlands	
Tidal Coastal Watersheds	Non-breeding Bird Habitat	
Vernal Pools	Northern Hardwood-Conifer Forest	
	Talus Slopes and Rocky Ridges	

*Appalachian oak-pine forest (424,943 ac), hemlock-hardwood-pine forest (2,688,744 ac), and lowland spruce-fir forest (770,048 ac), comprise 72% of New Hampshire's land area. Risk intensity varies within this extensive area; some lands are protected and others are developed. It is most accurate to state that among New Hampshire's large-scale habitats these 3 are in the highest risk category, rather than the total area of these habitats is in the highest risk category.

TABLE 4-2. Preliminary species risk groups. Data and taxonomic expertise were limiting factors for many fish and wildlife species. Obtaining peer review to validate the risk groups and completing assessments for poorly studied fish and wildlife are high priority tasks for WAP implementation.

LEVEL 4	LEVEL 3	LEVEL 2	LEVEL 1
American Brook Lamprey	American Eel	Alewife	Bats
Atlantic Salmon	American Marten	American Bittern	Burbot
Atlantic Sturgeon	American Shad	Banded Sunfish	Cooper's Hawk
Cobblestone Tiger Beetle	American Woodcock	Bicknell's Thrush	Eastern Racer
Common Loon	Bald Eagle	Blueback Herring	Eastern Red Bat
Common Tern	Blandings Turtle	Bobcat	Finescale Dace
Dwarf Wedgemussel	Brook Floater	Bridle Shiner	Hoary Bat
Eastern Pondmussel	Eastern Brook Trout	Common Nighthawk	Lake Trout
Jefferson Salamander	Eastern Pipistrelle	Grasshopper Sparrow	Northern Bog Lemming
Karner Blue Butterfly	Fowlers Toad	Lake Whitefish	Northern Harrier
Nelson's Sharp-tailed Sparrow	Hognose Snake	Marbled Salamander	Redbelly Dace
New England Cottontail	Indiana Bat	Northern Goshawk	Silver Haired Bat
Northern Leopard Frog	Lynx	Pied-billed Grebe	Slimy Sculpin
Piping Plover	Northern Myotis	Rainbow Smelt	Smooth Green Snake
Roseate Tern	Osprey	Redfin Pickerel	Tesselated Darter
Saltmarsh Sharp-tailed Sparrow	Peregrine Falcon	Red-shouldered Hawk	
Seaside Sparrow	Purple Martin	Ringed Boghaunter	
Shortnose Sturgeon	Racer	Round Whitefish	
Timber Rattlesnake	Ruffed Grouse	Rusty Blackbird	
Willet	Small Footed Bat	Sea Lamprey	
	Spotted Turtle	Sedge Wren	
	Spruce Grouse	Swamp Darter	
	Whip-poor Will	Three-toed Woodpecker	
	White Mountain Arctic	Upland Sandpiper	
	White Mountain Fritillary		
	Wood Turtle		

TABLE 4-3. Top 10 risk factors for New Hampshire's wildlife and habitats. Average scores should be interpreted only as a relative measure within each group below. Scores from fish risk assessments were not available for this analysis. Risk assessment scores for fish are being reviewed as data and expertise become available.

(A) Cumulative risk to habitats

	Issue	Average Score*
1	Development	2.6
2	Recreation	1.8
3	Transportation Infrastructure	1.4
4	Introduced Species	1.4
5	Acid Deposition	1.3
6	Unsustainable Harvest	1.1
7	Non-point Source Pollution	1.1
8	Altered Hydrology	1.0
9	Climate Change	0.9
10	Mercury	0.9

* Average across all ranked habitats, N = 26

(B) Cumulative risk to wildlife

	Issue	Average Score*
1	Development	2.1
2	Recreation	1.1
3	Scarcity	0.8
4	Transportation Infrastructure	0.8
5	Introduced Species	0.7
6	Non-point Source Pollution	0.6
7	Predation and Herbivory	0.6
8	Mercury	0.6
9	Unsustainable Harvest	0.5
10	Altered Hydrology	0.5

* Average across all species, N = 62

(C) High-intensity risks to habitats

	Issue	Average Score*
1	Development	2.7 (25)
2	Altered Natural Disturbance	2.3 (9)
3	Predation and Herbivory	2.3 (6)
4	Climate Change	2.0 (12)
5	Transportation Infrastructure	2.0 (18)
6	Non-point Source Pollution	1.9 (15)
7	Mercury	1.9 (12)
8	Altered Hydrology	1.8 (15)
9	Recreation	1.8 (26)
10	Acid Deposition	1.8 (19)

* Average across affected habitats, affected habitats (n) in parentheses

(D) High-intensity risks to wildlife

	Issue	Average Score*
1	Scarcity	2.6 (19)
2	Development	2.5 (51)
3	Altered Hydrology	2.1 (14)
4	Predation and Herbivory	2.0 (19)
5	Transportation Infrastructure	2.0 (24)
6	Mercury	1.9 (18)
7	Oil Spills	1.9 (9)
8	Climate Change	1.9 (14)
9	Introduced Species	1.8 (22)
10	Recreation	1.8 (38)

* Average across affected species, affected species (n) in parentheses

Acid Deposition

1. DEFINITION

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 falling 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. However, much of the acid deposition comes from industrial areas in the midwestern and southwestern United States (NH Comparative Risk Project 1997). The estimated acidity (pH) of rainfall in 1997 for the Northeast ranged from 4.3-4.7 (Driscoll et al. 2001); normal pH for rainfall is approximately 5.5. Although surface waters in New Hampshire are naturally acidic due to low acid-neutralizing capacity of its bedrock, anthropogenic acidification has stressed most natural communities. Acidic precipitation can alter terrestrial and aquatic ecosystems in the Northeast (Driscoll et al. 2001), and may have additive or synergistic effects with other ecosystem stressors.

2. EXPERT OPINION

Acid deposition may have critical effects on species and habitats of conservation concern in New Hampshire (Table 4-4). Impacts are expected to be critical for alpine habitats, high elevation spruce-fir forests, and northern hardwood-conifer forests. Effects are expected to be serious for montane watersheds, vernal pools, talus slopes and rocky ridges, lowland spruce-fir forests, and hemlock-hardwood-pine forests. For most habitats, these effects are possible in the near term, although such effects could be immediate in the case of vernal pools. With the exception of vernal pools, the impacts of acid deposition on these habitats are well documented.

TABLE 4-4. Number of habitats and species at highest risk due to acid deposition. See Table 4-5 and Appendix A and B for details. Risk Category 4 = Greatest risk.

Risk Category	Habitats	Species
4	0	0
3	3	1
2	5	9
1	11	4

3. KNOWN WILDLIFE EXPOSURE PATHWAYS

(A) Aquatic ecosystems

Low pH affects nearly all levels of the aquatic food web—including bacteria, fungi, algae, zooplankton, invertebrates, fish, and birds. At the individual level, chronic acidity affects embryonic development, growth, metabolism, respiration, reproduction, and survival. Community-level effects include shifts in species composition, community structure, and predator-prey interactions. Ecosystem processes such as decomposition of organic matter, primary productivity, and secondary production are strongly affected by pH (Haines 1981, Schindler et al. 1985).

Many species of aquatic organisms are sensitive to changes in pH. Aquatic insect diversity and abundance often declines in acidified lakes and streams (Haines 1981, Okland and Okland 1986). Crustaceans and molluscs are sensitive to acid deposition because it interferes with calcium uptake, and the state-endangered dwarf wedgemussel and brook floater may be affected by chronic acidity. Amphibians experience high mortality or reduced productivity in acidic environments via reduced abundance of egg masses, decreased hatching success, increased larval mortality, and inhibited development (Pough 1976, Rowe et al. 1992, Horne and Dunson 1994, Kiesecker 1996). Impacts to fish include reduced growth, reproductive failure, skeletal deformities, and mortal-

TABLE 4-5. Habitats and species at highest risk from effects of acid deposition, in descending order by Rank. Eastern brook trout is the only fish shown because of the volume of information available. Assessments for other species are currently being reviewed. See Appendix A and B for additional information on specific risk factors and rankings.

		Ranking Scores*						
Species	Habitat	1	2	3	4	5	Rank	Class
SPECIES								
Jefferson Salamander	Vernal Pools	4	3	4	2	4	2.92	3
Eastern Brook Trout	Aquatic	4	3	2	3	4	2.63	2
White Mountain Arctic	Alpine	4	3	2	2	4	2.33	2
White Mountain Fritillary	Alpine	4	3	2	2	4	2.33	2
Rusty Blackbird	Lowland Spruce-Fir Forest	3	3	4	2.5	2	2.13	2
American Marten	High Elevation Spruce-Fir Forest	4	3	1	3	3	2.04	2
Spruce Grouse	Lowland Spruce-Fir Forest	4	3	1	3	3	2.04	2
Bicknell's Thrush	High Elevation Spruce-Fir Forest	4	2	2	3	3	2.00	2
Common Loon	Aquatic	2	4	2	2	4	2.00	2
Three-toed Woodpecker	Lowland Spruce-Fir Forest	4	2	2	3	3	2.00	2
HABITATS								
	Alpine	4	3	2	3	4	2.63	3
	High Elevation Spruce-Fir Forest	4	3	2	3	4	2.63	3
	Northern Hardwood-Conifer Forest	4	3	2	3	4	2.63	3
	Montane Watersheds	4	3	1	3	4	2.33	2
	Talus Slopes and Rocky Ridges	4	3	2	2	4	2.33	2
	Vernal Pools	4	3	4	2	2	2.33	2
	Hemlock-Hardwood-Pine Forest	4	2	2	3	4	2.25	2
	Lowland Spruce Fir Forest	4	2	2	3	4	2.25	2

* 1=Scope, 2=Severity, 3=Timing, 4=Likelihood, 5=Information

ity (Haines 1981, Schindler 1988, Baker et al. 1996).

Through reduction in aquatic community diversity and biomass as discussed above, organisms at higher trophic levels may not be able to forage or reproduce effectively in acidified water bodies. Diet and foraging efficiency of some fish species may be affected by acid-induced changes in zooplankton community structure. Waterfowl and other birds that forage on aquatic invertebrates or fish might also be affected, including American bittern, common loon, American black duck, and rusty blackbird (Longcore et al. 1987, Rattner et al. 1987).

(B) Terrestrial ecosystems

Terrestrial plant productivity and health can be severely affected by acid deposition. Vegetation in high-elevation spruce-fir forests, alpine habitats, talus slope/rocky ridge habitats, and cliffs may suffer direct foliar damage from contact with acid fog and mist, which often has a much higher acidity than rain. Acidophilic plants will replace calciphilic plants due to chronic acidification, and some of New Hampshire's rarest alpine and cliff communities may be at risk (Rusek 1993). Acidity leaches nutrients from foliage and mobilizes aluminum, which damages roots and contributes to soil infertility. Acid deposition works in concert with cold temperatures to cause winter injury, a proximate cause of widespread red spruce decline in the Northeast. Nitrogen saturation is one impact of acid deposition that may have cascading ef-

fects within New Hampshire's terrestrial ecosystems on plant communities and wildlife habitat.

(C) Mobilization of heavy metals

An indirect effect of acidification may be increased bioavailability of toxic metals including mercury, aluminum, cadmium, and lead (Haines 1981, Schindler 1988, Spry and Weiner 1991). Mercury methylation is enhanced under acidic conditions, and methylmercury is one of the more pervasive and acute threats in New Hampshire. Acidity mobilizes aluminum that damages roots and contributes to soil infertility. Aluminum is acutely toxic to aquatic invertebrates and fish.

4. RESEARCH NEEDS

Given that the effects of acid deposition on species and habitats are generally well documented, relatively few research needs have been identified. On the broad scale, examples of potential topics include shifts in alpine community composition, while more focused studies could include investigation of prey availability for rusty blackbirds. Additional research may be relevant to determine the efficacy of any proposed mitigation measures.

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Agriculture

1. DEFINITION

Wildlife that depend on grassland habitats existed in pre-settlement New England in low numbers and increased as early settlers cleared the land for farming. Natural processes—such as fire, beaver activity, and flooding—maintained grassy areas prior to human settlement. As some natural disturbances have declined in the last 150 years, grassland species have become more reliant on remaining agricultural lands making them increasingly vulnerable to commonly used agricultural practices and loss of active farms.

Currently there are 101,175 ha of farmland in New Hampshire (United States Department of Agriculture 2004), mainly in Grafton, Merrimack, and Coos Counties. Wildlife species that use agricultural fields are vulnerable to mowing for hay, and converting fields to developments. Mowing can result in significant mortality to grassland birds (eggs and chicks), snakes, and turtles.

2. EXPERT OPINION

Most of the grasslands in New Hampshire are the direct result of the positive influence that agriculture has had on grassland-dependent species by clearing forested areas and maintaining them in an open state. At the same time, because of the limited distribution of these habitats, some agricultural practices pose a threat to these grassland species. Mowing practices, such as haying before July 15 (which we acknowledge is necessary to maximize forage quality), are in use throughout the state and present a threat to grassland nesting species such as the upland sandpiper and northern harrier. Collisions with mowing equipment can cause mortality for black racer, smooth green snake, wood turtle, Blanding's turtle, and spotted turtle, though impacts to populations are poorly documented. In a very localized area, mowing of salt marshes is a serious, short-term threat to Nelson's sharp-tailed sparrow, salt marsh sharp-tailed sparrow, seaside sparrow, and willet. Reductions of populations of grassland-dependent species is possible in the next 1 to 5 years. Run-off of herbicides, pesticides and fertilizers from agricultural lands in the Connecticut River watershed may pose a threat to aquatic habitat (Francis and Mulligan 1997).

TABLE 4-6. Number of habitats and species at highest risk due to agriculture. See Table 4-7 and Appendix A and B for details. Risk Category 4 = Greatest risk.

Risk Category	Habitats	Species
4	1	0
3	1	0
2	0	2
1	8	11

3. KNOWN WILDLIFE EXPOSURE PATHWAYS

(A) Hay Cropping

Hay cropping can kill grassland birds, turtles, and snakes. Reproduction in grassland birds is reduced through direct mortality of eggs and nestlings or subsequent egg and chick loss caused by nest abandonment or predation on exposed nests (Bollinger et al. 1990). Farmers mow their hayfields 2 to 3 times during the summer to provide high quality forage for livestock. The peak nesting period for grassland nesting birds is mid-May through mid-July, coinciding with the first and second hay crops. Direct mortality of wood turtles caused by collision with farm machinery has been documented in agricultural fields where turtles seek exposed soils for nesting (Saumure and Bider 1998).

(B) Habitat Conversion

The conversion of agricultural fields to development has been significant. For instance, active agricultural land acreage dropped by 50% in Rockingham and

TABLE 4-7. Habitats and species at highest risk from effects of agriculture, in descending order by Rank. See Appendix A and B for additional information on specific threats and rankings.

		Ranking Scores*						
Species	Habitat	1	2	3	4	5	Rank	Class
SPECIES								
Upland Sandpiper	Shrublands	3	3	3	3	4	2.50	2
Grasshopper Sparrow	Grasslands	3	3	3	3	4	2.50	2
HABITATS								
	Grasslands	4	4	4	4	4	4.00	4
	Connecticut River Mainstem Watersheds	3	3	4	3	4	2.75	3

* 1=Scope, 2=Severity, 3=Timing, 4=Likelihood, 5=Information

Strafford Counties between 1962 and 1998 (*see Development*). Historical conversion of floodplains for agriculture also has been significant. However, it is unlikely that floodplain habitat will be lost to agriculture in the future, and there are many opportunities to restore floodplains. The loss of agriculture to other non-grassland habitat uses reduces the amount of potential quality habitat available to grassland-dependent species.

(C) Pesticides and Runoff

See Non-point Source Pollution.

4. RESEARCH NEEDS

- Demographic studies to determine causes of grassland wildlife population declines
- Assess which extensive grasslands are important to grassland nesting birds and other priority wildlife species, and which of these species is harmed by early mowing. This likely requires more field surveys of nesting birds and other wildlife in large grasslands
- Collect data on species distribution (e.g., upland sandpipers, northern harriers, grasshopper sparrows) and land use, including frequency and timing of mowing, rates of habitat loss to development, and overall changes to landscape composition (including field size distributions). Such data could be useful in determining the potential for re-colonization of historic breeding sites where appropriate management could be implemented
- Identify and assess threats (e.g., land use practices in agricultural areas) to specific wood turtle populations.
- Determine value of Farm Bill programs in conservation of grassland wildlife

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Altered Hydrology

1. DEFINITION

The frequency and intensity of floods or droughts strongly influences the physical and biological characteristics of aquatic ecosystems (Poff et al. 1997). Plants and wildlife in riparian areas have adapted to natural variation in flows and water levels. Periodic flooding provides fish and amphibians with access to spawning areas, causes an influx of organic matter to streams, and prevents the encroachment of upland plant species into wetland habitats (Poff et al. 1997). Impoundments and water level fluctuation above and below dams, restricted tidal flows, water withdrawal for irrigation and other uses, increased impervious surface area, and seasonal lake drawdowns alter natural hydrology (Richter et al. 1996). Hydrologic alteration can profoundly affect stream connectivity and the ability of fish and wildlife to migrate freely along a stream corridor.

2. EXPERT OPINION

Altered hydrology affects species and habitats throughout New Hampshire. Impacts can be serious and immediate, especially for relatively small populations or habitats (e.g. tiger cobblestone beetles and salt marshes). In general, more densely populated, lower elevation watersheds are more affected by altered hydrology than are high elevation and northern watersheds. While the overall effects of altered hydrology on aquatic ecosystems are well documented, species-specific impacts are poorly understood.

TABLE 4-8. Number of habitats and species at highest risk due to altered hydrology. See Table 4-9 and Appendix A and B for details. Risk Category 4 = Greatest risk.

Risk Category	Habitats	Species
4	0	1
3	1	5
2	7	4
1	9	11

3. KNOWN WILDLIFE EXPOSURE PATHWAYS

(A) Man-made Dams

Dams cause changes in water temperature, transparency, substrate composition, and flow, all of which influence biological communities. Increased flows below impoundments may result in high sediment loads, suffocating fish and invertebrates and altering spawning substrates (Baxter and Glaude 1980). The leaching of plant nutrients and toxic substances (e.g. mercury) from flooded soils upstream of dams can lead to algal blooms and accumulated toxins in fish tissue (Baxter and Glaude 1980). Increased biological oxygen demand from the decomposition of flooded soil and vegetation may cause lower dissolved oxygen levels, typically in the deep water near the dam (Baxter and Glaude 1980). Fluctuating water levels upstream and downstream from dams on the Connecticut River pose a threat to cobblestone tiger beetles by inundating their habitat more frequently than natural flooding events (Nothnagle 1993). Water level management for hydropower or flood control on high order rivers may decrease the frequency and intensity of flooding events needed to maintain floodplain forest communities (Bornette and Amoros 1996; see Altered Natural Disturbance Regime). Dams restrict the movements of aquatic species, especially anadromous fish, which migrate upstream to spawn, and freshwater mussels, which depend on fish for dispersal and development.

(B) Development

Flow regimes are altered by channelization, stream bank stabilization, construction fill, and road or railroad crossings. The effects are most obvious in coastal salt marshes where development and drainage ditches

TABLE 4-9. Habitats and species at highest risk from effects of altered hydrology, in descending order by Rank. Atlantic salmon is the only fish shown because of the volume of information available and recent initiatives to restore the species. Assessments for other species are currently being reviewed. See Appendix A and B for additional information on specific risk factors and rankings.

		Ranking Scores*						
Species	Habitat	1	2	3	4	5	Rank	Class
SPECIES								
Atlantic Salmon	Aquatic	4	4	4	4	4	4.00	4
Dwarf Wedgemussel	Aquatic	3	3	4	4	4	3.00	3
Nelson's Sharp-tailed Sparrow	Salt Marshes	3	3	4	4	4	3.00	3
Saltmarsh Sharp-tailed Sparrow	Salt Marshes	3	3	4	4	4	3.00	3
Seaside Sparrow	Salt Marshes	3	3	4	4	4	3.00	3
Willet	Salt Marshes	3	3	4	4	4	3.00	3
Brook Floater	Aquatic	2	3	4	4	4	2.50	2
Blandings Turtle	Marsh and Shrub Wetlands	2	3	4	3	3	2.08	2
Cobblestone Tiger Beetle	Aquatic	4	4	2	2	2	2.00	2
Pied-billed Grebe	Marsh and Shrub Wetlands	2	3	4	2	3	1.88	2
HABITATS								
	Salt Marshes	3	3	4	4	4	3.00	3
	Tidal Coastal Watersheds	3	3	4	3	3	2.50	2
	Non-Tidal Coastal Watersheds	3	3	4	3	3	2.50	2
	Connecticut River Mainstem Watersheds	3	3	2	4	4	2.50	2
	Coastal Transitional Watersheds	3	3	4	3	3	2.50	2
	Floodplain Forests	4	3	2	3	3	2.33	2
	Southern Upland Watersheds	2	3	4	3	3	2.08	2
	Peatlands	2	3	3	3	3	1.88	2

* 1=Scope, 2=Severity, 3=Timing, 4=Likelihood, 5=Information

have restricted tidal flooding. Without tidal influence, typical salt marsh vegetation is replaced with invasive reeds and grasses (Sinicrope et al. 1990). River bank stabilization restricts the dynamic nature of a river and often causes erosion problems downstream. Culverts at road crossings also alter natural hydrological patterns by constricting and channeling flow. Culverts reduce stream connectivity, acting as dispersal barriers to fish, amphibians, and some invertebrates (Watters 1996, Warren and Pardew 1999).

(C) Seasonal draw-down

Water levels in some New Hampshire lakes and ponds are reduced in the fall to prevent ice damage and reduce spring flooding. Drawdowns ranging from 1 to 10 feet occurred in 53 lakes and ponds in the fall of 2004 (New Hampshire Department of Environmental Services 2003). Artificially low water levels subject shoreline communities to freezing temperatures and interfere with the spring spawning activity of fish and amphibians. Reduced water levels decrease the habitat available to reef spawning fish, and lowering water levels after spawning may expose eggs to desiccation (Anras et al.1999). Significant changes in water level during the breeding season of shoreline nesting birds may flood nests or increase predation risk.

(D) Impervious surfaces

A landscape with a significant area of impervious surfaces can cause shorter, more intense flood periods, which alter stream morphology and potentially kill or inhibit the movement of some species (United States

Environmental Protection Agency 2003). Impervious surfaces prevent rainwater from replenishing groundwater, which is the primary source of water for small streams and wetlands during the summer.

(E) Water withdrawal

Water withdrawal for irrigation, municipal water supplies, or industry can decrease water levels and flows in aquatic habitats. An estimated 320 million gallons of water is withdrawn daily from the Merrimack River during the summer (Merrimack River Watershed Council 2001). In addition to impeding the movements of aquatic species, low flows can create higher water temperatures and stagnant conditions that encourage algal blooms. Water withdrawn for irrigation may reenter aquatic systems, containing increased nutrient levels (Baxter and Glaude 1980). Low summer flows modify invertebrate and fish communities to favor generalist species. Unusually low summer flows in the Ipswich River in Massachusetts have resulted in a high proportion of generalist fish species (Massachusetts Executive Office of Environmental Affairs 2004).

4. RESEARCH NEEDS

- Research the impacts of water level fluctuation on natural communities
- Expand the impervious surfaces assessment done in the coastal watershed to other watersheds in New Hampshire
- Continue to monitor the results of salt marsh restoration projects on the coast
- Investigate the quantitative effects of seasonal drawdowns on species diversity in aquatic habitats
- Investigate the potential correlation between drawdown and methyl mercury production

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Altered Natural Disturbance Regime

1. DEFINITION

Before European settlement, forested habitats were continuously altered by disturbances such as wildfire, beaver impoundments, Native American burning, agriculture, flooding, erosion and deposition, insect outbreaks, hurricanes, and openings created by massive passenger pigeon breeding colonies. Now, the effects of some of these natural agents of forest disturbance are substantially lessened (DeGraaf et al. 2005).

Centuries of land use and reduction of many natural disturbances have created a landscape of relatively homogenous, middle-aged to mature forest of similar size and structure amidst cities, suburbs, and highways and relatively little grassland, shrubland, or young forest habitat (DeGraaf et al. 2005). Pitch pine barrens, a critical habitat that supports a large number of rare and declining species, and Appalachian oak-pine forests are particularly vulnerable to altered natural disturbance regimes. To maintain the native diversity of wildlife on the New Hampshire landscape, including at-risk and rare species, habitat management and restoration are needed (DeGraaf et al. 2005).

2. EXPERT OPINION

Altered natural disturbance regimes critically impact pine barrens, Appalachian oak pine forests, and shrubland habitats and related species (e.g., Karner blue butterfly) and seriously affect species dependant on young forest habitats including American woodcock and ruffed grouse. To a lesser degree they also affect grasslands habitat and associated species (e.g., northern harrier, upland sandpiper, and grasshopper sparrow), as well as Blanding's and spotted turtles that use both grassland and shrubland habitats for nesting.

TABLE 4-10. Number of habitats and species at highest risk due to altered natural disturbance regimes. See Table 4-11 and Appendix A and B for details. Risk Category 4 = Greatest risk.

Risk Category	Habitats	Species
4	1	0
3	4	1
2	2	4
1	2	14

3. KNOWN WILDLIFE EXPOSURE PATHWAYS

(A) Mechanical ecological processes

Fire, beaver, and passenger pigeon roosting are among the mechanical ecological processes that once had a significant impact on New Hampshire's landscape. The decline, and in some cases the cessation of these natural disturbances, combined with habitat loss due to development, is reducing some critical habitats to levels at or below historical levels (e.g., grasslands, shrublands, young forests, pine barrens, and Appalachian oak-pine forests) (Brooks 2003, Litvaitis 2003).

For instance, fire suppression may alter the community structure of fire-adapted habitats by reducing the establishment of seeds that prefer bare mineral soil, and by increasing competition with fire tolerant species. Fire suppression has led to the succession of most of New Hampshire's remaining pine barrens to dense canopied forest that are becoming dominated by white pine and/or hardwoods (e.g., oak, red maple, and aspen). These conditions are ill suited for a large suite of rare and declining species (e.g., Karner blue butterfly, Persius duskywing skippers, and Fowler's toad) (Grundel 1998, VanLuven 1994). Fire suppression also can allow a dangerous accumulation of fuel load (duff, litter, dead wood), and subsequent fires can be intense enough to kill large number of animals and significantly threaten human safety.

The passenger pigeon, considered to have been

TABLE 4-11. Habitats and species at highest risk from effects of altered natural disturbance regimes, in descending order by Rank. See Appendix A and B for details additional information on specific threats and rankings.

		Ranking Scores*						
Species	Habitat	1	2	3	4	5	Rank	Class
SPECIES								
Karner Blue Butterfly	Pine Barrens	4	3	3	3	4	2.92	3
American Woodcock	Shrublands	3	3	3	3	4	2.50	2
Ruffed Grouse	Shrublands	3	3	3	3	4	2.50	2
Racer	Pine Barrens	4	4	2	3	1	2.00	2
Whip-poor Will	Pine Barrens	3	2	3	3	3	1.88	2
HABITATS								
	Pine Barrens	4	4	4	3	4	3.67	4
	Appalachian Oak Pine Forest	4	3	4	3	3	2.92	3
	Hemlock-Hardwood-Pine Forest	3	3	4	3	4	2.75	3
	Lowland Spruce Fir Forest	4	3	3	3	3.4	2.74	3
	Shrublands	3	4	3	3	3	2.63	3
	Northern Hardwood-Conifer Forest	2	3	4	3	3	2.08	2
	Talus Slopes and Rocky Ridges	4	3	1	3	3	2.04	2

* 1=Scope, 2=Severity, 3=Timing, 4=Likelihood, 5=Information

North America's most abundant land bird in historical times (e.g. flocks of 1 to 2 billion birds), also occurred in high numbers in New Hampshire (Foss 1994). High densities of roosting pigeons toppled small trees and broke off branches, increasing the amount of sunlight reaching the forest floor and perhaps exacerbating wildfires (Ellsworth and McComb 2003). Both conditions would have favored the maintenance of Appalachian oak-pine forest, pine barrens, grasslands, and shrublands, all of which were more abundant historically than they are today (Brooks 2003, Ellsworth and McComb 2003). Based on recent research, 2-6% of the state may have been affected annually (Ellsworth and McComb 2003).

(B) Chemical ecological processes

Fire and flooding events result in chemical processes that alter species composition in a variety of ways. Fire generates readily available nutrients, creates a blackened ground surface that increases soil temperatures and enhances nutrient cycling, and reduces competition with other plants (Brown and Smith 2000). These factors, coupled with pitch pine's post-fire ability to re-sprout and drop seeds, aids in the maintenance of pine barrens communities (Brown and Smith 2000).

Flooding provides a regular source of nutrients for floodplain areas (Osgood 1996, Wistendahl 1958). Floodplain soils tend to be rich in nutrients and have been targeted throughout history as excellent lands for agriculture (Nichols et al. 2000). With nearly 5,000 man-made dams in New Hampshire, many floodplains now do not benefit from these added nutrients.

(C) Hydrological processes

Seasonal flooding and flooding by beavers are hydrological processes that also had a more significant impact historically than today. Seasonal flooding of high order or high gradient rivers was a regular natural disturbance. This disturbance maintained the conditions suited to many types of floodplain forests (Bornette and Amoros 1996). Today, there are nearly 5,000 man-made dams in New Hampshire. Many of these dams inhibit the frequency and intensity of floods on high-order or high-gradient rivers (Nislow

and Magilligan 2000), resulting in reduced species and structural diversity of floodplain vegetation and reduced diversity of wildlife using floodplain areas (Nilsson et al. 1997).

Unlike man-made dams, beaver dams are generally constructed on low order or low gradient streams. This form of natural disturbance creates marshes, meadows, and shrublands beneficial to many species of wildlife. After a beaver dam degrades and becomes breeched after abandonment, the previously ponded area succeeds to a meadow and without further disturbance will succeed into shrubland, and eventually back to forest (Naiman et al. 1988). However, areas available for damming by beavers has declined significantly. An analysis of wet flats in New Hampshire (the floodplain that would be affected by beavers) shows that nearly 30% (267 out of 961) are affected by agriculture. Another 17% (165 out of 961) are affected by development (CSRC 2002, TNC 2003).

4. RESEARCH NEEDS

- Compare vegetation composition and structure, nutrient loading, and soil chemistry along impounded and free flowing rivers in New Hampshire
- Assess interactive impacts of fire suppression, land use history, ecological history, microclimate alterations, and habitat patch isolation on vegetation structure and composition of pine barrens and relative abundance and distribution of pine barrens, grasslands, and shrublands
- Investigate impacts of beaver population level changes on natural communities and habitat distribution

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Climate Change

1. DEFINITION

Natural variations in global climate occur over very long periods. Human activities influence the global climate by increasing atmospheric concentrations of carbon dioxide, methane, CFCs, and nitrous oxide that trap heat at the earth's surface (Firor 1990, Gates 1993). Human induced climate change is likely to profoundly affect the climatology, ecosystems, and native biodiversity of New Hampshire and the region (IPCC 2001, New England Regional Assessment (NERA) 2001, Nedeau 2004).

The greatest effects of climate change will be on regional air and water temperatures, precipitation patterns, storm intensity, and sea levels. These types of changes have been well documented already (NERA 2001, Wake and Markham 2005), and global climate models are in general agreement that trends will continue and even accelerate in the next century (IPCC 2001). The ten hottest years of the last millennium have all occurred since 1983 (NERA 2001), and regional climate change models predict a 6.0-10.0 F temperature increase in the next century in New England, which would make our climate comparable to portions of the southeastern United States.

Because of their complex nature, broad patterns of change are still difficult to predict. Climatic changes have been linked to local ecological changes, including range shifts and asynchrony with seasonal habitat requirements. Not every species is obviously threatened by climate change. But no ecosystem can sustain the breadth of changes likely to result from climate change without harm to many taxa.

TABLE 4-12. Number of habitats and species at highest risk due to climate change. See Table 4-13 and Appendix A and B for details. Risk Category 4 = Greatest risk.

Risk Category	Habitats	Species
4	0	0
3	1	2
2	7	7
1	3	6

2. EXPERT OPINION

Climate change will broadly affect every species and habitat of conservation concern in New Hampshire. Impacts will likely be most severe for habitats with narrow temperature and water level regimes, such as alpine, high and low elevation spruce-fir forests, coastal islands, vernal pools, and aquatic habitats. For some animals, changing snow depths (e.g., American marten and lynx) and high altitude seasonal timing (e.g., alpine butterflies) may begin to have impacts during the next decade. Thermal habitat of New Hampshire's native fishes will likely decline substantially. Invasive species, diseases, and pathogens will likely become more problematic, as warmer regional temperatures facilitate their introduction and proliferation. High altitude and coastal impacts are fairly well documented.

3. KNOWN WILDLIFE EXPOSURE PATHWAYS

(A) Snow depth and winter ice

In New Hampshire, average wintertime air temperatures increased by 3.5 F during the period from 1895-1999 (well above the regional average) (NERA 2001). Freeze-free periods have increased, snow cover has decreased, and lake ice duration (as measured by ice-out dates) has decreased (NERA 2001, Hodgkins et al. 2002, Huntington and Hodgkins 2004, Wake and Markham 2005). Snow depth and frequency are important factors affecting distribution of American marten (Krohn et al. 1995, Raine 1983) and lynx (Hoving et al. 2005). Changes to lake ice duration and surface water temperatures will strongly affect primary productivity, dissolved

TABLE 4-13. Habitats and species at highest risk from effects of climate change, in descending order by Rank. See Appendix A and B for details additional information on specific threats and rankings.

Species	Habitat	Ranking Scores*					Rank	Class
		1	2	3	4	5		
SPECIES								
White Mountain Arctic	Alpine	4	3	2	3	4	2.63	3
White Mountain Fritillary	Alpine	4	3	2	3	4	2.63	3
Lynx	Upland Forests	4	4	2	2	3	2.33	2
American Marten	High Elevation Spruce-Fir Forest	4	3	2	3	3	2.33	2
Common Tern	Coastal Islands	4	3	2	3	2	2.04	2
Piping Plover	Dunes	4	3	2	3	2	2.04	2
Roseate Tern	Coastal Islands	4	3	2	3	2	2.04	2
Spruce Grouse	Lowland Spruce-Fir Forest	4	3	1	3	3	2.04	2
Common Loon	Aquatic	4	4	1	3	2	2.00	2
HABITATS								
	Alpine	4	4	2	3	4	3.00	3
	High Elevation Spruce-Fir Forest	4	4	1	3	3	2.33	2
	Hemlock-Hardwood-Pine Forest	4	3	1	3	4	2.33	2
	Northern Hardwood-Conifer Forest	4	3	1	3	4	2.33	2
	Talus Slopes and Rocky Ridges	4	3	2	2	4	2.33	2
	Coastal Islands	4	3	1	3	3	2.04	2
	Dunes	4	3	1	3	3	2.04	2
	Lowland Spruce Fir Forest	4	3	1	3	3	2.04	2

* 1=Scope, 2=Severity, 3=Timing, 4=Likelihood, 5=Information

oxygen, thermal habitat, and invertebrate and fish communities.

(B) Seasonality

In the last 50 years, dates of the last hard frost and lilac blooming have both become significantly earlier in New England (Cooter and Leduc 1995, Schwartz and Reiter 2000). Scientists in Wisconsin studied 55 springtime events—from the appearance of pussywillows to robins to trillium blooms—and found that for all combined, these events occurred an average of 0.12 days earlier per year over 61 years (7.3 days) (Bradley *et al.* 1999). 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 have the potential to decouple bird migration peaks from peaks in food supply (e.g., McCarty 2001).

(C) Shifts in forest communities and wildlife

The southern range of cold-adapted forest trees—such as spruce, fir, aspen, and sugar maple—will likely retreat northward, dramatically altering the composition of New Hampshire's northern and high-elevation forests and dependant wildlife species. Forest damage—resulting from increased storm intensity, warmer periods, droughts, and damaging ozone—will stress many forest communities.

Terrestrial wildlife whose southern range extends into New Hampshire will likely shift their range northward as climate warms. These include species such as the northern bog lemming, moose, and snowshoe hare. Alpine herbaceous communities are strongly affected by climate change (Walker et al. 1995, Kimball and Weihrauch 2000, Lessica and McCune 2004, Sperduto and Nichols 2004). Walther (2002) has documented climate-related elevation

shift of alpine plants, rising tree line, and northward range shifts of 39 butterfly species. For *Boloria titania montinus* and *Oeneis melissa semidea*, the combination of climate change and isolation will likely result in local extirpation without a northward range shift (e.g., extinction).

(D) Loss of thermal habitat

Many fish species, such as brook trout and salmon, have narrow temperature tolerances. Others, such as yellow perch and smallmouth bass, are more tolerant. As climate change causes water to warm, many of New Hampshire's cold-water fish will be replaced by warm-water species (Eaton and Scheller 1996). Some of the fish hosts of New Hampshire's two endangered freshwater mussel species (dwarf wedgemussel and brook floater) are coldwater fish whose thermal habitat will likely diminish as climate warms, ultimately affecting the reproductive success of the mussels. Marine productivity—and thus marine fisheries—may be affected by changes in thermohaline circulation of coastal waters, a changing thermal regime, and reduced oxygen availability.

(E) Climate volatility and storms

Climate models predict an increase in the frequency and intensity of coastal storms. Besides fundamentally changing the climate of important habitats, storm cycles can introduce new threats to animals. Inclement weather can disrupt bird migrations and make breeding and nesting sites inhospitable, forcing birds into marginal habitats. Similarly, storms batter coastal ecosystems, disrupting dunes, salt marshes, and estuaries, and bringing additional stress to species living there (Michener et al. 1997). Nesting plovers, saltmarsh birds, and colonial seabirds are highly susceptible to storms.

(F) Rising sea level

Sea level in the United States is rising 2.5 to 3.0 mm/yr. Global warming could raise the sea level 15 cm by 2050 and 34 cm by 2100 (Titus and Narayanan 1995, Titus 1990). Under this scenario, low elevation coastal habitats will likely be flooded or overwashed more frequently by storm surges (Gulf of Maine Council Habitat Restoration Subcommittee 2004). These habitats are important for nesting and loafing seabirds, including Roseate terns, common terns, and marine mammals. Sea level rise may affect habitat availability and the timing of nesting and migration for seabirds (Kushlan et al. 2002, Galbraith et al. 2002). Sea level rise will destroy dunes, salt marshes, and their associated species, negating any current protection efforts (Simas et al. 2001).

(G) Invasive Species

Climate change will facilitate the introduction and spread of invasive species (including new diseases and pathogens) in New Hampshire. For instance, the hemlock woody adelgid, whose range is limited by temperature, has been steadily pushing north and has reached Portsmouth, New Hampshire. Loss of hemlock would have dramatic effects on forest composition, wildlife habitat, and ecosystem processes in terrestrial and aquatic ecosystems. The wasting disease pathogen (*Labyrinthula zosterae*), which has decimated eelgrass beds in the past, might become more of a problem because it prefers higher salinity waters (which are expected in some estuaries because of sea-level rise) and warmer water. Many non-native warmwater fish will become more predominant in many watersheds, especially where they are currently limited by temperature. West Nile Virus will likely become more of a threat if climate conditions (milder winters, wetter summers) facilitate mosquito survival and breeding.

4. RESEARCH NEEDS

- Monitor indicators of range shifts of alpine lepidoptera and habitat plants
- Monitor impacts of decreased snow depth on marten and lynx
- Study impacts of early ice release on aquatic communities
- Monitor effect of storms and rising sea levels on coastal habitats, such as dunes, salt marshes, and lower tidal watersheds, as well as on their associated species

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Development

1. DEFINITION

Development includes residential, commercial, and industrial construction, mining extraction operations, and recreational areas (e.g., ski areas, athletic fields). Human population growth, property values, and local land planning vary between towns and regions. Activities associated with development often result in the loss or fragmentation of wildlife habitats and direct wildlife mortality during or after construction. Some effects are subtle; light pollution can distract or disorient moths, or expose terrestrial animals to predation. Indirect effects of development, including altered hydrology, introduced species, pollutants, non-point source pollution, transportation infrastructure, recreational use, and predation are discussed independently.

2. EXPERT OPINION

All habitats and species are affected by development to varying degrees. New Hampshire's human population is rapidly expanding, especially in the south, and those species restricted to southern New Hampshire are at immediate risk.

Development is a widespread threat to wetland and terrestrial habitats and species. Species or habitats with a limited distribution, restricted habitat requirements, and/or low population sizes are at greatest risk. Effects can be extensive and critical for some species (e.g., timber rattlesnake, New England cottontail, Karner blue butterfly, Blanding's and spotted turtles, common loon, Jefferson salamander, and salt marsh birds). Development of uplands surrounding salt marshes, freshwater marshes, shrub wetlands, and vernal pools is likely to be extensive and critical. Impacts will be chronic or serious for forest habitats, watersheds, and area-sensitive species. Impacts are generally well documented.

TABLE 4-14. Number of habitats and species at highest risk due to development. See Table 4-15 and Appendix A and B for details. Risk Category 4 = Greatest risk.

Risk Category	Habitats	Species
4	9	10
3	3	17
2	9	7
1	10	22

3. KNOWN WILDLIFE EXPOSURE PATHWAYS

(A) Rapid population growth

New Hampshire's population grew by 17% between 1990 and 2004, twice the rate of other New England states (Society for the Protection of New Hampshire Forests 2005). Previously undeveloped land is being subdivided and developed to meet growing demands for housing and services at a rate of nearly 6,900 ha per year.

Rising land values contribute to development, since high property values limit the amount of land that can be protected with existing funds. Currently, 28% of New Hampshire's land area is protected, and only 25% of protected land area is in the southern half of the state, where development is most intense and land values are highest (Society for the Protection of New Hampshire Forests 2005). Southern New Hampshire also harbors the greatest diversity of the state's wildlife, including many rare or endangered species. At the current rate of protection and development, many more species will likely become rare, and several species may become extirpated. Some species are at greater risk due to limited distribution, low population densities (e.g., Karner blue butterfly, timber rattlesnake), life history characteristics (e.g., high adult survivorship, late age of maturity, large home ranges), or ease of development (e.g., pitch-pine barrens).

TABLE 4-15. Habitats and species at highest risk from effects of development, in descending order by Rank. See Appendix A and B for details additional information on specific threats and rankings.

Species	Habitat	Ranking Scores*					Rank	Class
		1	2	3	4	5		
SPECIES								
Common Loon	Aquatic	4	4	4	4	4	4.00	4
Karner Blue Butterfly	Pine Barrens	4	4	4	4	4	4.00	4
Nelson's Sharp-tailed Sparrow	Salt Marshes	4	4	4	4	4	4.00	4
Northern Leopard Frog	Grasslands	4	4	4	4	4	4.00	4
Saltmarsh Sharp-tailed Sparrow	Salt Marshes	4	4	4	4	4	4.00	4
Seaside Sparrow	Salt Marshes	4	4	4	4	4	4.00	4
Willet	Salt Marshes	4	4	4	4	4	4.00	4
New England Cottontail	Shrublands	4	4	3	4	4	3.67	4
Jefferson Salamander	Vernal Pools	4	3	4	4	4	3.50	4
Timber Rattlesnake	Appalachian Oak Pine Forest	4	4	3	3	4	3.33	4
Fowlers Toad	Pine Barrens	4	3	3	4	4	3.21	3
Blandings Turtle	Marsh and Shrub Wetlands	4	4	3	3	3	3.00	3
Brook Floater	Aquatic	3	3	4	4	4	3.00	3
Common Tern	Coastal Islands	4	4	4	1	4	3.00	3
Dwarf Wedgemussel	Aquatic	3	3	4	4	4	3.00	3
Roseate Tern	Coastal Islands	4	4	4	1	4	3.00	3
Spotted Turtle	Marsh and Shrub Wetlands	4	4	2	3	4	3.00	3
Spruce Grouse	Lowland Spruce-Fir Forest	2	4	4	4	4	3.00	3
Wood Turtle	Floodplain Forests	4	4	2	3	4	3.00	3
American Marten	High Elevation Spruce-Fir Forest	3	4	3	4	3	2.92	3
Eastern Pondmussel	Aquatic	4	3	4	4	2	2.92	3
Whip-poor Will	Pine Barrens	4	3	4	3	3	2.92	3
Bald Eagle	Aquatic	3	3	4	3	4	2.75	3
Racer	Pine Barrens	4	4	2	3	3	2.67	3
American Woodcock	Shrublands	3	4	3	3	3	2.63	3
Hognose Snake	Pine Barrens	4	3	3	3	3	2.63	3
Non-breeding Birds		4	3	3	3	3	2.63	3
Ruffed Grouse	Shrublands	3	4	3	3	3	2.63	3
American Bittern	Marsh and Shrub Wetlands	1	4	4	4	4	2.50	2
Osprey	Marsh and Shrub Wetlands	3	3	4	3	3	2.50	2
Ringed Boghaunter	Peatlands	1	4	4	4	4	2.50	2
Sedge Wren	Marsh and Shrub Wetlands	1	4	4	4	4	2.50	2
Common Nighthawk	Pine Barrens	4	3	3	2	3	2.33	2
Northern Goshawk	Upland Forests	4	3	2	3	3	2.33	2
Piping Plover	Dunes	4	3	1	4	3	2.33	2
Red-shouldered Hawk	Floodplain Forests	3	2	4	3	4	2.29	2

* 1=Scope, 2=Severity, 3=Timing, 4=Likelihood, 5=Information

TABLE 4-15. (continued)

Species	Habitat	Ranking Scores* 1	2	3	4	5	Rank	Class
HABITATS								
	Pine Barrens	4	4	4	4	4	4.00	4
	Salt Marshes	4	4	4	4	4	4.00	4
	Dunes	4	3	4	4	4	3.50	4
	Hemlock-Hardwood-Pine Forest	4	3	4	4	4	3.50	4
	Lowland Spruce Fir Forest	4	3	4	4	4	3.50	4
	Non-Tidal Coastal Watersheds	4	3	4	4	4	3.50	4
	Tidal Coastal Watersheds	4	3	4	4	4	3.50	4
	Vernal Pools	4	3	4	4	4	3.50	4
	Appalachian Oak Pine Forest	4	4	3	3	4	3.33	4
	Floodplain Forests	3	4	4	3	4	3.21	3
	Northern Hardwood-Conifer Forest	4	3	3	4	4	3.21	3
	Coastal Transitional Watersheds	3	3	4	3	3	2.50	2
	Connecticut River Mainstem Watersheds	3	3	2	4	4	2.50	2
	Marsh and Shrub Wetlands	1	4	4	4	4	2.50	2
	Peatlands	1	4	4	4	4	2.50	2
	Grasslands	4	4	2	2	3	2.33	2
	High Elevation Spruce-Fir Forest	1	4	4	3	4	2.29	2
	SShrublands	3	3	3	3	3	2.25	2
	Coastal Islands	3	3	3	2	4	2.25	2
	Southern Upland Watersheds	2	3	2	4	4	2.08	2

* 1=Scope, 2=Severity, 3=Timing, 4=Likelihood, 5=Information

(B) Wetland draining and filling

Filling of freshwater or estuarine wetlands can cause immediate severe harm to local flora and fauna. New Hampshire still has the majority of its historic freshwater wetlands (Dahl 1990, 2000), whereas impacts to salt marshes in the region have been more extensive (Shriver et al. 2004). Currently, freshwater wetlands (see Marsh and Shrub Wetlands and Peatlands profiles), salt marshes, rivers, and streams are regulated by the New Hampshire Department of Environmental Services (NHDES) (RSA 482-A and Wetlands Bureau Administrative Rules). Vernal pools, although regulated by RSA 482-A, are vulnerable to filling because of their small size, ephemeral hydroperiod, and overlooked wildlife value. Landowners may remove beaver dams 'to protect private property' with little regulatory oversight.

The greatest threat to wetland habitats in New Hampshire is the development of surrounding uplands. Many wetland species require an intact upland buffer for nesting (e.g., American black duck, turtles), foraging (e.g., Jefferson salamander, Fowler's toad, odonates), dispersal (e.g., Blanding's and spotted turtles), and hibernation (e.g., Jefferson salamander) (Semlitsch and Bodie 2003). Current state regulations do not require development setbacks from wetlands, unless designated as a Prime wetland by the town. Town zoning and wetland regulations vary considerably.

Shoreline development reduces habitat quality for wildlife through vegetative modification or removal, pollution, creation of structures in close proximity to nesting or wintering sites, increased predator densities and human activity, and, potentially, declines in

reproductive success and local population numbers (Alvo 1981, Dahmer 1986, McIntyre 1988, Buehler 2000). The Comprehensive Shoreland Protection Act (RSA 483-B) regulates shoreline cutting and development of major rivers and large surface bodies (larger than 10 ac); however, most of the smaller perennial tributaries receive no upland protection. Sites favored by nesting common loons and wintering and nesting bald eagles often are of prime development value and/or receive intense recreational use (K. Taylor, Loon Preservation Committee; C. Martin, NHA, personal communications). Removal of riparian vegetation reduces the habitat quality for wood turtles (Tuttle and Carroll 1997) and makes them more vulnerable to collection and predation.

(C) Unregulated upland development

Development of terrestrial habitats is largely unregulated by the state. Site-specific permits are required by the NHDES for impacts exceeding 0.93 ha, but this review is focused on storm water discharge, with little or no review of wildlife or rare natural community impacts. Approximately 7,000 ha of forestland have been lost annually in New Hampshire since the mid-1980s, largely because of development (Society for the Protection of New Hampshire Forests 2005). Among matrix forests, Appalachian oak pine forests and hemlock-hardwood forests appear to be at greatest risk. Ninety-five percent of predicted Appalachian oak pine forests occurred in Cheshire, Hillsborough, Rockingham, and Strafford Counties (New Hampshire Fish and Game GIS; C. Foss, NHA, personal communication), all areas experiencing heavy human population growth (SPNHF 2005). Pine barrens are at particular risk because of their limited distribution and because the soils they occur on are favorable for development. Early successional shrublands in southern New Hampshire are ephemeral but are rapidly being developed, leaving the New England cottontail at serious risk.

(D) Fragmentation

Habitat is fragmented when it is subdivided into increasingly smaller patches that are segregated from one another. Fragmentation of habitat has numerous and widespread impacts on wildlife populations and habitats, both aquatic and terrestrial (Saunders et al. 1991). As forests in New Hampshire are subdivided, ecological processes may be disrupted and edge effects may increase. Most pitch pine-scrub oak woodland communities have been fragmented into relatively small habitat patches (Howard et al. 2005), reducing the potential for large natural disturbances (especially fire) of sufficient frequency, intensity, and extent to maintain natural ecological processes (Wagner et al. 2003). Population level impacts from fragmentation are serious or critical for species requiring large areas of habitat (e.g., American marten, bobcat, lynx, timber rattlesnake, Blanding's turtle). Wetlands, including vernal pools, are becoming increasingly fragmented by development, especially in southern New Hampshire, making wetland dependent organisms vulnerable. Where these species must disperse through inhospitable habitat, local populations are vulnerable to reduced gene flow or extirpation (Semlitsch and Bodie 1998, Marsh and Trenham 2001).

(E) Light Pollution

Outdoor lighting by streetlights, parking lot lights, and illumination associated with buildings has sharply increased over the last half century (Frank 1988, Cinzano et al. 2000). Light pollution has adverse effects on many species of insects, particularly nocturnal taxa such as moths. Lepidopterists have long attributed moth population declines, especially those of northeastern saturniids, to increasing artificial light pollution (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). Heavily lit urban areas can attract nocturnally migrating birds (e.g., many songbirds, cuckoos, owls, rails), which become disoriented and may suffer mortality from collisions with buildings or other structures (Klem 1989). 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.

(F) Commercial extraction

Commercial extraction removes vegetation and abiotic resources used by wildlife. In addition, large machinery may be a source of direct mortality. Commercial extraction of sand and gravel is a threat

to timber rattlesnakes, eastern hognose snakes, and wood turtles. Abandoned gravel pits may be valuable habitat for some wildlife (e.g., early successional obligates such as New England cottontail and nesting turtles). However, following extraction of abiotic resources, properties often are sold for development, permanently altering the site for wildlife.

4. RESEARCH NEEDS

- Identify priority areas for protection, restoration, and management among all critical habitat types
- Identify landscape connections for protection and restoration
- Identify critical habitat needs of species at greatest risk through monitoring
- Identify land planning that is least likely to affect significant natural resources

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Diseases and Pathogens

1. DEFINITION

Wildlife diseases are most commonly bacterial but can also be viral or fungal. Diseases are transmitted or enhanced by the poultry industry, unsanitary birdhouses, mosquitoes, and chemical applications and often are persistent. Great improvements in the speed and efficiency of international commerce have facilitated the spread of diseases that were once isolated to certain regions. The threat of disease to wildlife populations in New Hampshire is likely to increase with the expansion of global trade. Diseases can have dramatic affects on fish and wildlife populations due to widespread mortality in infected areas. In addition, wildlife diseases also can pose risks to human health.

2. EXPERT OPINION

Diseases may locally affect fish, wildlife, and plants that comprise habitats of conservation concern in New Hampshire. Impacts will likely be serious for several species over the short and long-term. Impacts on vernal pool species, fish, purple martins, a variety of raptors and corvids, and coastal bird species such as the common and roseate tern, can be at extreme risk due to large magnitudes of mortality associated with diseases. Impacts are well documented for coastal island birds, fish, purple martins, and raptors and are poorly documented for vernal pool habitats.

3. KNOWN WILDLIFE EXPOSURE PATHWAYS

Chronic wasting disease (CWD) appears to be transmitted via abnormal proteins called prions. Transmission is through physical contact or through infected feed. Infected prions are most concentrated in the nervous system tissue such as the brain or lymphatic tissue. CWD is a contagious neurological disease that is fatal to ungulates (primarily deer and elk). It is considered a transmissible spongiform encephalopathy or TSE that attacks the brains of infected animals. As a result, the animal becomes emaciated, exhibits abnormal behavior, and eventually dies (Animal and Plant Health Inspection Services 2005).

TABLE 4-16. Number of habitats and species at highest risk due to diseases and pathogens. See Table 4-17 and Appendix A and B for details. Risk Category 4 = Greatest risk.

Risk Category	Habitats	Species
4	0	0
3	0	0
2	1	0
1	2	3

Avian cholera is an increasing threat to seabirds (USFWS 1998) and may be linked to contamination by the poultry industry. Avian cholera is a highly infectious disease caused by the bacterium *Pasteurella multocida* that is quickly lethal and can kill entire colonies if not contained.

Avian botulism is also carried through a bacterium that is transmitted through the discharge of sewage or buildup of organic matter. The botulism bacterium accumulates in dead birds and scavengers are vulnerable to transmission. The source and transmission of salmonella in birds is not well understood.

In 1988, 37 common terns were found dead on Eastern Egg Rock in Maine 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 been identified as the bacterium that killed terns, gulls, and eiders on seabird islands in Maine. In 2004, close to 2000 common tern chicks were found dead on the nests at Monomoy Island,

TABLE 4-17. Habitats and species at highest risk from effects of diseases and pathogens, in descending order by Rank. See Appendix A and B for details additional information on specific threats and rankings.

Species	Habitat	Ranking Scores*					Rank	Class
		1	2	3	4	5		
HABITATS								
	Appalachian Oak Pine Forest	4	3	1	3	3	2.04	2

* 1=Scope, 2=Severity, 3=Timing, 4=Likelihood, 5=Information

Massachusetts with no evidence of external trauma. Salmonella was determined to be the cause of death.

Diseases spread by various pathogens (e.g., viruses, bacteria, parasites) can harm fish populations in New Hampshire. While diseases in wild fish populations are natural, more widespread incidents of disease are present under adverse environmental conditions. Fish pathogens are more likely to occur in areas with crowded conditions (aquaculture facilities) and poor water quality. Studies on the transmission of diseases from hatchery fish stocks to wild fish populations are inconclusive. Whirling disease, infectious pancreatic necrosis, bacterial kidney disease, and gas bubble disease are examples of salmonid diseases known to have occurred in NHFG fish culture facilities.

West Nile Virus (WNV) is carried in birds and spread through the bite of infected mosquitoes, often causing encephalitis 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 raptors appear to be particularly susceptible to the disease (Gancz et al. 2002). 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 other species in New Hampshire have been exposed to WNV.

By September 2005, 51 birds, representing 22 species, tested positive for eastern equine encephalitis. It is not known if there are population level effects from this disease.

International trade in wildlife, especially amphibians, is a major pathway for the potential introduction of foreign diseases to native wildlife populations in the United States (Daszag et al. 1999, Mazzoni et al. 2003). Over one million bullfrogs are imported into the United States each year. Many of these frogs are raised on farms in South America where they may become carriers for diseases that could potentially spread to wild populations (Mazzoni et al. 2003).

4. RESEARCH NEEDS

- Establish rapid diagnostic techniques for ungulates potentially infected with CWD
- Assess threats from diseases to species of concern in New Hampshire
- Assist health officials with understanding interactions of wildlife diseases and human health

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Energy and Communication Infrastructure

1. DEFINITION

Wind energy and communication tower infrastructure (e.g., television, radio, cell towers) are known to degrade wildlife habitats and cause direct mortality of individuals (Kerlinger 2000, Kerns and Kerlinger 2003, Schwartz 2004). This may lead to reduced population size, alterations of population structure, and perhaps cause local extirpations. Communication towers are common in New Hampshire. Commercial wind energy development is considered the fastest growing sector of the energy market in the United States (deVries 2004, Winegrad in Resolve 2004). Although New England has historically lagged behind the nation in wind resource development, high sustained winds at high elevation sites and production tax credits appear to be creating a competitive siting environment (McLeish 2002).

2. EXPERT OPINION

Wind energy and communication tower infrastructure (e.g., television, radio, cell towers) could degrade critical habitat and cause direct mortality and thereby reduce population size, alter population structure, and perhaps cause local extirpation.

Energy and communication infrastructures are considered a chronic to serious local threat for a variety of species and habitats but could be potentially serious for some species (e.g., American marten, bats, spruce grouse, and migratory birds including osprey) and habitats (e.g., alpine, high elevation spruce fir, talus slope/rocky ridges). Impacts to habitats are somewhat well documented, but weakly documented for most wildlife species.

TABLE 4-18. Number of habitats and species at highest risk due to energy and communication infrastructure. See Table 4-19 and Appendix A and B for details. Risk Category 4 = Greatest risk.

Risk Category	Habitats	Species
4	0	0
3	0	0
2	3	4
1	6	9

3. KNOWN WILDLIFE EXPOSURE PATHWAYS

(A) Habitat loss and degradation

Habitat alteration stemming from the construction of wind and telecommunication structures and access roads can be substantial (Bodin 2004), and can perhaps be exacerbated by the unique and fragile habitats where these structures are often placed (i.e., alpine, cliff and high elevation spruce-fir habitats). American marten, spruce grouse, and Bicknell's thrush are sensitive to the threats posed by towers and turbines. Offshore wind turbines may affect nearby waters and the ocean floor, particularly during the construction phase when the seafloor is disturbed (Kerlinger and Curry 2002).

(B) Collision and mortality

There is extensive evidence that migratory birds and bats, including species of conservation concern in New Hampshire, may experience substantial mortality at some telecommunication towers and wind turbines (Kerlinger 2000, Shire et al. 2000, Kerns and Kerlinger 2003, Resolve 2004, Schwartz 2004). Nocturnally migrating birds may be attracted to lights on towers, become disoriented, and crash into towers or associated guy wires. There is less information available for impacts associated with nearshore or offshore wind facilities, especially in the United States (Kerlinger 2000, Kerlinger and Curry 2002). Impacts would expectedly be greatest when wind facilities are sited near migration pathways or concentrations of wintering or foraging waterfowl and waterbirds

TABLE 4-19. Habitats and species at highest risk from effects of energy and communication infrastructure, in descending order by Rank. See Appendix A and B for details additional information on specific threats and rankings.

Species	Habitat	Ranking Scores*					Rank	Class
		1	2	3	4	5		
SPECIES								
American Marten	High Elevation Spruce-Fir Forest	1	4	3	3	4	2.08	2
Osprey	Marsh and Shrub Wetlands	1	4	4	2	4	2.08	2
Spruce Grouse	Lowland Spruce-Fir Forest	1	4	3	3	4	2.08	2
Peregrine Falcon	Cliffs	2	3	3	3	3	1.88	2
HABITATS								
	High Elevation Spruce-Fir Forest	2	4	3	3	4	2.50	2
	Alpine	3	4	2	2	3	2.04	2
	Talus Slopes and Rocky Ridges	4	3	2	3	2	2.04	2

* 1=Scope, 2=Severity, 3=Timing, 4=Likelihood, 5=Information

(Kerlinger 2000). Mortality may be considered insignificant at some locations, but it is not known what cumulative impacts might occur at a regional level (Winegrad in Schwartz 2004).

Towers over 200 feet tall may pose the greatest threat, and as of 1999, there were approximately 60 such towers in New Hampshire (Braile 1999). Although large mortalities from tower collisions have not been recorded in New Hampshire, the issue has received little study, and its overall magnitude remains unknown. Although there are no active wind turbine facilities in New Hampshire, there are several proposals being evaluated by state and local regulators. In an attempt to minimize wildlife impacts, the United States Fish and Wildlife Service (USFWS) produced guidelines for the siting and operation of both communication towers and wind turbines.

4. RESEARCH NEEDS

- More information is needed on the direct threats (habitat loss, mortality, wildlife behavior modifications) of wind farms and communication towers proposed in the Northeast, including New Hampshire. USFWS recommends a minimum of 3 years pre-construction surveys to document impacts to wildlife. Post-construction surveys should assess impacts and lead to modified design and siting criteria.
- Conduct a cost-benefit analysis for each proposed wind energy project and determine its effects on the environment. Benefits should clearly outweigh environmental costs before a project proceeds.

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Introduced Species

1. DEFINITION

Introduced species may compete directly with native species for food or space, may compete indirectly by changing the food web or physical environment, or may prey on or hybridize with native species (Stein and Flack 1996). Rare species with limited ranges and restricted habitat requirements are particularly vulnerable to introduced species. Invasive species (i.e., species that spread rapidly or colonize vigorously) are now regarded as the second-leading threat to at-risk species nationwide, behind only habitat destruction (Stein and Flack 1996). Approximately 42% of federal threatened or endangered species are at risk from invasive species (Stein and Flack 1996). Impacts to many threatened or endangered species is not well known.

2. EXPERT OPINION

Introduced animals (e.g., mammalian predators, zebra mussels) may have extreme impacts on island nesting birds (Roseate tern), dwarf wedgemussels, and eastern pondmussels in the near future. Hemlock-hardwood-pine forests, Karner blue butterflies, and coastal transitional wetlands are seriously threatened as well. Salt marshes and associated at-risk birds and watersheds in the Lakes and Monadnock regions will likely undergo serious impacts from introduced plants in the near future. Invasive species seriously impact several other habitats including pine barrens, floodplain forests, and many watersheds.

3. KNOWN WILDLIFE EXPOSURE PATHWAYS

(A) Invasive invertebrates

A number of invasive exotic invertebrates have been introduced to the United States via mechanisms ranging from importation of commercial goods to intentional release for control of other invasive species.

TABLE 4-20. Number of habitats and species at highest risk from introduced species. See Table 4-21 and Appendix A and B for details. Risk Category 4 = Greatest risk.

Risk Category	Habitats	Species
4	0	3
3	2	1
2	8	6
1	12	13

New Hampshire officially recognizes 16 invasive exotic invertebrates that are prohibited for collection, importation, sale, distribution, propagation, or release (Chapter Agr 3800 Invasive Species).

Introductions of invasive invertebrates have significant consequences on critical habitats and associated wildlife species. For instance, hemlock wooly adelgid, first observed in New Hampshire in 2000, is a significant threat to the state's hemlock forests. The insects suck sap from young twigs, retarding or preventing tree growth and causing needles to turn grayish-green and drop prematurely, usually resulting in significant die-offs (McClure et al. 2001). There is some evidence that the adelgid's northward spread is controlled by winter temperatures, but it is unknown if control is sufficient to minimize impacts on New Hampshire's hemlock forests (Sheilds and Cheah 2003).

Ladybird beetles (*Coccinella septempunctata*) introduced to control aphids on agricultural crops are known to prey on Karner blue larvae and immature Monarch butterflies (Schellhorn et al. 2005). Being a generalist predator, ladybird beetles may also harm other species of butterflies.

Wasps and flies marketed and released as biological controls for agricultural pests are often generalist parasites with potentially widespread but undocumented effects on native Lepidoptera.

Zebra mussels have a high potential to signifi-

TABLE 4-21. Habitats and species at highest risk from introduced species, in descending order by Rank. See Appendix A and B for details additional information on specific threats and rankings.

		Ranking Scores*						
Species	Habitat	1	2	3	4	5	Rank	Class
SPECIES								
Dwarf Wedgemussel	Aquatic	4	4	3	3	4	3.33	4
Eastern Pondmussel	Aquatic	4	4	3	3	4	3.33	4
Roseate Tern	Coastal Islands	4	4	4	2	4	3.33	4
Karner Blue Butterfly	Pine Barrens	3	4	4	2	4	2.92	3
Nelson's Sharp-tailed Sparrow	Salt Marshes	3	2	4	4	4	2.50	2
Saltmarsh Sharp-tailed Sparrow	Salt Marshes	3	2	4	4	4	2.50	2
Seaside Sparrow	Salt Marshes	3	2	4	4	4	2.50	2
Willet	Salt Marshes	3	2	4	4	4	2.50	2
New England Cottontail	Shrublands	4	2	3	3	3	2.25	2
Brook Floater	Aquatic	2	3	3	2	4	1.88	2
HABITATS								
	Hemlock-Hardwood-Pine Forest	4	4	2	3	4	3.00	3
	Coastal Transitional Watersheds	3	3	3	4	4	2.75	3
	Salt Marshes	3	2	4	4	4	2.50	2
	Floodplain Forests	3	3	2	3	4	2.25	2
	Marsh and Shrub Wetlands	3	3	2	3	4	2.25	2
	Connecticut River Mainstem Watersheds	2	3	2	3	4	1.88	2
	Non-Tidal Coastal Watersheds	2	3	2	4	3	1.88	2
	Pine Barrens	2	3	2	3	4	1.88	2
	Southern Upland Watersheds	2	3	2	4	3	1.88	2
	Tidal Coastal Watersheds	2	3	2	4	3	1.88	2

* 1=Scope, 2=Severity, 3=Timing, 4=Likelihood, 5=Information

cantly affect the state's freshwater mussels, especially the state endangered dwarf wedgemussel. After their discovery in Lake Saint Clare in 1988, zebra mussels quickly spread throughout many regions of the United States and parts of Canada. Adult zebra mussels are transported to waterbodies 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 (Strayer 1999). The Connecticut River is at high to serious risk of zebra mussel colonization (Michelle Babione, Silvio O. Conte National Wildlife Refuge, personal communication).

(B) Range expansions and local introductions

A number of species have expanded their range or increased in abundance in the last 100 years either naturally or with the assistance of humans. For instance, coyotes have been expanding eastward since the mid-1900s. The first verified account of a coyote in New Hampshire was in Grafton County in 1944. Between 1972 and 1980 coyotes spread across the state and are now common in every county (O'Brien, undated).

People have likely contributed to the range expansion and increased abundance of mammalian predators (e.g., coyotes, foxes, raccoons, etc.). Readily available food sources (e.g., agricultural crops, trash, pet food, etc.) are thought to facilitate

population increases in landscapes fragmented by agriculture and development (Oehler and Litvaitis 1996). Boat visitation has been the vehicle for rat introductions on both Star and Appledore Islands, and raccoons were introduced to the island through an unknown source in 2004. Predation by medium-sized mammals is the most common proximate mortality factor of New England cottontail and has caused high mortalities of common and roseate terns on the Isles of Shoals (Barbour and Litvaitis 1993, Brown and Litvaitis 1995, DeLuca 2005).

(C) Horticultural introductions

Horticulture (arboretums, botanic gardens, nurseries, etc.) has been responsible for the introduction and spread of a number of exotic plants. In fact, the majority of woody invasive plants in the U.S. (85%) were introduced for horticultural purposes including landscaping, gardening, mitigation of soil erosion, and improving wildlife habitat (Reichard 1997 as cited in Reichard and White 2001). Some of these are officially listed as invasive in New Hampshire, including autumn olive, Japanese barberry, glossy buckthorn, and others (Eckardt 1997, Reinartz 1997, Silander and Klepeis 2001, New Hampshire Department of Agriculture 2005). These and other invasive exotic plants may decrease plant species diversity, produce allelopathic chemicals that retard other species, modify disturbance regimes, and significantly modify the species' composition and structure of vegetation (Silander and Klepeis 2001). These mechanisms may inhibit forest regeneration and degrade wildlife habitat.

(D) Aquatic pathways

Invasive exotic aquatic plants and animals enter lakes, streams, and rivers of New Hampshire watersheds via commercial transport, ballast water discharges, aquaculture, boating, landscaping, water transport, private aquarium releases, and bait handling (Courtenay and Robins 1973, Glassner-Shwayder 1996). Negative effects include alterations in nutrient cycling pathways, decreased habitat value of infested waters, decreased water quality, altered community structure, and threats to endangered species (e.g., dwarf wedgemussel) (Estuarine and Freshwater Working Group 2005). Eight of the 14 invasive plants prohibited in New Hampshire already occur in the state, with variable milfoil (*Myriophyllum heterophyllum*) and fanwort (*Cabomba caroliniana*), both aquatic plants, being the most common (Varney and Christie 2003). Twenty-three non-indigenous fish species have been introduced into New Hampshire waters. Of these, 17 are species native to the United States and 6 are species introduced from other countries (exotic). Fifty percent of the exotic species introductions resulted in establishing self-sustaining populations (Estuarine and Freshwater Working Group 2005).

(E) Disturbances that lead to invasions

Disturbance of a salt marsh, such as the construction of a road that restricts tidal flow, can exacerbate the proliferation of invasive plants (e.g., common reed (*Phragmites australis*) and purple loosestrife (*Lythrum salicaria*) (Niering and Warren 1980, Benoit and Askins 1999). The invasion of salt marsh habitats by exotic plants reduces habitat quality for a number of wildlife species. For instance, salt marsh sparrows, a species normally found in *Spartina* grasses, are unlikely to use a marsh dominated by tall, thick stands of common reed. Further, the density of these stands of reed may make prey inaccessible or may reduce foraging success (Benoit and Askins 1999).

Timber harvest in upland habitats can also exacerbate invasions. If invasive exotic plants are already present in or near a forest stand, opening the forest floor to additional sunlight and scarifying the soil with harvesting equipment can create conditions conducive to the spread of invasive exotic plants.

4. RESEARCH NEEDS

- Identify and monitor existing and potential transport mechanisms for invasive species
- Research and evaluate forms of invasive plant and animal control
- Collect data on invasive species abundance and distribution to identify current threat areas
- Identify species and sites for invasive species management, which can be combined with existing efforts (e.g., Invasive Plant Atlas of New England and New Hampshire's Estuarine and Freshwater Working Group)
- Research effects of introduced species on at-risk wildlife and associated habitats
- Assess habitat characteristics that facilitate invasions by exotic plants

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Mercury

1. DEFINITION

Though naturally occurring, mercury is an air and water quality issue that affects human and ecological health. The redistribution of inorganic mercury (Hg) that is available for methylation is a serious ecological issue in New Hampshire. Fossil fuel burning (particularly coal) and incineration of municipal and hospital waste has significantly enhanced availability of mercury. Some areas of New Hampshire are affected by within-state emission or point sources, while regional and global emissions have statewide impacts (Evers 2005). Mercury distribution is well characterized for northeastern North America (Evers and Clair 2005a). Many habitats are vulnerable to methylmercury (MeHg) production and availability, and species at risk are typically predators or are long-lived (Evers et al. 2005).

2. EXPERT OPINION

Methylmercury availability greatly affects species and habitats of conservation concern in New Hampshire, though habitat and species sensitivity varies. Impacts will likely be serious in salt marshes, marsh and shrub wetlands, and floodplain forests. Mercury will likely have a serious effect on aquatic and high-elevation habitats in the short-term. Methylmercury is well documented in aquatic habitats, somewhat documented in salt marsh, marsh and shrub wetlands, and high-elevation habitats, and weakly or undocumented in alpine and peatlands.

3. KNOWN WILDLIFE EXPOSURE PATHWAYS

(A) Piscivorous food webs

Fish are a primary food web pathway for methylmercury, making aquatic habitats and a broad suite of aquatic species at risk (Evers and Clairs 2005a).

TABLE 4-22. Number of habitats and species at highest risk from the effects of mercury. See Table 4-23 and Appendix A and B for details. Risk Category 4 = Greatest risk.

Risk Category	Habitats	Species
4	0	0
3	0	3
2	6	7
1	6	9

The loon is a long-lived fish eating bird and has been well studied across North America and in New Hampshire (Evers et al. 1998, 2003). Southeastern New Hampshire was identified as a biological hotspot for methylmercury availability (Evers 2005), and loon blood and egg mercury levels indicate approximately 14% of New Hampshire's breeding population is at risk to behavioral, physiological, and reproductive impacts. DeSorbo and Evers (2005) recently documented that lower bald eagle productivity for the past 10 years in Maine is significantly correlated to chick blood mercury levels. In rivers and streams, ospreys, common mergansers, and belted kingfishers are high trophic level species and have been shown to have elevated mercury levels (Evers et al. 2005). Mercury levels in kingfishers living on lakes are 4 times higher than those on the ocean. Marine foraging terns are less affected by methylmercury than are those foraging in estuaries and freshwater systems (BRI unpublished data). Aquatic mammals dependent on crayfish (Pennuto et al. 2005) and fish are also at high risk, particularly the mink and river otter (Yates et al. 2005).

(B) Insectivorous food webs

Recent work strongly indicates that insectivores can have elevated body burdens of mercury. A Massachusetts study in riverine scrub-shrub wetlands showed that methylmercury can biomagnify through

TABLE 4-23. Habitats and species at highest risk from the effects of mercury, in descending order by Rank. See Appendix A and B for details additional information on specific threats and rankings.

		Ranking Scores*						
Species	Habitat	1	2	3	4	5	Rank	Class
SPECIES								
Bald Eagle	Aquatic	3	4	4	2	4	2.92	3
Osprey	Marsh and Shrub Wetlands	4	3	2	3	4	2.63	3
Peregrine Falcon	Cliffs	4	3	2	3	4	2.63	3
Common Loon	Aquatic	3	2	4	4	4	2.50	2
Common Tern	Coastal Islands	4	2	3	3	4	2.50	2
Roseate Tern	Coastal Islands	4	2	3	3	4	2.50	2
Nelson's Sharp-tailed Sparrow	Salt Marshes	3	3	2	3	3	2.00	2
Saltmarsh Sharp-tailed Sparrow	Salt Marshes	3	3	2	3	3	2.00	2
Seaside Sparrow	Salt Marshes	3	3	2	3	3	2.00	2
Willet	Salt Marshes	3	3	2	3	3	2.00	2
HABITATS								
	Coastal Islands	4	2	3	3	4	2.50	2
	Appalachian Oak Pine Forest	4	2	2	3	4	2.25	2
	Hemlock-Hardwood-Pine Forest	4	2	2	3	4	2.25	2
	Northern Hardwood-Conifer Forest	4	2	2	3	4	2.25	2
	Salt Marshes	4	2	2	3	3	2.00	2
	High Elevation Spruce-Fir Forest	4	1.5	3	2	3	1.83	2

* 1=Scope, 2=Severity, 3=Timing, 4=Likelihood, 5=Information

the avian insect food web. Some individual northern waterthrushes and red-winged blackbirds had blood mercury levels that exceeded levels in all bald eagles sampled across New England (Evers et al. 2005). Other species at risk in marsh and shrub wetlands include the American bittern and Virginia rail. Estuaries, particularly those surrounded by developed landscapes, and floodplain forest, are prone to methylmercury pollution. Studies of the salt marsh and Nelson's sharp-tailed sparrow and seaside sparrow in four New England National Wildlife Refuges and other estuaries show that blood mercury levels exceed safe standards set for insectivorous songbirds (0.82 ppm, wet weight). These levels were consistently higher than those in associated insectivores, indicating upper trophic level foraging (Lane and Evers 2005). In floodplains, high blood mercury levels in the northern waterthrush indicate New Hampshire breeding species such as the red-shouldered hawk and Louisiana waterthrush could be at risk.

(B) Acidic habitats

Ecosystems sensitive to acidic conditions are of high interest for investigating potential impacts of methylmercury. The synergy of acidity and mercury deposition may harm breeding songbird populations. Long-term acid deposition has lowered calcium availability in the Northeast (Hames et al. 2002) and likely elsewhere in eastern North America (Driscoll et al. 2001), has changed invertebrate faunal assemblages (Schindler et al. 1985), and has increased methylmercury availability (Spry and Wiener 1991). Although not well studied, methylmercury in insectivorous birds and small terrestrial mammals such as shrews and bats may be more of a risk than previously considered. Two consistently acidic

habitats are peatlands and high elevation areas. Recent evidence from a riverine scrub-shrub wetland study of a 15-species insectivorous guild found red-winged blackbirds to carry the highest Hg body burdens (Evers et al. 2005). The rusty blackbird, which commonly inhabits peat lands, is a species of high conservation concern that may be harmed by elevated mercury levels. Since 1970, this species has declined precipitously, though the reasons for its troubles remain largely unexplained (Greenough 2005). However, blackbirds depending on insect food webs with an origin in acidified habitats may be harmed by the synergistic relationship of elevated methylmercury and low calcium levels during times of increased energy needs for proper eggs and chick production. Pied-billed grebes in peatland habitats could also be at high risk.

Higher mercury levels and lowered calcium levels in acidified environments at high elevation is of great concern. Rimmer et al. (2005) quantified the distribution of mercury across the Northeast and showed elevated blood mercury levels in the Bicknell's thrush. This species only breeds on mountaintops, generally in areas removed from standing water, indicating that mercury is much more pervasive than once thought and that it could be problematic for some terrestrial systems.

4. RESEARCH NEEDS

- Initiate a steering committee of state agencies (NHFG and NHDES) to work with federal agencies (US EPA, USFWS, USDA, and USGS), industry, universities, and non-profit organizations that will facilitate operations of the National Mercury Monitoring Network. Process should follow the successful mercury network by BRI with the Northeastern Ecosystem Research Cooperative.
- Compile a document that identifies the best indicator species and represents all relevant taxa for sensitive habitats and geographic areas in New Hampshire
- Conduct a spatial and temporal analysis of common loon exposure and risk statewide (in process with NHDES)
- Establish a long-term monitoring effort using common loon tissue levels and link with existing and new demographic data collected by the Loon Preservation Committee
- Conduct a risk assessment for species at greatest risk, including the common loon and bald eagle
- Conduct a risk assessment for habitats and their species assemblages
- Collect new tissue samples from species and habitats with little empirical information on mercury exposure, particularly those with compelling evidence of mercury injury. The priority species are the red-shouldered hawk, Bicknell's thrush, and rusty blackbird. Priority habitats are peatlands, high elevation areas, and floodplain forest. Secondary priority should be on the pied-billed grebe, American bittern, and Virginia rail in selected wetland habitats (depending on geography and types).

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Non-point Source Pollution

1. DEFINITION

Non-point source pollution results from land use that allows harmful substances, such as sediments, road salt, fertilizers, pesticides, and petrochemicals, to be flushed into water bodies by rain or snowmelt (New Hampshire Department of Environmental Services (NHDES) 1999). Non-point source pollution is more pervasive and difficult to address than point sources, which are regulated by the Clean Water Act (amended in 1977). Improving water quality will require a broad effort to identify and address the many pathways by which pollutants enter aquatic habitats.

2. EXPERT OPINION

Non-point source pollutants affect many species and habitats of concern in New Hampshire. Impacts will likely be serious for lowland spruce-fir forests and some watershed groups and associated fish, as well as all three freshwater mussel species on the SGNC list in New Hampshire. The impacts from non-point source pollution—primarily from pesticides/fertilizers, stormwater runoff, and sedimentation—to these habitats and associated species are well documented. Severe impacts to other natural communities also likely occur but are not well documented.

3. KNOWN WILDLIFE EXPOSURE PATHWAYS

(A) Stormwater runoff

In 1998, non-point source pollution was the suspected cause for 92% of sampled water bodies that did not achieve state water quality standards in New Hampshire (NHDES 1999). Runoff from agricultural lands, forestry operations, faulty septic systems, industry, landscaping activities, roads, golf courses, landfills, junkyards, and wastewater treatment facilities can affect aquatic systems by contributing excessive nutrients (e.g., phosphorus and nitrogen) and other pollutants (e.g., heavy metals, organic compounds, and sediment) (Richter et al. 1997, NHDES 1999, Francis and Mulligan 1997). Introduced nutrients from fertilizers entering aquatic systems can change plant composition in wetland communities and cause algal blooms, reducing dissolved oxygen concentrations enough to kill or displace fish and invertebrates (Carpenter et al. 1998).

TABLE 4-24. Number of habitats and species at highest risk from the effects of non-point source pollution. See Table 4-25 and Appendix A and B for details. Risk Category 4 = Greatest risk.

Risk Category	Habitats	Species
4	0	0
3	3	3
2	7	4
1	14	20

Combined Sewer Overflows (CSOs), which allow waste water treatment plants to release untreated wastewater into water bodies during heavy rain, increase nutrient and turbidity levels and prolong the presence of persistent toxins in riverine habitats. New Hampshire currently has 47 identified CSOs in 6 communities (NHDES 2003).

Stormwater runoff from impervious surfaces (e.g., roofs, roads, and parking lots) often flows directly into aquatic systems. These surfaces accumulate a variety of contaminants including petroleum products, lead, PCBs, road salt, sand, pesticides, and fertilizers (United States Environmental Protection Agency 2005). The decline in aquatic species diversity as watersheds become more urbanized is well documented (Weaver and Garman 1994, Richter et al. 1997). In a Massachusetts fen community, species richness, evenness, and the abundance of individual species were adversely impacted by high sodium and

TABLE 4-25. Habitats and species at highest risk from the effects of non-point source pollution, in descending order by Rank. See Appendix A and B for details additional information on specific threats and rankings.

		Ranking Scores*						
Species	Habitat	1	2	3	4	5	Rank	Class
SPECIES								
Dwarf Wedgemussel	Aquatic	4	3	4	4	3	3.21	3
Brook Floater	Aquatic	3	3	4	4	3	2.75	3
Eastern Pondmussel	Aquatic	3	3	4	4	3	2.75	3
Northern Leopard Frog	Grasslands	4	3	2	3	3	2.33	2
Bald Eagle	Aquatic	3	2	2	3	4	1.88	2
Osprey	Marsh and Shrub Wetlands	3	2	2	3	4	1.88	2
Peregrine Falcon	Cliffs	3	2	2	3	4	1.88	2
HABITATS								
	Lowland Spruce Fir Forest	3	4	3	3	4	2.92	3
	Connecticut River Mainstem Watersheds	3	3	4	3	4	2.75	3
	Non-Tidal Coastal Watersheds	3	3	4	4	3	2.75	3
	Coastal Transitional Watersheds	3	3	3	3	3	2.25	2
	Tidal Coastal Watersheds	3	3	3	3	3	2.25	2
	Montane Watersheds	2	3	4	3	3	2.08	2
	Hemlock-Hardwood-Pine Forest	3	3	2	2	4	2.00	2
	Northern Upland Watersheds	3	3	3	3	2	2.00	2
	Peatlands	2	3	3	3	3	1.88	2
	Southern Upland Watersheds	2	3	3	3	3	1.88	2

* 1=Scope, 2=Severity, 3=Timing, 4=Likelihood, 5=Information

chloride concentrations along a turnpike (Richburg et al. 2001). Roadside vernal pools in New Hampshire had higher levels of both sodium and chloride and lower embryonic survival of spotted salamander larvae when compared to woodland vernal pools (Turtle 2000).

(B) Sedimentation

Bank erosion and sediment deposition are natural processes that can be accelerated by human activity. Increased impervious surfaces, road upgrades, poor forestry practices, residential development, wetland filling, dredging and filling, mining, water level fluctuations, recreational vehicles, riparian zone alterations, channelization, and boat wakes increase bank erosion (Alexander and Hansen 1983, Connecticut River Joint Commission (CRJC) 2002, Francis and Mulligan 1997, Zankel 2004). Shoreline stabilization projects may reduce erosion at a specific location, but negatively affect downstream locations (CRJC 2002). Sedimentation can alter natural community composition and reduce population sizes of fish, amphibians, and benthic invertebrates by increasing turbidity and burying cobble, gravel, and boulder substrates (Hedrick et al. 2005). Soil particles entering wetlands can affect hydrology and vegetation (Mahaney et al. 2004). A survey of 1,300 landowners along the Connecticut River indicated bank erosion as their primary concern (NHDES 1999).

(C) Chemical applications

Broad-spectrum chemical herbicides and insecticides applied to forests to control hardwood regeneration and outbreaks of eastern spruce budworm caterpillars (*Choristoneura feranafumi*) can enter stream systems soon after application, affecting wildlife, aquatic

habitats, and human health (Miller 1982, Rashin and Graber 1993). Developed resistance from insecticides by spruce budworms makes chemical applications less effective (Natural Resources Canada 1997).

Toxic effects of pesticides involve the bioaccumulation of toxins within fat tissue. At high doses, exposure can result in acute toxicity and death. At lower doses, toxins may be released during periods of negative energy balance such as hibernation or lactation in species such as bats (Kunz et al. 1977). Deposited heavy metals and organic compounds accumulate and persist in the sediment and bioaccumulate in the tissue of fish and benthic communities (NHDES 1999).

The use of chlorinated hydrocarbons (e.g., DDT) causes eggshell thinning in raptors. Although DDT has been banned in the U.S., it is still used on the wintering grounds of many raptor prey species (NatureServe 2005). Continued exposure by raptors to DDT is hypothesized to result from foraging on contaminated migratory birds returning from the tropics.

4. RESEARCH NEEDS

- Expand water quality monitoring to include a greater variety of aquatic habitats
- Compare areas known to be receiving polluted runoff with areas that are relatively pristine
- Monitor the long-term effects of pesticides on the reproductive fitness of avian predators

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Oil Spills

1. DEFINITION

Oil can be introduced into marine and coastal environments by spills, leaks, or discharges from onshore tanks, vehicles, offshore facilities, and boats. Offshore oil spills from tanker accidents or leakage can significantly harm coastal species and habitats. Oil runoff from impervious surfaces may have smaller and more localized impacts. Due to the high concentration of some species during the breeding or wintering seasons, oil spills can decimate local wildlife. Oil spills are likely to cause immediate adverse effects on wildlife and long-term effects because oil is persistent in some areas (Johnston 1984).

2. EXPERT OPINION

The effect of oil spills may be very localized or very extensive depending on the source and timing of the contamination and the affected species or habitat. Impacts could be serious for sand dunes and coastal islands and associated species (i.e., roseate and common terns, piping plovers) either immediately or in the long term. The effects of oil spills on dunes and coastal islands are well documented.

3. KNOWN WILDLIFE EXPOSURE PATHWAYS

Oil can enter fresh and marine waters from platform construction, drilling, shipping, and spillage, and low-level seepage from surface runoff or subsurface sources (Boesch et al. 2001). Animals coated in oil may experience direct mortality or reduced reproductive success, food can become contaminated, toxins can build up in upper trophic levels, and oil can coat the shores and degrade habitat (Kushlan et al. 2002). The harmful effect of oil on birds is well documented (Chardine 1990). Externally, even a small amount of oil can destroy the weatherproofing and insulating properties of avian plumage resulting in hypothermia and inability to fly, stay afloat, and forage. Ingestion of oil can have equally life threatening toxic effects on the gastrointestinal tract, pancreas, and liver (Pierce 1991).

TABLE 4-26. Number of habitats and species at highest risk from the effects of oil spills. See Table 4-27 and Appendix A and B for details. Risk Category 4 = Greatest risk.

Risk Category	Habitats	Species
4	0	2
3	1	1
2	1	2
1	2	5

In 1996, 1,000 gallons of fuel oil were spilled into the Piscataqua River, rapidly entering Great and Little Bays. Nests in the Hen Island tern colony in Little Bay were oiled during incubation. The island was used to anchor containment booms and serve as point for cleanup activity. Data from the New Hampshire Gulfwatch monitoring program documented high levels of polycyclic aromatic hydrocarbons (PAH) in mussels following the spill, followed by a gradual recovery to baseline levels within 2 years (Gulf of Maine Council on the Marine Environment 2003).

An oil spill off the Rhode Island coast resulted in the loss many loons (Evers et al. 2002), and the potential for oil spill impacts to New Hampshire's wintering loon population exists as well. The concentration of common terns and roseate terns on Seavey Island and piping plovers on Seabrook/ Hampton beaches makes an oil spill in the nearby waters potentially catastrophic. Other species potentially harmed include nesting and wintering birds, marine mammals, fish, turtles, and marine and estuarine invertebrates (Research Planning, Inc. 2004). Locations and critical time periods for species and habitats were identified and mapped in case an oil spill occurs again (Research Planning, Inc. 2004).

TABLE 4-27. Habitats and species at highest risk from the effects of oil spills, in descending order by Rank. See Appendix A and B for details additional information on specific threats and rankings.

Species	Habitat	Ranking Scores*					Rank	Class
		1	2	3	4	5		
SPECIES								
Common Tern	Coastal Islands	4	4	4	2	4	3.33	4
Roseate Tern	Coastal Islands	4	4	4	2	4	3.33	4
Piping Plover	Dunes	4	4	4	1	3	2.67	3
Common Loon	Aquatic	3	4	2	1	4	2.04	2
Bald Eagle	Aquatic	1	4	3	2	4	1.88	2
HABITATS								
	Dunes	4	4	2	2	4	2.67	3
	Coastal Islands	3	4	1	2	4	2.04	2

* 1=Scope, 2=Severity, 3=Timing, 4=Likelihood, 5=Information

4. RESEARCH NEEDS

- Assess potential impacts of an oil spill near threatened and endangered species breeding grounds (i.e., Seavey Island, Hampton Beach State Park and Seabrook Town Beach)
- Conduct long-term assessments and biodiversity surveys of coastal islands, dunes, and salt marshes before and after oil spills to determine effects
- Identify appropriate mitigation for loss of wildlife due to oil spills

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Predation and Herbivory

1. DEFINITION

Wildlife abundance and distribution can increase dramatically in response to human modifications to habitats and from the provision of supplemental food sources. For example, landfills and coastal developments provide gulls with nearly limitless food, and gulls subsequently eliminate other seabirds through competition and predation. Species with broad diets, such as raccoons, skunks, and crows, can thrive on food provided by trash, gardens, and bird feeders. Cats and dogs are capable predators with no natural population constraints. In the absence of predators or hunting, white-tailed deer can reach densities high enough to reduce or eliminate insect host food plants. Beaver can affect certain wetland natural community types (e.g., black gum swamps) that beavers historically rarely used. Rare species are often vulnerable to predation and competition from species that are better adapted to human activity.

2. EXPERT OPINION

Coastal birds of conservation concern are highly susceptible to mortality from subsidized predators, especially gulls. The threat is well documented and somewhat localized, yet severe, in dunes and coastal islands. More widespread but less severe harm likely occurs to species in cities and towns where predator densities are high and where domestic animals prey on wildlife.

3. KNOWN WILDLIFE EXPOSURE PATHWAYS

(A) Gulls

The protection of all seabirds, changes in human land use along coastal islands, a rise in the fishing industry, and the use of open landfills allowed for exponential increases in the numbers of gulls along the entire northeastern coast. Herring gulls began nesting on the Isles of Shoals in the 1920s, and the population peaked at 5,000 pairs in the late 1970s. Great black-backed gulls began nesting on the Islands in the 1950s and have steadily been replacing herring gulls (numbers compiled from Drury 1973, Borror and Holmes 1990, United States Fish and Wildlife Service (USFWS) Colonial Waterbird Survey 1995). These larger, more aggressive birds compete with terns for nesting sites and can prey directly on tern eggs and chicks (Goodale 2000, Donehower 2003). Data suggest that lobster bait is the primary food of herring gull chicks in Penobscot Bay. The frequency of lobster bait in the herring gull chick diet on 5 study islands was 56% in 1999 (n=251) and 41% in 2000 (n=605) (Goodale 2000).

TABLE 4-28. Number of habitats and species at highest risk from the effects of predation and herbivory. See Table 4-29 and Appendix A and B for details. Risk Category 4 = Greatest risk.

Risk Category	Habitats	Species
4	1	3
3	1	3
2	1	2
1	2	12

(B) Other Predators

Increased development and human use of coastal areas have allowed for an abundance of potential tern and plover predators (USFWS 1998, Kress and Hall 2004). Mammalian predators such as feral cats, rats, raccoons, mink, skunk, and fox that gain access to breeding habitats can devastate some local bird populations. Additionally, avian predators such as Great horned owls and black-crowned night herons feed on tern chicks and adults. Predation is a proximate mortality factor for New England cottontails, particularly those that occupy small habitat patches (Barbour and Litvaitis 1993, Brown and Litvaitis 1995, Villafuerte et al. 1997).

TABLE 4-29. Habitats and species at highest risk from the effects of predation and herbivory, in descending order by Rank. See Appendix A and B for details additional information on specific threats and rankings.

Species	Habitat	Ranking Scores*					Rank	Class
		1	2	3	4	5		
SPECIES								
Piping Plover	Dunes	4	4	4	3	4	3.67	4
Common Tern	Coastal Islands	4	3	4	4	4	3.50	4
Roseate Tern	Coastal Islands	4	3	4	4	4	3.50	4
New England Cottontail	Shrublands	4	3	3	4	4	3.21	3
Karner Blue Butterfly	Pine Barrens	3	3	3	4	4	2.75	3
Purple Martin	Grasslands	4	3	2	3	4	2.63	3
Rusty Blackbird	Lowland Spruce-Fir Forest	2	4	4	3	3	2.50	2
Non-breeding Birds		3	2	3	3	3	1.88	2
HABITATS								
	Coastal Islands	4	3	4	4	4	3.50	4
	Dunes	4	3	4	3	4	3.21	3
	Shrublands	2	3	3	3	4	2.08	2

* 1=Scope, 2=Severity, 3=Timing, 4=Likelihood, 5=Information

(C) Herbivory

Heavy browsing of blue lupine plants by white-tailed deer and woodchuck can severely reduce blue lupine populations and result in Karner blue butterfly mortality by accidental ingestion of eggs and larvae.

4. RESEARCH NEEDS

- Evaluate predator control techniques to protect common, roseate, and arctic terns and piping plovers
- Determine ecology of gull populations at Isle of Shoals, including sources and importance of human-subsidized food
- Evaluate modifications to fishing and aquaculture practices to minimize subsidization of gulls and other predators
- Evaluate effect of landfills on predator abundance, impacts to at-risk species, and modifications to reduce impacts
- Evaluate locations and extent of human food supplements for predators in rare species habitats

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Recreation

1. DEFINITION

Most Americans participate in some kind of outdoor recreation. Recreation demand and trends in New Hampshire show a marked increase in the past 10 years (New Hampshire Office of State Planning 2003). For example, the White Mountain National Forest saw a 23 percent increase in trail use between 1974 and 1995 (New Hampshire Office of State Planning, 1997). Between 1996 and 2003, wheeled off-highway recreational vehicle (a.k.a., ATV) registrations in New Hampshire more than doubled for resident and more than tripled for non-resident owners. Similarly, boating registrations doubled between 1980 and 1990 and continued to increase by 19 percent from 1990 to 2000.

Recreational activities often degrade land, water, and wildlife resources by simplifying plant communities, increasing animal mortality, displacing and disturbing wildlife, and distributing refuse (Boyle and Samson 1985). Some activities may have little or no effect. A number of factors influence the nature and severity of recreational impacts on wildlife, including the characteristics of the activity (type, location, time, predictability, frequency, magnitude) and the characteristic of the habitat or wildlife (species, group size, age, and sex) (Knight and Cole 1995).

2. EXPERT OPINION

Recreational activity is currently affecting species and habitats of conservation concern in New Hampshire. These effects are projected to continue into the foreseeable future. Impacts are likely serious to critical and well-documented for species inhabiting the rarest habitats, such as dunes, caves, coastal islands, cliffs, rocky ridges, and some aquatic habitats (such as sand-cobble shores and banks). Recreation is a serious localized threat to a subset of alpine natural communities. Grasslands, forests, and aquatic habitats may be seriously impacted, depending on specific local recreational activities.

TABLE 4-30. Number of habitats and species at highest risk from the effects of recreation. See Table 4-31 and Appendix A and B for details. Risk Category 4 = Greatest risk.

Risk Category	Habitats	Species
4	1	2
3	3	7
2	9	6
1	19	27

3. KNOWN WILDLIFE EXPOSURE PATHWAYS

(A) Human disturbance

Activities such as wildlife viewing, fishing, climbing, caving (or spelunking), boating, snowmobiling, ATV-ing, and hiking can cause unintentional disturbance. Disturbance from these activities may alter behavior and in some cases cause nest abandonment. For example, disturbance by anglers and boaters can disturb nesting and foraging activity of common loons (Titus 1978, Titus and VanDruff 1981, Christenson 1981, Kelly 1992). Depending on the time of year, water-based recreation can disturb roosting, feeding, or breeding by a variety of wildlife (Knight and Cole 1995). Offshore boating activities (whale watching, fishing, tour boats) can flush species from coastal islands, causing them to expend energy reserves (United States Fish and Wildlife Service (USFWS) 1994). Piping plovers lose valuable foraging time when beach goers and their pets are present (Burger 1991, Staine and Burger 1994). Snowmobiles can disturb deer that are concentrated in deer yards.

A study by Thomas (1995) of non-tactile disturbance from visits to hibernacula indicated a dramatic arousal of bats (little brown bats and northern myotis) and an increase in flight activity, and repeated

TABLE 4-31. Habitats and species at highest risk from the effects of recreation, in descending order by Rank. See Appendix A and B for details additional information on specific threats and rankings.

Species	Habitat	Ranking Scores*					Rank	Class
		1	2	3	4	5		
SPECIES								
Piping Plover	Dunes	4	4	4	4	4	4.00	4
Common Loon	Aquatic	4	3	4	4	4	3.50	4
Peregrine Falcon	Cliffs	4	3	4	3	4	3.21	3
Cobblestone Tiger Beetle	Aquatic	4	3	3	3	4	2.92	3
Eastern Pipistrelle	Caves and Mines	4	3	3	3	4	2.92	3
Bald Eagle	Aquatic	4	2	3	4	4	2.75	3
Indiana Bat	Caves and Mines	4	3	3	3	3	2.63	3
Northern Myotis	Caves and Mines	4	3	3	3	3	2.63	3
Small Footed Bat	Caves and Mines	4	3	3	3	3	2.63	3
Osprey	Marsh and Shrub Wetlands	4	2	3	4	3	2.50	2
Brook Floater	Aquatic	1	4	4	4	3	2.29	2
Common Tern	Coastal Islands	3	3	3	2	4	2.25	2
Roseate Tern	Coastal Islands	3	3	3	2	4	2.25	2
Karner Blue Butterfly	Pine Barrens	2	3	4	3	3	2.08	2
Spruce Grouse	Lowland Spruce-Fir Forest	3	1	4	4	3	1.83	2
HABITATS								
	Dunes	4	4	4	4	4	4.00	4
	Caves and Mines	3	3	4	4	4	3.00	3
	Cliffs	3	3	4	3	4	2.75	3
	Talus Slopes and Rocky Ridges	3	3	4	3	4	2.75	3
	Hemlock-Hardwood-Pine Forest	4	2	4	3	3	2.50	2
	High Elevation Spruce-Fir Forest	2	3	4	4	4	2.50	2
	Northern Hardwood-Conifer Forest	4	2	4	3	3	2.50	2
	Appalachian Oak Pine Forest	4	2	3	3	3	2.25	2
	Coastal Islands	3	3	3	2	4	2.25	2
	Coastal Transitional Watersheds	3	3	3	3	3	2.25	2
	Pine Barrens	2	3	4	3	3	2.08	2
	Shrublands	3	3	3	3	2	2.00	2
	Lowland Spruce-Fir Forest	1	3	4	4	4	2.00	2

* 1=Scope, 2=Severity, 3=Timing, 4=Likelihood, 5=Information

disturbance may lead to energy depletion to the point of mortality. The presence of low flying aircraft can frighten cliff nesting avian species from their nests, causing them to inadvertently kick out eggs or chicks from the nest (White et al. 2002). Noise disturbance from off-highway recreational vehicles and boats may cause detectable behavioral changes (Bowles 1995). Off-road all terrain vehicles (ATVs) and snowmobiles can be a significant disturbance to wildlife.

(B) Habitat degradation

All forms of recreation can modify vegetation, soil, water, and microclimate, affecting those species that depend on specific habitat conditions (Cole and Landres 1995). ATVs and snowmobiles can significantly degrade terrestrial and wetland habitats, causing erosion, sedimentation, altered hydrology, and acting as a vector for invasive species.

Though robust in their ability to withstand severe environmental conditions, alpine communities and their soils have low tolerances for trampling, particularly dwarf heath shrubs and erect forbs (Sperduto and Cogbill 1999, Cole and Monz 2002). Hikers can trample vegetation, causing soil erosion and reductions in vegetative cover and height. The removal of vegetation to create new climbing routes can cause wind and rain to wash away any remaining soil in the cracks, preventing new plants from being established (Camp and Knight 1991). Rock climbing can introduce non-native species when propagules travel on climbing equipment, shoes, and clothing that are transferred from one location to another (McMillian and Larson 2002).

Snow-based recreation can also affect soils and vegetation. The most pronounced impacts are those associated with ski-resort development that involves tree cutting and ground surface leveling and facility construction. Snowmobiles damage shrubs and saplings (Neumann and Merriam 1972), reduce vegetation abundance, and change species composition (Keddy et al. 1979). Water is affected both by water–based recreation, such as fishing and boating, and by land-based activities such as hiking and off-road vehicles. Trampling affects shorelines by eroding soils, eliminating protective cover, and causing sedimentation and turbidity (Cole and Landres 1995).

(C) Mortality

Recreation may directly or indirectly result in wildlife mortality. Off-road vehicles can be a source of mortality for ampibians, reptiles, and other wildlife. Walkers can inadvertently trample eggs and chicks if walking across coastal islands or dunes. Fourteen percent of loon mortality in New England from 1989 to 1996 was due to boat trauma (Miconi et al. 2000), and lead poisoning by ingesting lead fishing sinkers and jigs is the largest cause of known adult loon mortality in New Hampshire (Tufts University Wildlife Clinic, unpublished data). Additionally, incidental take occurs when one species is mistaken for another, as when upland bird hunters mistake spruce grouse for ruffed grouse and when American marten are caught in fisher traps (Jillian Kelly, NHFG, personal communication). Studies on recreational effects on tiger beetle populations have indicated populations were low to nonexistent where heavy recreational activities were observed and that abundance increased in areas where recreational use was limited and vehicles were prohibited (USFWS 1990). A long-term study in Connecticut documented the extirpation of two wood turtle populations following an increase in human recreation (Garber and Burger 1995).

4. RESEARCH NEEDS

- Studies of site-specific potential for mortality and other threats to New Hampshire's priority wildlife
- Measure energetic costs of behavioral responses to disturbance
- Measure habitat responses to recreation and population responses to recreationally induced habitat change

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Scarcity

1. DEFINITION

All wildlife species have a minimum effective (self-sustaining) population size (Allee et al. 1949). In populations that are depressed or isolated, the reproductive contribution of successfully breeding individuals may be disproportionately high, limiting natural buffering of random demographic and genetic variation and decreasing population stability (Allee et al. 1949, Richter-Dyn and Goel 1972, Ferson and Burgman 1990, Dennis et al. 1991). Susceptibility to failure of demographic processes may be compounded by normal (extrinsic) ecological events, such as weather, competition, or predation, or natural disturbance, resulting in extinction (Caughley 1994). Some wildlife have naturally low minimum effective population sizes because of their life history traits or dependency on uniquely occurring ecological conditions (Allee et al. 1949, Adler and Nuernberger 1994). In either case, the balance between reproductive success and ecological process is precarious, and the risk of localized extinction is high.

2. EXPERT OPINION

Small population size is an extensive to somewhat localized threat for a small number of New Hampshire's wildlife, and particularly severe for species with highly specialized habitat or life history traits. Threats are well documented for timber rattlesnakes, piping plovers, roseate terns, cobblestone tiger beetles, and Karner blue butterflies.

3. KNOWN WILDLIFE EXPOSURE PATHWAYS

(A) Demographic stochasticity

Some severely depressed or declining populations of wildlife are immediately at risk of extirpation (Dennis et al. 1991, Goodman 1987). New Hampshire's timber rattlesnake population is very small and is extremely isolated from other populations, and potential den sites are rare. The host plant of the Karner blue butterfly is rare. After declining sharply between 1980 and 2001, with a corresponding decline in fecundity (United States Fish and Wildlife Service, unpublished data), Karner blues were not observed in the wild until translocated butterflies were released in 2002 (NHFG, unpublished data). Low population densities and skewed age and sex ratios have raised concerns over the effect of road mortality on the viability of some turtle populations in the region (Marchand and Litvaitis 2004, Gibbs and Steen 2005).

TABLE 4-32. Number of habitats and species at highest risk from the effects of scarcity. See Table 4-33 and Appendix A and B for details. Risk Category 4 = Greatest risk.

Risk Category	Habitats	Species
4	0	5
3	0	9
2	0	3
1	1	6

(B) Ecological conditions

Until population health is restored, some severely depressed or recovering populations of wildlife are immediately at risk of extirpation due to widespread ecological conditions (Caughley 1994), like weather (Pollard 1991) and predation. Failure to exclude predators has resulted in the failure of common and roseate terns colonies in the Gulf of Maine (Donehower 2003). Annually in New Hampshire, a significant proportion of the state's few piping plover nests fail because of predation and storms (NHFG, unpublished data). Overwintering survival of Karner blues may be limited by the number of days with snow cover (Dirig 1994), and in general, mating success, oviposition, and lepidopteran survival are limited by

TABLE 4-33. Habitats and species at highest risk from the effects of scarcity, in descending order by Rank. See Appendix A and B for details additional information on specific threats and rankings.

Species	Habitat	Ranking Scores*					Rank	Class
		1	2	3	4	5		
SPECIES								
Timber Rattlesnake	Appalachian Oak Pine Forest	4	4	4	4	4	4.00	4
Cobblestone Tiger Beetle	Aquatic	4	4	4	3	4	3.67	4
Karner Blue Butterfly	Pine Barrens	4	4	4	3	4	3.67	4
Roseate Tern	Coastal Islands	4	4	4	3	4	3.67	4
Piping Plover	Dunes	4	3	4	4	4	3.50	4
Blandings Turtle	Marsh and Shrub Wetlands	4	4	1	4	4	3.00	3
Lynx	Upland Forests	4	4	2	3	4	3.00	3
Spotted Turtle	Marsh and Shrub Wetlands	4	4	1	4	4	3.00	3
American Marten	High Elevation Spruce-Fir Forest	3	4	4	4	2	2.92	3
White Mountain Arctic	Alpine	4	4	3	3	2	2.67	3
White Mountain Fritillary	Alpine	4	4	3	3	2	2.67	3
Spruce Grouse	Lowland Spruce-Fir Forest	4	3	4	3	2	2.63	3
Marbled Salamander	Marsh and Shrub Wetlands	4	4	3	3	1	2.33	2
Hognose Snake	Pine Barrens	4	3	3	2	3	2.33	2
Ringed Boghaunter	Peatlands	2	4	3	2	3	2.00	2

* 1=Scope, 2=Severity, 3=Timing, 4=Likelihood, 5=Information

weather (Pollard 1991, USFWS 2002). Cobblestone tiger beetle larvae inhabit burrows for 2 years at one location in the Connecticut River, and population estimates seldom exceed 100 individuals. Flooding or hydrologic alteration could decimate the population (Nothnagle 1993). During winters with unusually shallow snow depth, New Hampshire's small marten population may be limited by competition with overlapping fisher populations. Kelly (2005) found that areas with low catch per unit effort for fisher were more likely to have higher values for marten. Krohn et al. (1995) observed differing age and recruitment ratios for marten across areas of overlap with fisher.

(C) Population isolation

Isolated or sparsely distributed populations may be subject to adverse demographic and genetic effects because of limited immigration (Nei 1972, Brown and Kodric-Brown 1977, Fahrig and Merriam 1985, Pulliam 1988, Taylor et al. 1993). Viability of the low density New Hampshire lynx population may depend on lynx dispersing from larger populations (Litvaitis et al. 1991). Increasing southern Canadian and northern Maine human populations may hamper lynx dispersal (Carroll 2005). Spruce grouse are isolated in the WMNF (Todd 2003), and their habitats are fragmented by conversion of low elevation spruce and fir habitat to deciduous land cover (NHFG GIS). Historic Karner blue butterfly and extant frosted elfin populations are separated by distances greater than documented dispersal capabilities (King 1998). Ringed boghaunter populations are sparsely distributed, little is known about their dispersal, and habitat utilization may be hampered by development.

(C) Natural rarity and sensitive life history

Because of their life history traits or unique ecological niches, some species have naturally small breeding populations (Allee et al. 1949). Small changes in survival rates, landscape connectivity, or habitat availability may result in extirpation. Blanding's, box, wood, and spotted turtles may require 5 to 15

years to reach sexual maturity in New Hampshire (Carroll 1991, Degraaf and Yamasaki 2001) and therefore require high adult survival. Bog lemming observations are rare in New Hampshire. Although little is known about the life history traits driving their rarity in New Hampshire, elsewhere the species appears to occur in isolated metapopulations with few individuals in each location and limited dispersal (Clough and Albright 1987, Reichel and Corn 1997). Disruption of individual colonies in a metapopulation may jeopardize the entire metapopulation (Hanski and Simberloff 1997). Marbled salamanders are extremely rare in New Hampshire but little is known about their population dynamics. White Mountain fritillary and arctic butterflies are endemic to New Hampshire, occur only on Mt. Washington, and may be susceptible to climate change (Pollard 1991, McFarland 2003).

4. RESEARCH NEEDS

- Evaluate population genetic structure for the New Hampshire timber rattlesnake population
- Evaluate opportunities to develop captive breeding in zoos for high priority species, especially invertebrates
- Investigate link between species population dynamics and habitat / natural community distribution and conditions

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Transportation Infrastructure

1. DEFINITION

As human populations grow and expand, the demand for improved and more extensive transportation networks rises. Major transportation infrastructures in New Hampshire include roads, railroads, and airports. Direct threats from construction, improvements, maintenance, and regular use of transportation networks include habitat loss and fragmentation, inhibition of wildlife dispersal, and direct mortality. Several indirect threats are known and summarized under Altered Hydrology, Development, Introduced Species, Mercury, Non-point Source Pollution, and Predation and Herbivory (see Forman et al. 2003 for a detailed review of known impacts).

2. EXPERT OPINION

Roads have a somewhat to very extensive effect on species and habitats of conservation concern in New Hampshire. Well-documented impacts are likely to be critical for Appalachian oak pine forests, and serious for pine barren species, vernal pools, marsh and shrub wetlands, and floodplain forests in the near term. In the next decade, threats may become critical or serious to rare species, including timber rattlesnake, hognose snake, black racer, Blanding's, spotted, and wood turtles, Jefferson salamander, Fowler's toad, American marten, and Karner blue butterfly. In the longer term, threats will be serious or greater for many forest habitats, watersheds, and wide-ranging species, and area-sensitive species.

3. KNOWN WILDLIFE EXPOSURE PATHWAYS

(A) Rapid growth

New Hampshire's human population density and associated development are rapidly increasing, especially in the southern counties (Society for Protection of New Hampshire Forests 2005).

TABLE 4-34. Number of habitats and species at highest risk from the effects of transportation infrastructure. See Table 4-35 and Appendix A and B for details. Risk Category 4 = Greatest risk.

Risk Category	Habitats	Species
4	1	0
3	3	8
2	8	4
1	6	12

Increasing human population density leads to increasing road densities, road widening, and traffic volume (see Development threat).

(B) Uncoordinated planning

Local land use planning efforts often are isolated from large-scale conservation planning efforts. Lack of planning and coordination among towns, transportation and natural resources agencies, and the conservation community may result in the most ecologically significant resources being affected.

(C) Habitat loss and fragmentation

The construction of roads, railroads, and airports results in a considerable loss of habitat (Trombulak and Frissell 2000). Wildlife is affected well beyond the scope of the actual physical disturbance (Forman 2000, Forman and Deblinger 2000, Jones et al. 2000). For example, effects of roadway noise may extend hundreds of meters from a heavily traveled road, reducing species occupation (e.g., forest interior birds) and altering behavior (Forman and Deblinger 2000, Forman et al. 2003). Areas bisected by roads result in smaller blocks of contiguous habitat, fragmenting the landscape, reducing habitat quality, and isolating populations (Saunders et al. 1991)

(D) Vegetation management

Areas surrounding airport runways and roadsides

TABLE 4-35. Habitats and species at highest risk from the effects of transportation infrastructure, in descending order by Rank.See Appendix A and B for details additional information on specific threats and rankings.

		Ranking Scores*						
Species	Habitat	1	2	3	4	5	Rank	Class
SPECIES								
Jefferson Salamander	Vernal Pools	4	3	3	4	4	3.21	3
Blandings Turtle	Marsh and Shrub Wetlands	4	4	2	3	4	3.00	3
Spotted Turtle	Marsh and Shrub Wetlands	4	4	2	3	4	3.00	3
Fowlers Toad	Pine Barrens	4	3	2	4	4	2.92	3
Northern Leopard Frog	Grasslands	4	3	2	4	4	2.92	3
Karner Blue Butterfly	Pine Barrens	2	4	4	4	3	2.75	3
Racer	Pine Barrens	4	4	2	3	3	2.67	3
Hognose Snake	Pine Barrens	4	3	3	3	3	2.63	3
Wood Turtle	Floodplain Forests	4	3	1	3	4	2.33	2
American Marten	High Elevation Spruce-Fir Forest	3	2	4	4	3	2.29	2
Bobcat	Upland Forests	4	3	2	3	2	2.04	2
Spruce Grouse	High Elevation Spruce-Fir Forest	2	2	4	4	4	2.00	2
HABITATS								
	Appalachian Oak Pine Forest	4	4	3	3	4	3.33	4
	Vernal Pools	4	3	3	4	4	3.21	3
	Floodplain Forests	4	3	2	3	4	2.63	3
	Marsh and Shrub Wetlands	4	3	2	3	4	2.63	3
	Coastal Transitional Watersheds	3	3	4	3	3	2.50	2
	Lowland Spruce-Fir Forest	2	3	4	4	4	2.50	2
	Salt Marshes	2	3	4	4	3	2.29	2
	Non-Tidal Coastal Watersheds	3	3	3	3	3	2.25	2
	Tidal Coastal Watersheds	3	3	3	3	3	2.25	2
	Hemlock-Hardwood-Pine Forest	3	2	3	3	3	1.88	2
	Northern Hardwood-Conifer Forest	3	2	3	3	3	1.88	2
	Southern Upland Watersheds	2	3	3	3	3	1.88	2

* 1=Scope, 2=Severity, 3=Timing, 4=Likelihood, 5=Information

often are cleared of native vegetation and are maintained as homogenous mowed habitat, largely due to safety concerns (Forman et al. 2003). Because roads are extensive in the landscape, roadside habitat loss can be substantial. Mowing during critical times can have serious effects on local populations of plants or wildlife (e.g., Karner blue butterfly, frosted elfin butterfly, Persius duskywing skipper, and grasshopper sparrow). Karner blue butterflies are attracted to abundant non-native nectar plants along road edges (S. Fuller, NHFG, unpublished data).

(E) Dispersal

The effects of roads as barriers to wildlife movement are widespread (Forman et al. 2003, Trombulak and Frissell 2000). Roads that bisect seasonal or annual wildlife migration routes are of particular concern, especially for rare amphibians and reptiles that migrate

between wetlands and uplands or between wetland complexes (Fahrig et al. 1995, Trombulak and Frissell 2003). New England cottontails may be reluctant to cross a wide road because of the break in dense cover that they prefer (J. Litvaitis, University of New Hampshire, personal communication). Lepidoptera may be impeded from crossing roads by vehicular wind (S. Fuller, NHFG, personal communication). Road design can block wildlife; Jersey barriers and steep-sloping granite curbs can trap small organisms on roadways and increase mortality risk (Klemens 2000; M. Marchand, NHFG, personal observation). Underpasses (e.g., culverts) at stream crossings may be ineffective for passage of aquatic organisms (Jackson 2003).

(D) Mortality and collision

Mortality can affect the dispersal and viability of isolated populations, and eventually cause local extirpation (Trombulak and Frissell 2000, Forman et al. 2003). At greatest risk are slow-moving species (e.g., reptiles and amphibians), species that depend on high adult survivorship (turtles), species that are long range dispersers (bobcat, American marten, wolves), or species with scarce populations (timber rattlesnake). Low population densities and skewed age and sex ratios have raised concerns about the effect of road mortality on the viability of some turtle populations in the region (e.g., Marchand and Litvaitis 2004, Gibbs and Steen 2005). Turtles are attracted to the bare soil and open canopy of road shoulders, but adults and hatchlings are at risk from vehicles. Snakes may be attracted to roads to bask on warm pavement surfaces (Trombulak and Frissell 2000). Wide-ranging mammals, such as bobcat, lynx, American marten, and wolves, are likely to encounter and cross roads. As traffic volume increases, vehicle collisions become increasingly probable, reducing local population abundances and decreasing the likelihood and frequency of dispersal to unoccupied or low-density habitats (Litvaitis, University of New Hampshire, personal communication). Large mammals crossing roadways (e.g., black bear, moose, and deer), although not likely to be a population viability concern, may cause safety concerns for motorists.

4. RESEARCH NEEDS

Note: A group of biologists from NHFG and other environmental agencies and staff from the Department of Transportation will meet in the future to determine research priorities related to roads as determined by a Roads Working Group forum held on December 1, 2004 hosted by the NHFG, Concord.

- Identify specific areas of the landscape where connectivity is limited by a road and identify options for increasing safe passage of wildlife
- Identify significant travel corridors for species of concern to provide guidance to transportation planners
- Monitor (e.g., with radio-telemetry, remote cameras, or mark-recapture) wildlife populations in areas where underpass systems have been installed or are proposed, to evaluate success
- Expand collection of road-killed data. Currently, the only species monitored are deer, bear, moose, and turkey. Data collection could make use of volunteers (e.g., Reptile and Amphibian Reporting Program) and those likely to encounter road kill (New Hampshire Department Of Transportation road agents).
- Evaluate road design, roadside habitat management, and road placement so that it is least detrimental to significant natural resources

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Unregulated Take

1. DEFINITION

Loss of individuals may result in locally reduced population size, altered population structure, or extirpation, especially for small or isolated populations and species that depend on high adult survivorship. In New Hampshire, many species are currently unregulated (exceptions include threatened or endangered species, game species, and those protected under New Hampshire Fish and Game possession rules). Regulated species may be vulnerable to incidental take from legal activities (e.g. hunting, trapping, and commercial fishing). Enforcement of incidental take may be difficult, and penalties may not be sufficient to deter illegal take.

2. EXPERT OPINION

Unregulated take is considered a chronic to serious threat for wildlife species found in pine barren, cliff, alpine, floodplain, and peatland habitats. Unregulated take was considered very localized but may have more extensive and more severe effects on wildlife populations with limited distributions (e.g., timber rattlesnakes and hognose snakes) or high exposure to human populations (e.g., Blanding's and spotted turtles) or human activities (i.e., trapping of American marten). Some local populations are likely to be affected in the short-term. However, effects on populations of long-lived species may go undetected for years. Effects are weakly to somewhat documented for most species or habitats and well documented for timber rattlesnakes.

3. KNOWN WILDLIFE EXPOSURE PATHWAYS

(A) Commercial collection

Many reptiles and amphibians are popular pets, and the international pet trade market is large (Franke and Telecky 2001). Most native reptiles and amphibians are vulnerable to commercial collection and sale. Those species characterized by late ages of maturity and high adult survival rates are generally most vulnerable (e.g., turtles and some snakes). Also, some species are extremely vulnerable due to the congregation of individuals (e.g., timber rattlesnakes and wood turtles). It is illegal to possess, sell, or import timber rattlesnakes (state endangered), eastern hognose snakes (state threatened), Blanding's turtles, spotted turtles, wood turtles, eastern box turtles, and marbled salamanders (state endangered) (RSA 212-A, New Hampshire Fish and Game (NHFG) Rules Fis 800). It is not known to what extent illegal collection of protected species occurs in New Hampshire, but some rare species have been sold in the past (Levell 2000). No other reptiles and amphibians are regulated at this time. Painted turtles were one of the top reptile species exported from the United States (Franke and Telecky 2001). Harvesting snapping turtles for food is currently unregulated in New Hampshire, and at least one commercial collector has been reported (Taylor in Tyning 1997, M. Marchand, personal observation); strict regulations in surrounding states (e.g., Maine) may increase collection pressure for New Hampshire's populations.

TABLE 4-36. Number of habitats and species at highest risk from the effects of unregulated take. See Table 4-37 and Appendix A and B for details. Risk Category 4 = Greatest risk.

Risk Category	Habitats	Species
4	0	0
3	0	1
2	0	2
1	6	13

(B) Human values

Humans have a negative perception (fear) of some species and regard others as pests. Negative

TABLE 4-37. Habitats and species at highest risk from the effects of unregulated take, in descending order by Rank. See Appendix A and B for details additional information on specific threats and rankings.

		Ranking Scores*						
Species	Habitat	1	2	3	4	5	Rank	Class
SPECIES								
Timber Rattlesnake	Appalachian Oak Pine Forest	4	3	3	3	4	2.92	3
American Marten	High Elevation Spruce-Fir Forest	3	2	4	4	3	2.29	2
Spruce Grouse	High Elevation Spruce-Fir Forest	1	4	4	4	3	2.29	2
Hognose Snake	Pine Barrens	3	3	2	3	3	2.00	2

* 1=Scope, 2=Severity, 3=Timing, 4=Likelihood, 5=Information

perceptions may lead people to destroy wildlife regardless of actual danger. Only 1 of the 11 native New Hampshire snakes are venomous, and this species (timber rattlesnake) is extremely rare and unlikely to strike unless provoked. Slaughter of individuals or purposeful destruction of critical habitat (e.g., den sites) may result in the local or state extirpation of some species (e.g., timber rattlesnakes, Brown 1992). Bats found in homes may be killed. Bug zappers often kill non-target species such as beetles and moths that are attracted to light. Some insect control programs are implemented to ease public concern (e.g., mosquito spraying to control West Nile virus), but may harm non-target species.

Conversely, many humans are fascinated with wildlife. Humans with positive intentions may move animals from what seems unfavorable habitat to another location, with adverse consequences. For example, relocating turtles may be the functional equivalent of removing the turtle from the wild because the relocated turtle can no longer interact with wild individuals.

(C) Incidental take

Some species, including those that are rare or endangered in New Hampshire, are incidentally taken because of legal harvesting activities (hunting, trapping, and recreational or commercial fishing). For example, lynx and bobcat may be incidentally captured in leghold traps designed for canids or killing (e.g., conibear) traps designed for mustelids. American marten may be taken in fisher traps. Spruce grouse may be confused with ruffed grouse and taken by hunters (J. Kelly, NHFG, personal communication). Turtles may be taken in conibears set under water for beaver and otter but the impact on at-risk turtle populations is unknown (K. Tuttle and E. Orff, NHFG, personal communication). On a larger scale, incidental take of non-target species is a persistent problem in the commercial fishing industry (National Marine Fisheries Service 1998).

(D) Scientific collection

Scientific research has been conducted on a variety of taxonomic groups in New Hampshire, often resulting in take of individuals. Although this activity is often regulated, some species, especially invertebrates that are not state or federally threatened or endangered, are not regulated. Also, those species that are protected may be difficult to identify. For example, collection of some pine-barrens Lepidoptera (butterflies and moths) could have an impact on highly fragmented or small populations.

4. RESEARCH NEEDS

- Monitor focal populations to assess survivorship and loss of individuals from local populations, especially where human activity is intense (e.g., timber rattlesnakes, hognose snakes, wood turtles, Blanding's turtles, spotted turtles)
- Create list of pet stores, pet trade expos, and web sites that sell reptiles and amphibians in New Hampshire; survey which species of reptiles and amphibians are for sale (both native and non-native)
- Assess Cliff, Floodplain Forest, and other vulnerable habitats for risk of over collection of vegetation

- Compile information on incidental captures (e.g., survey trappers and hunters) and assess ways to eliminate or reduce mortality of non-target species

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Unsustainable Forest Harvesting

1. DEFINITION

Timber harvests greatly affect (positively or negatively) the current and future condition of New Hampshire's forests and associated wildlife habitats (NHDFL and SPNHF 1997). When done in an ecologically sustainable manner, timber harvesting can enhance New Hampshire's economy while enhancing certain wildlife habitat. However, if neglected or overlooked, non-timber values such as soil quality, wetland and water quality, forest age structure, plant and wildlife habitat, and others may suffer (Hansen et al. 1991, DeGraaf et al. 1992, Cullen 1996). For instance, high-intensity harvesting that exceeds forest growth over large areas increases habitat fragmentation and dramatically decreases age-class diversity (McCarthy 1995, Hunter 1999). This, in turn, results in less available wildlife habitat, especially for species that require mature forest or abundant coarse woody debris (e.g., American marten) (Hargis et al. 1999). Additionally, ecologically unsustainable harvesting can result in forest type conversion (e.g., from spruce-fir to tolerant hardwoods) (Hunter 1990, Hunter 1999), thereby reducing habitat for certain species.

2. EXPERT OPINION

Ecologically unsustainable forest harvesting, including liquidation harvesting and harvesting that leads to forest type conversions, is a serious to critical threat to New Hampshire's lowland spruce fir forests and associated wildlife species, especially American marten, spruce grouse, and three-toed woodpecker. Harvesting without regard to soil productivity and erosion, water quality, plant and wildlife habitat, and other non-timber values is a serious threat in most forest types. Harvesting in general is ecologically unsustainable in high-elevation spruce-fir forests and floodplain forests and is a serious threat in both forest types.

TABLE 4-38. Number of habitats and species at highest risk from the effects of unsustainable forest harvesting. See Table 4-39 and Appendix A and B for details. Risk Category 4 = Greatest risk.

Risk Category	Habitats	Species
4	1	0
3	0	4
2	7	1
1	9	15

3. KNOWN WILDLIFE EXPOSURE PATHWAYS

(A) Liquidation harvesting

The state of Maine defines liquidation harvesting as "the purchase of timberland followed by a harvest that removes most or all commercial value in standing timber, without regard for long-term forest management principles, and the subsequent sale or attempted resale of the harvested land within 5 years" (Sec. A-1. 12 MRSA c. 805). Liquidation harvesting commonly leads to subdivision and development that causes a decrease in available wildlife habitat and fragmentation of what remains (Maine Forest Service (MFS) 2002). MFS has concluded that 3% to 12% of all harvests in Maine are liquidations (6,300 to 25,200 ha/yr) (MFS 2002). No such assessment has yet been completed for New Hampshire. However, based on observations of wildlife and forestry professionals, similar percentages are expected in this state, mostly in the north. This has serious implications for American marten, three-toed woodpecker, spruce grouse, and other species. The Society for the Protection of New Hampshire Forests and the Timberland Owners Association is in the process of assessing timber harvest patterns in New Hampshire.

(B) Forest type conversion

Forest type conversion is most pronounced in low

TABLE 4-39. Habitats and species at highest risk from the effects of unsustainable forest harvesting, in descending order by Rank. See Appendix A and B for details additional information on specific threats and rankings.

		Ranking Scores*						
Species	Habitat	1	2	3	4	5	Rank	Class
SPECIES								
American Marten	High Elevation Spruce-Fir Forest	3	4	4	4	3	3.21	3
Spruce Grouse	High Elevation Spruce-Fir Forest	3	4	4	4	3	3.21	3
Common Tern	Coastal Islands	4	3	3	3	4	2.92	3
Roseate Tern	Coastal Islands	4	3	3	3	4	2.92	3
Three-toed Woodpecker	Lowland Spruce-Fir Forest	2	3	3	3	4	2.08	2
HABITATS								
	Lowland Spruce Fir Forest	4	3	4	4	4	3.50	4
	Hemlock-Hardwood-Pine Forest	3	3	4	3	3	2.50	2
	High Elevation Spruce-Fir Forest	2	3	4	4	4	2.50	2
	Northern Hardwood-Conifer Forest	3	3	4	3	3	2.50	2
	Appalachian Oak Pine Forest	2	3	4	4	3	2.29	2
	Northern Upland Watersheds	3	3	3	3	2	2.00	2
	Floodplain Forests	2	3	3	3	3	1.88	2
	Peatlands	2	3	3	3	3	1.88	2

* 1=Scope, 2=Severity, 3=Timing, 4=Likelihood, 5=Information

elevation spruce-fir forests when stands are clear-cut prior to the establishment of adequate levels of advanced regeneration (Frank and Bjorkbom 1973, Demming et al. 1995). In these situations, spruce-fir is generally replaced by light tolerant hardwoods (e.g., pin cherry, birch, aspen, red maple) (Demming et al. 1995). Eventually, spruce-fir forest may become reestablished, but it will take many more decades than if harvests were carefully planned to ensure advanced regeneration. According to mapping conducted for the Comprehensive Wildlife Conservation Strategy (see low elevation spruce-fir forest profile), New Hampshire only has 34% of the low elevation spruce-fir forest that is ecologically possible (106,411 ha of 311,629 ha possible).

(C) Lack of on-timber values

Timber harvesting can have a significant impact on soil quality, wetland and water quality, plant and animal habitats, and other non-timber values. For instance, timber harvesting can compact soil, particularly organic soils such as peat, leading to increased runoff and nutrient loading (NHDFL and SPNHF 1997).

Harvesting near vernal pools may reduce canopy cover, increase water temperatures not suitable to breeding amphibians, and cause premature drying of the pool (Calhoun and deMaynadier 2004).

Short rotation harvesting limits the availability of bark beetles in dead and dying spruce trees, which is the major food item for three-toed woodpeckers (Leonard 2001). It also limits the size and amount of coarse woody debris, which is required by American marten for denning and foraging (Hargis et al. 1999).

Timber harvesting can also limit the number of large trees with strong upper branches to support the nests of bald eagle, osprey, red-shouldered hawk, and Cooper's hawk, unless such trees are deliberately identified and protected during harvesting operations (Titus and Mosher 1981, Speiser and Bosakowski 1991, Bosakowski et al. 1992, Buehler 2000).

4. RESEARCH NEEDS

- Assess current timber harvest levels and patterns in New Hampshire to better understand the extent of

unsustainable harvesting in the state
- Determine the forest structure and management actions needed to sustain three-toed woodpeckers
- Define long- and short-term impacts of clear-cutting on vernal pool wildlife survival and reproductive success

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CHAPTER FIVE

Conservation Strategies

Overview

Element 4 of the NAAT Guidelines requires "descriptions of conservation actions proposed to conserve the identified species and habitats and priorities for implementing such actions." This chapter summarizes conservation actions to address challenging issues identified in chapter 4. It also incorporates recommendations from species and habitat profiles. The strategies and actions identified in species and habitat profiles were used to generate a preliminary list of objectives. The objectives that make up the WAP were developed to be inclusive of all wildlife, with a focus on priority wildlife and wildlife habitats named in chapter 2. Objectives were cross-referenced to information about threats, affected species and habitats, and feasibility. These linked data will form the basis for objective prioritization of the WAP (chapter 7). Throughout this chapter, specific objectives are referenced by their number (e.g., 101, 703, 1201).

Actions were developed at the following levels of detail:

- Four broad focus areas: regional air and water quality, local land and water conservation, statewide biodiversity stewardship, conservation science and information management
- The short summaries of objectives presented in this chapter, which are based on the strategy template (provided in Appendix O) and organized by strategic program areas
- The complete strategy templates (not provided) containing detailed information relevant to feasibility and priorities, which NHFG is using internally to guide implementation. See chapter 6, page 6-6, for an example of a complete strategy.
- "Conservation Actions" section of the species and habitat profiles (Appendix A and B), containing detailed conservation actions and information about potential monitoring protocols for each species and habitat

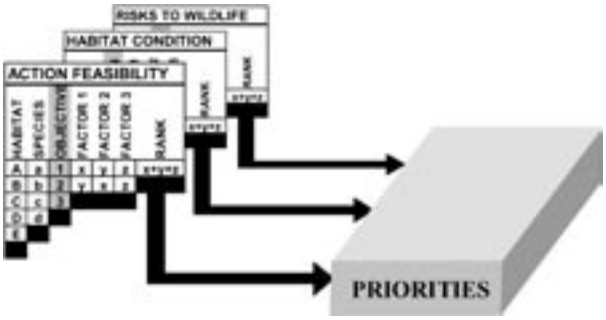

FIGURE 5-1. Risk assessments, condition assessments, and actions identified in species and habitat profiles were used to identify general strategies important to many wildlife species and habitats.

Monitoring, performance evaluation, and adaptive management systems are integrated with all objectives and are the topic of Chapter 6. Since these subjects are an integral part of the WAP, they are introduced below.

Monitoring: Effective monitoring requires an efficient set of indicators that are surrogates for species or habitat health. The Monitoring Strategy prescribes a starting point for identifying an efficient set of indicators for each habitat.

TABLE 5-1 A comparison of conservation strategies found in this chapter and corresponding Big Game Plan goals and objectives (Appendix E).

Conservation strategy	Corresponding Big Game Plan Goals/Objectives
100 Intra-Agency Coordination and Policy	Not applicable
200 Conservation Planning	Black bear goal 4, objective 4-2
	Moose goal 4, objective 4-2
	White-tailed deer goal 4, objective 4-2
300 Education and Technical Assistance	Black bear goal 3, objective 3-1; goal 4, objectives 4-2 and 4-3
	Moose goal 2, objectives 2-1 and 2-2; goal 3, objective 3-1; goal 4, objectives 4-1, 4-2, and 4-3
	White-tailed deer goal 4, objectives 4-1, 4-2 and 4-3
	Wild turkey goal 2, objectives 2-1 and 2-2
400 Environmental Review	Black bear goal 4
	Moose goal 4
	White-tailed deer goal 4
500 Habitat Management	Black bear goal 4, objectives 4-2 and 4-3
	Moose goal 4, objectives 4-1, 4-2 and 4-3
	White-tailed deer goal 4, objectives 4-1, 4-2 and 4-3
	Wild turkey goal 2, objectives 2-1 and 2-2
600 Interagency Regulation and Policy	Black bear goal 4, objective 4-1
700 Land Protection	Black bear goal 4, objective 4-3
	Moose goal 4, objectives 4-1 and 4-3
	White-tailed deer goal 4, objective 4-1 and 4-3
800 Landowner Incentives	Black bear goal 4, objectives 4-2 and 4-3
	Moose goal 4, objectives 4-1, 4-2 and 4-3
	White-tailed deer goal 4, objectives 4-1, 4-2 and 4-3
	Wild turkey goal 2, objectives 2-1 and 2-2
900 Monitoring	Black bear goal 1; goal 4, objectives 4-1 and 4-3
	Moose goal 1; goal 4, objective 4-1
	White-tailed deer goal 1; goal 3; goal 4, objective 4-1
	Wild turkey goal 2, objective 2-1
1000 Population Management	Black bear goals 1 and 3
	Moose goal 1
	White-tailed deer goals 1 and 3
	Wild turkey goal 1
1100 Regional Coordination	Not applicable
1200 Research	Not applicable
1300 Local Regulation and Policy	Black bear goal 4, objectives 4-2 and 4-3
	Moose goal 4, objectives 4-2 and 4-3
	White-tailed deer goal 4, objectives 4-2 and 4-3

Performance Evaluation: Performance evaluation is built into each objective by explicitly identifying affected threats, expected benefits, and critical inputs. Two monitoring objectives were developed to measure the first two aspects of performance, the direct effects of management (affected threats), and ecological response (expected benefits).

Adaptive Management: Annual summary reports will include baseline information, measured indicators, trends in threatened and endangered populations, changes in the level of managed threats, and a summary of inputs. This information will be used to adapt management to current conditions.

Integration With the Big Game Plan

As we prepared to develop the WAP, another major planning effort was scheduled to take place: the New Hampshire Big Game Plan (focused on black bear, moose, white-tailed deer and turkey, see Appendix E). To ensure the long-term protection of all wildlife species and habitats in the state, we integrated the planning efforts of the Big Game Plan into the overarching WAP. While the Big Game Plan and its goals and objectives may be viewed separately from the WAP, the integration of these two planning processes ensured that conservation strategies were consistent with each other. In Table 5-1, we identify those goals and objectives in the Big Game Plan that are parallel to the conservation strategies described in this chapter. In this way, we hope to more fully integrate wildlife conservation actions in the state, whether directed toward game or non-game species.

Fisheries Operational Plan

The goals of the WAP overlap with the objective of the NHFG Anadromous and Inland Fisheries Operational Management Investigations to "monitor and assess the status of New Hampshire's freshwater and anadromous fisheries resources through a planned scientific approach and to develop, implement, and evaluate management strategies that are consistent with resource capabilities". Restoration efforts for anadromous species are guided by the Strategic Plan for the Restoration of Atlantic Salmon to the Connecticut River (revised 1998), the Status Review of the Anadromous Fish Restoration Program for the Merrimack River (revised 1997), and The Saco River Fish Passage Assessment Plan 2004-2007 (approved 2003).

Broad Focus Areas

Regional Air and Water Quality Action Plan

Even the best-protected wildlife populations and habitats are increasingly threatened by climate change. Meanwhile, atmospheric pollutants in the form of acid deposition, mercury, and other heavy metals continue to degrade water quality and diminish forest health. The overarching goal is to reduce harmful air and water pollutants by promoting sustainable energy, transportation, and industrial development practices.

- Promote the adoption of structured risk assessments by state and federal agencies engaged in energy, transportation, and industrial development projects. Assessments include a goal, identification of risks, risk monitoring, and mitigation for unavoidable impacts (601, 602, 603, 604, 607)
- Promote the use of regional and national air and water quality policies and funding in New Hampshire (1103, 1104)
- Advise the coordinators of regional conservation initiatives on air and water quality issues in New Hampshire that need to be addressed at the regional or national level (1103, 1104)

Local Land and Water Conservation Action Plan

Wildlife habitats are diminished or destroyed by rapid urban development in many parts of New Hampshire. Many areas are degraded by indirect effects of development, such as non-point source pollution and light pollution. We must promote sustainable development and resource use to support wildlife health and diversity through a combination of coordinated working groups, technical guidance, and the production of targeted educational materials.

- Develop and disseminate up-to-date information, including maps, about wildlife and sensitive habitat areas that is pertinent to developers, permit applicants, land managers, municipalities, conservation commissions, and regional planning commissions

(206, 401, 1301)
- Develop and promote guidelines and best management practices to mitigate common development and land use impacts in sensitive habitat areas (304, 305, 403, 406)
- Provide technical guidance on the application of conservation science, planning tools, maps, and other information to land planning (609, 1302, 1303)
- Provide technical guidance on monitoring protocols so the success of restoration and mitigation can be clearly demonstrated (408, 904, 905)
- Promote inter-agency working groups to address broad threats with strategies outlined in the WAP (104, 105, 106, 605, 606, 608)
- Develop and implement a program to provide landowner incentives for land conservation (703, 802, 803)
- Educate the public about smart growth, safe resource use, sensitive habitat areas, and sustainable development (302, 307)

Statewide Biodiversity Stewardship Program

To maintain New Hampshire's biodiversity and habitats, the state needs coordinated voluntary and regulatory management, restoration, and land protection.

- Protect and restore rare and declining plants and animals (101, 102, 103, 208, 804, 1004, 1005)
- Protect and restore threatened habitats and natural communities (405, 407, 409, 502, 503, 505, 507, 508, 701, 702, 801)
- Coordinate agencies to protect populations and habitats (107, 402, 404, 410)
- Coordinate agencies to plan and implement restoration (610, 1101, 1102)
- Manage human impacts on plant and animal diversity (501, 504, 506, 1003, 1006)

Conservation Science and Information Management Program

There is a critical need to obtain, store, and manage data on the status and condition of New Hampshire's species and habitats of greatest conservation concern. Protection, restoration, and management activities all require knowledge of on-the-ground priority locations. Successful management activities must assess ecological responses of habitats and organisms. Protocols for monitoring and management will help ensure consistency, efficacy, and a measured response. Therefore, the overall goal of this focal area is to use best available science and protocols to monitor those species and habitats of greatest conservation concern.

- Gather and refine information about the locations of New Hampshire's wildlife and habitats and maintain a database to map populations and habitats (201, 202, 901)
- Gather and refine information about the condition of New Hampshire's landscape and maintain a database to assess the status of populations and habitats to help direct management actions (204, 205, 902, 903)
- Research and comparatively analyze threats to the condition of wildlife populations and habitats to identify critical problems (203, 204, 1001)
- Prioritize proposed conservation actions before implementation to ensure that resources are targeted effectively (207, 1201, 1202)
- Track and evaluate performance to determine the success of management actions. This entails measuring changes in the level of a risk factor, demonstrating a beneficial ecological response, and establishing a correlation between management and changes in threat levels (207, 904, 905)
- Continually refine and adapt management activities to reflect new conservation science (207, 904, 905, 1002)
- Manage information and develop media for dissemination to all levels in conservation (201, 202, 206, 401)
- Develop a system to monitor ecological health that includes under-surveyed taxa, indicators of condition, threatened and endangered species, effects of management, and ecological responses to management. Produce succinct, standardized annual reports on wildlife health by habitat (901, 902, 903, 904, 905, 906, 907)

STRATEGY 100

Intra-Agency Coordination and Policy

Native New Hampshire wildlife should be adequately protected by state laws and regulations for the enjoyment of New Hampshire's residents and visitors. These laws should be clearly understood by all individuals, agencies, and organizations affected by them. Conservation officers should be trained, equipped, and funded to enforce wildlife laws, including those pertaining to non-game, threatened, and endangered species. NHFG oversees the protection, restoration, and conservation of wildlife in New Hampshire, and regulates its take, sale, and possession. RSA 212-A and associated rules protect endangered and threatened wildlife. Under this law, other state agencies that authorize, fund, or carry out activities must consider potential impacts to state-listed wildlife.

101 Objective: Revise protocols to review threatened and endangered wildlife habitat

Long-term recovery of endangered and threatened species is best achieved by focusing on protecting high quality habitat rather than only preventing the take of individuals. New Hampshire's Endangered Species Conservation Act (RSA 212-A) should be revised to provide more comprehensive habitat protection for endangered and threatened wildlife and protect buffers around critical habitats. Representatives from state agencies, business, timber, energy, agriculture, and government should be engaged in the development of revisions to the RSA 212-A, and an advisory committee with a legislative liaison should be established to assure successful implementation.

102 Objective: Revise endangered wildlife list

Resources for wildlife conservation are limited, and a revision of the NHFG threatened and endangered wildlife list (Administrative Rule FIS 1000) would ensure that these resources are directed toward those species most in need of management, intensive monitoring, or similar recovery efforts. Revising the threatened and endangered wildlife list also would ensure that regulatory protection goes to those species in greatest need. Detailed assessments have been completed for those species of greatest conservation concern as part of the WAP, and NHFG rules (Chapter FIS 1000) identify threatened and endangered species.

Conservation partners and taxonomic experts from universities should assist in identifying those species in need of greater protection or those no longer in need of protection under RSA 212-A. This objective is best accomplished through the formation of taxon-specific technical committees. For taxa where expertise is readily available, the organizational framework for revision is already in place and simply requires that the appropriate parties convene and develop a plan for reviewing existing lists. For more obscure taxa, experts must first be identified.

103 Objective: Develop protocols for limiting activity in sensitive habitats

Fragile and sensitive ecosystems can be damaged by human presence, even when no harm is intended. To prevent disturbance, sensitive threatened and endangered species areas should be buffered from human disturbance. Adopting rules that specify where these areas are and how they can be properly protected would improve enforcement. Sensitivity to private property rights is necessary when considering the approach to this objective. We recognize the value of working cooperatively with landowners to balance use of their property with the need to protect threatened and endangered species of wildlife (also see "Safe Harbor Agreements" objective 804).

104 Objective: Revise/Enforce Chapter FIS 800: The Importation, Possession, and Use of Wildlife

Revising administrative rules on the importation,

possession, and use of wildlife (Administrative Rule FIS 800) will help prevent unnecessary take, diseases, and invasive species from harming wild populations. A number of species are unregulated, and reptiles and amphibians are particularly vulnerable. New rules might prohibit the sale of any native New Hampshire wildlife, add new rules for reptiles, amphibians, and some invertebrates, add protected wildlife from neighboring states to New Hampshire's rules, eliminate non-native species, and change wording from no possession of 'venomous reptiles' to 'venomous species'.

105 Objective: Minimize OHRV wildlife impacts

Eliminating OHRV use in sensitive endangered and threatened species habitats, such as coastal dunes and pine barrens, removes a potential mortality factor especially for piping plovers and rare pine barrens species such as the Karner blue butterfly. Where OHRV use is deemed appropriate, well designed and maintained trail systems will reduce impacts to wildlife and will provide OHRV riders with safe and reliable recreational opportunities.

NHFG conservation officers, land managers, and biologists in cooperation with DRED staff, have training and capabilities to implement this objective. The Cooperative State Lands Management Program is an interagency agreement among NHFG, DRED, NHDES, and NHDOT that coordinates state land management, including OHRV use. Local OHRV clubs develop and maintain trails under the guidance of the DRED.

The Cooperative State Lands Management Program needs to review and implement policies that reduce impacts to wildlife and provide OHRV riders with safe and reliable recreational opportunities. DRED and NHFG staff need to develop and implement trail management practices that minimize environmental degradation and avoid impacts to significant habitats.

106 Objective: Reduce public water access impacts

Use of lakes and rivers by motorized and non-motorized boats can harm wildlife populations and habitats. Coordinated planning prior to the initiation of specific projects, and prioritizing projects based on potential impacts to natural resources, will help protect wildlife and habitats. Boat access projects should consider ecological significance and potential effects before selecting priority sites for public water access. Access sites that will harm significant natural resources should not be funded.

The Public Water Access Advisory Board advises, monitors, and coordinates state public access efforts. When projects are proposed, wetland permits must be requested from the NHDES Wetlands Bureau.

107 Objective: Enforce wildlife regulations

The NHFG has a law enforcement division with approximately 40 conservation officers spread across six districts. These conservation officers are primarily responsible for enforcing NHFG rules and regulations. Biologists at NHFG have extensive knowledge regarding the identification and biology of regulated species. Greater coordination among conservation officers and biologists at NHFG will help ensure that wildlife rules and regulations are enforceable and that conservation officers are trained to enforce regulations pertaining to species of conservation concern, and other fish and wildlife.

STRATEGY 200

Conservation Planning

Conservation planning entails organizing and analyzing data derived from direct observation of wildlife and habitats. Scientists with advanced training in conservation biology and wildlife ecology are needed to lead efforts to use computer models to synthesize statewide patterns of wildlife health and to develop strategies for conserving biodiversity. Critical analysis of perceived threats to wildlife is an important part of strategy development. One of the outputs of conservation planning are maps that depict the ability of lands to support wildlife health and help guide land use planning decisions. The goals of conservation planning are as follows:

- Describe the potential of the land to sustain wildlife
- Develop conservation objectives that balance human interests with wildlife health and avoid costly interventions for endangered species
- Organize and prioritize diverse projects to maintain ecological integrity across the landscape
- Deliver information supporting conservation objectives in media that can be integrated into state and local planning processes

201 Objective: Model Validation and Refinement

Continually validate and refine maps of predicted distributions of wildlife populations and habitats, beginning with the most scarce and imperiled and progressing to the most abundant and stable. Confirming or refuting predicted locations of wildlife populations and habitats will improve efficacy of and support for the implementation of local and statewide conservation strategies and actions.

Computer models predicting the distributions of species and habitats were developed to produce maps for the WAP. NHFG has adequate expertise, facilities, and equipment for oversight of model development and validation, but staff for ground-truthing is limited. NHFG will likely partner with DRED for this objective because NHNHB ecologists are trained to identify habitats and natural communities and can train others to do so. Model validation and refinement is highly feasible because staff and resources already exist, and efforts can begin immediately.

202 Objective: Maintain Wildlife Database

New Hampshire should maintain its ability to acquire, verify, and maintain records of wildlife observations. Improved knowledge of species distributions, particularly species of conservation concern, will greatly benefit conservation and regulatory actions.

NHFG and NHNHB currently have staff dedicated to acquiring, verifying, and maintaining wildlife records derived from NHFG, partner organizations (e.g., NHA, RAARP, contractors), and the New Hampshire Wildlife Sightings web page. Staff may be inadequate to address incoming records in a timely manner.

203 Objective: Assess Threats to Wildlife Health

Assess threats to wildlife and habitats based on methodologies developed during the WAP. Focus efforts on taxa with significant knowledge gaps, such as invertebrates, amphibians, and fish, as well as on emerging threats. Identifying patterns of risk to wildlife may allow management to adapt incrementally, before species decline to threatened or endangered status and before habitats are seriously degraded. This may preempt drastic and costly interventions and increase resources for other potentially threatened or endangered species.

204 Objective: Map Landscape Potential for Wildlife Habitat

Create maps that portray the potential of the land-

scape to support a sustainable and diverse array of wildlife and wildlife habitats. Maps should incorporate wildlife distributions, ecological processes, and influence of human activities on the landscape. Maps will identify critical areas to support priority wildlife habitats and biodiversity, resulting in more efficient and effective protection.

Much of the data gathering and mapping has already been completed for the WAP. NHFG has adequate expertise, facilities, and equipment to conduct analyses to assess the potential condition of the landscape; however, expert consultation will be required to develop and refine methodology. Key partners include TNC and NHNHB.

205 Objective: Map Potential Wildlife Corridors and Buffers

Map landscape connectivity using models to represent spatial processes, such as dispersal, migration, colonization, and foraging. Mapping connectivity and buffering critical wildlife areas can target lands that help retain ecological connectivity and sustain wildlife diversity.

Mapping landscape connectivity will be achieved through coordinated inter-agency and inter-organizational efforts, and NHFG is not likely to lead the effort. TNC and NHFG have completed a fragmentation model that will contribute to mapping of connectivity, and NHFG has contracted UNH to develop methodology for modeling movements of large carnivores. Initiatives are in place to secure funding to model landscape connectivity from transportation planning resources.

206 Objective: Produce and Deliver Planning Maps

Produce and distribute summary maps of wildlife habitat at town and ecoregional scales. Summary maps will provide town and regional planners with easily interpreted information that supports wildlife conservation objectives. Technical guidance will help planners use available tools for implementing a range of objectives, from land protection to mitigating impacts of development. In the long-term, conservation planning practices will be integrated with land use planning. Maps will guide the public, developers, land-use planners, regulatory agencies, and land managers in decision-making.

NHFG developed preliminary wildlife conservation maps and distributed them to planning organizations during 2004-2005. Coordinated data management and publication mechanisms will be required to publish and distribute updated maps to all towns and regions. GRANIT and Complex Systems are equipped to manage, publish, and distribute mapped data via the Internet and other media.

207 Objective: Prioritize and Refine Strategies to Conserve Wildlife

The efficacy of wildlife conservation efforts will be improved by focusing on the most effective and feasible strategies for sustaining wildlife populations, habitats, and landscapes, and to abate the most pressing causes of degraded wildlife health. Information gathered for the WAP should guide this effort in coming years.

Input on strategies from partners, stakeholders, and the public has been obtained via collaboration, review, forum, and web-based survey. For each objective, feasibility will be reviewed thoroughly by NHFG with input from relevant experts upon completion of the WAP and prior to implementation.

208 Objective: Use Natural Communities and Systems as Surrogates for Poorly Represented Taxa

There is a wide variety of taxa, predominantly invertebrates, for which very little information exists. By identifying and protecting the full range of natural communities and systems that occur in the state, it should be possible to provide habitat for all native species, including those not represented in the WAP.

Natural Communities of New Hampshire (Sperduto and Nichols 2004) provides the most up-to-date descriptions of natural communities in the state. Likewise, systems are described in *Natural Community Systems of New Hampshire* (Sperduto 2005). The NHNHB database contains records of all known occurrences of exemplary natural communities and systems throughout the state, and NHNHB staff is continuously updating it as new information is gathered.

STRATEGY 300

Education, Information, and Technical Guidance

Education includes formal (school-based) and non-formal (camp, agency, adult, non-government, volunteer, conservation commission, and professional) instruction and involvement across a variety of media. Technical guidance is primarily non-formal instruction and direction through workshops, field tours, one-on-one consultation, publications and presentations.

Education and technical assistance create an aware and ecologically knowledgeable citizenry who has the appropriate skills to identify and help resolve environmental challenges and participate in activities that lead to positive action on behalf of the wildlife resources. Through an educated citizenry many of the issues facing wildlife can be ameliorated. The ultimate goal is a change in human behavior leading to a sustainable and environmentally friendly quality of life.

This strategy identifies both immediate, discrete actions and long-term processes that can be taken to address conservation issues through education, information and technical guidance. While we recognize the importance of prioritizing education, information and technical guidance needs and supporting actions (objective 301), the WAP process has allowed us to better understand many of the critical conservation needs. We have provided direction to address some of the most critical needs in objectives 302-307.

301 Objective: Identify actions to address through education, information, and technical guidance

Identify and implement conservation actions that can productively be addressed through various means of education, information and technical guidance. Public support will lead to additional conservation, management, and legislation that will protect wildlife and habitat.

There is great potential for partnerships to develop in the process of reaching this general education, information and technical guidance goal. NHFG has a Public Affairs Division, with personnel, training, facilities, and equipment for conducting education activities. UNH Cooperative Extension has personnel, training, and facilities for conducting education and technical guidance. Funding and personnel are needed to develop curricula and other educational materials.

302 Objective: Landowner education series

Work with partners to inventory and evaluate existing homeowner/landowner wildlife educational materials. Assess need for additional materials in light of new information. Work with partners to develop and distribute a homeowner/landowner education series including brochures, web based information, and program presentations. These projects would address issues such as living with wildlife, landscaping native plants and preventing the spread of invasive species.

Programs can be developed either on the regional or national level and could benefit the state regarding homeowner education series and guide. NHFG and UNH Cooperative Extension currently have the capacity to implement and distribute such materials. In addition there are many willing partners including state agencies and non-government organizations who could be involved, including USDA -Wildlife Services, Association of Federated Garden Clubs, DRED, and NHDES.

303 Objective: Foster supply of native plants

New Hampshire should encourage landowners and landscapers to use native plants. Increasing the availability of native plants from nurseries is important to encourage the use of more native plants with wildlife benefits in lieu of introduced and invasive species. By fostering the supply of native plants we also reduce the risk that non-native pests and diseases will be introduced into New Hampshire.

Ornamental horticulture in New Hampshire is a $380 million industry, representing 56% of total agricultural productivity in the state. This industry has more than adequate resources and potential to develop a healthy supply of native plants if there is a financial incentive to do so. The New England Wild Flower Society has nurseries in Massachusetts that supply native plants to New Hampshire and other states, but are limited in capacity. NHDFL maintains a state nursery that provides more than 50 species of trees, shrubs, and vines for forestry, conservation and education purposes, including many native species. The Jordan Institute, UNH Cooperative Extension, NHFG, and UNH Thompson School are collaborating on a grant-funded project to complete a manual on integrated landscaping practices. This new manual describes natural landscaping techniques and encourages people to buy native plants from local growers.

NHFG and UNH Cooperative Extension can play a key role in organizing and motivating partners to foster an increased supply of native plants. The first step would be to organize a meeting of the potential partners to develop a feasible approach to fostering an increased supply of native plants. NHFG can work with the NHDFL State Nursery to assess the potential to increase their supply of native plants, including expansion into the perennial and aquatic plants areas. With funding, UNH Cooperative Extension can develop demonstration sites based on the new integrated landscaping practices manual and provide education, information and technical guidance to growers, homeowners, landscapers, and other relevant audiences.

304 Objective: Revise and promote agricultural best management practices

Work with partners in the agricultural community to revise voluntary best management practices that would improve conditions for key wildlife species and habitats, particularly in grasslands, floodplain forests, and aquatic habitats. Potential revisions to best management practices would include mowing techniques and timing, pesticide and fertilizer applications, stream buffer widths, vegetation composition buffers, and floodplain farming recommendations.

NHFG and UNH Cooperative Extension could take the lead in revising agricultural best management practices. They could work with partners to publicize and encourage adoption of the revised best management practices. There are many potential collaborators, including UNH Cooperative Extension, New Hampshire Department of Agriculture, New Hampshire Farm Bureau, USDA-NRCS, and County Conservation Districts.

305 Objective: Promote sustainable forestry practices

Continue to work with partners in the forestry and conservation communities to strategically promote sustainable forestry. This will benefit many species and habitats throughout New Hampshire. Encouraging sustainable forestry can encourage landowners to derive economic benefit from their forestlands and maintain them in an undeveloped state. A key element of a successful program is the proactive, purposeful targeting of owners of larger lands with significant wildlife resources. This program should consider actions mentioned in the sustainable forest management recommendation of the Northern Forest Lands Council Tenth Anniversary Forum Final Report.

NHFG, NHDFL, and UNH Cooperative Extension should continue to work with the land trust community (e.g., through the Center for Land Conservation Assistance) to promote the acquisition of easements (targeting lands with high wildlife value) that help maintain land in private ownership. Such groups should encourage easements to be accompanied by resources needed to support sustainable management.

Other potential collaborators include the New Hampshire Timberland Owners Association, New Hampshire Timber Harvesting Council, Granite State Division of the Society of American Foresters, Tree Farm Program, SPNHF, USDA-NRCS, USDA Forest Service, local and regional conservation organizations, and private consulting foresters. Forest Legacy and other easement programs represent funding sources for the purchase of development value of land and ensure that forestry is sustainable.

306 Objective: Advise town conservation commissions and planning boards

Develop a program to provide technical assistance to town conservation commissions and planning boards regarding key wildlife species and habitats in and around their communities. Key species and habitats

will benefit from local actions to protect additional lands, manage habitats in an ecologically sustainable manner, and encourage appropriate stewardship on private lands. As this increased awareness leads to action, conservation commissions and planning boards may seek changes in regulations and policies that would benefit targeted wildlife and habitats. Access to data and maps depicting key wildlife species and habitat focal areas should be provided to both partners and the target audiences. The availability of educational materials, information and technical guidance on this new information should be marketed by partners via multiple communications media.

Potential collaborators include NHFG, UNH Cooperative Extension, Regional Planning Commissions, NHDES, New Hampshire Office of Energy and Planning, New Hampshire Municipal Association, New Hampshire Association of Conservation Commissions, and Center for Land Conservation Assistance, and other non-government organizations. NHFG will work with potential partners to develop such a program, although NHFG will require funding for personnel, training, equipment, and communications media. A grant proposal is currently pending from one potential funding source, the Landowner Incentives Program, which would aid greatly in achieving this objective.

307 Objective: Educate recreational users regarding threats to wildlife and natural communities

Reduce the impact of recreation through informational materials and programs developed for recreational users, including climbers, hikers, boaters, wildlife watchers, and others. This will benefit many species and habitats, including cliffs, dunes, marsh and shrub wetlands, alpine, and aquatic habitats.

There is great potential to develop educational materials and programs on the regional or national level, particularly working with national or regionally based recreational users. There is a need for a coordinated effort to target recreation users on specific issues in New Hampshire.

There are many willing partners including state agencies, non-government organizations and recreationally based user groups who could support the work described in this objective. There is a role for NHFG to provide information regarding impacts and to foster collaboration on education programs and materials.

STRATEGY 400

Environmental Review

Various state, federal, and local agencies or boards currently have the authority to review potential environmental impacts of a proposed activity on protected resources (e.g., wetlands, threatened and endangered species). Project evaluation ranges from database searches to extensive interactions with developers, engineers, and environmental consultants. Site inspections by a biologist are often essential to provide recommendations needed to minimize and mitigate impacts. Several potential enhancements could be pursued to improve the established environmental review process in New Hampshire, and subsequently species conservation. In particular, greater coordination among agencies and dissemination of information to stakeholders will improve the environmental review process. The identification and implementation of changes will be done in collaboration with other state agencies, non-government organizations, and the public.

401 Objective: Release Wildlife Maps to the Public

The state should make wildlife-related information accessible to developers and public, while also protecting sensitive information and landowner rights. If developers and consultants have access to information prior to planning their projects, they will know which agencies to contact for a full review or for help in developing project designs before investing large amounts of time and money in a project. This will also help to streamline the review process and reduce redundancy in review requests.

Data layers are currently available or are being developed which could be made available to the public on a limited basis. The Complex Systems Research Center at UNH (GRANIT) or a state agency website would be a proper venue for public access to this data. NHDES currently provides public access to environmental information through its OneStop database.

402 Objective: Improve inter-agency coordination for environmental reviews

Revise protocols to improve coordination and efficiency among state and local regulators and advisory boards. State and local regulators and advisory boards should coordinate with NHDES, NHFG, and NHNHB to establish the order in which projects are reviewed and responded to. This will reduce redundancy, provide critical information for formulating recommendations, and ensure that recommendations made by different groups are not contradictory.

403 Objective: Develop guidelines to minimize impacts to endangered, threatened, and special concern species

NHFG should develop guidelines for reviewing projects affecting threatened, endangered, and special concern species. Guidelines will allow the NHFG to provide a more consistent and effective response to proposed development projects. Through these guidelines, the expectations of NHFG reviewers will be better understood by developers and engineers so that conflicts can be avoided prior to the permit process.

NHFG has developed informal guidelines for reviewing projects threatening some species (e.g., freshwater mussels). However, guidelines have not been developed for all species. NHFG staff should work with species experts and other state and federal wildlife agencies to develop guidelines for reviewing projects.

404 Objective: Expand environmental review to other projects potentially threatening wildlife

Many projects receiving minimal environmental review could be improved by having access to information and resources from NHFG and NHNHB, which may help reduce impacts to rare wildlife, plants, and natural communities. Expanding the review process

to include both agencies will facilitate habitat and species conservation in these projects. For example, review of site-specific permits will allow NHFG and NHNHB to evaluate threats to uplands where wetland impacts do not occur.

Expanding the scope of environmental reviews may be as simple as applying existing procedures to other projects. New or revised rules may be needed for programs that currently lack a review process. Cooperation between NHDES, NHFG, NHNHB, NHDFL, and Division of Parks and Recreation will be necessary to determine which projects warrant additional review procedures. The NHDES Site Specific Program is currently working on rule revisions; NHFG and NHNHB should provide input on these rule changes.

405 Objective: Expand existing protection to include significant wildlife habitats that currently lack protection.

Wetlands are currently regulated by the NHDES Wetlands Bureau. Protection should be expanded for other significant wildlife habitats that currently lack adequate regulatory protections in New Hampshire. Providing additional protection for these habitats will be critical to maintaining the biodiversity of New Hampshire, especially in the rapidly developing southern part of the state. Examples of unprotected or inadequately protected significant wildlife resources might include vernal pools, floodplains, and beaver impoundments (See Appendix B, Habitat Profiles).

This objective will require meetings among many parties (i.e., regulatory agencies, conservation groups, private wetland consultants) to identify specific tasks and timelines. In some cases, existing rules and regulations may be adjusted relatively easily. Vernal pools have existing protection as wetlands but need to be explicitly protected as significant wildlife habitat. In other cases, new regulations may be needed to expand protection, and this process will require interdisciplinary coordination and support.

406 Objective: Develop stream crossing guidelines and restoration protocols

Roads, driveways, and trails frequently bisect streams, rivers, and wetlands. Structures may impede passage of aquatic organisms and change the natural flow and structure of streams or rivers. Upgrading or replacing ineffective structures (e.g., culverts and bridges) with well-designed ones will enhance connectivity of wildlife populations and will increase population viability.

Project designers and engineers are more likely to incorporate environmentally friendly designs if information is readily available. Various BMP guidelines have been developed in New Hampshire or elsewhere (e.g., erosion and sedimentation control), and further guidance and training will bolster this objective. Recommendations for stream crossing design have been developed in Massachusetts and a New Hampshire Stream Team has been formed to focus on this topic. Two meetings have been hosted recently by the NHDES, in cooperation with the NHFG, in an effort to initiate this objective. Sources of funding should be identified to upgrade ineffective culverts during scheduled maintenance or replacement.

407 Objective: Support wetland compensatory mitigation program at NHDES

NHFG and NHNHB should be active participants and supporters of the NHDES wetland mitigation in-lieu-fee program by participating in drafting rules and becoming active on the site selection committee. A bill to establish an in-lieu wetland compensation program is currently under consideration. The program will allow permit applicants that propose to harm wetlands to pay a fee rather than selecting land for protection or restoration. Payment into the fund would be allowed only after applicants demonstrated that wetland harm was minimized. Once established, this program could generate up to several million dollars annually for the protection and restoration of wetland habitats in New Hampshire.

NHDES Wetlands Bureau has held multiple meetings with many stakeholders including representatives from state (e.g., NHFG) and federal regulators (e.g, EPA, USFWS) and other agencies, conservation organizations, private consultants, the New Hampshire Association of Conservation Commissions, the New Hampshire Association of Natural Resources Scientists, and the Conservation Law Foundation. When the program is implemented, a committee will need to make recommendations for disbursal of mitigation funds.

408 Objective: Require monitoring to demonstrate success of mitigation

Monitoring the effects of a project on habitats and wildlife will enable biologists to determine if mitigation procedures were effective. Landowners involved in projects that have the potential to endanger rare species or natural communities, or who have engaged in habitat restoration as part of a mitigation requirement, should be required to provide scientifically sound habitat or species monitoring. Environmental consultants, University faculty, and graduate students may be contracted to conduct monitoring research.

Existing NHDES permit requirements involving restoration or creation of wetlands as mitigation currently require a minimum of 3 years of monitoring to determine project success. Longer periods may be needed to accurately determine the impacts to a given species or community and could be expanded to include more specific monitoring. Monitoring results should be shared broadly and be used to adapt future recommendations and management.

409 Objective: Integrate environmental review to include all natural resources on a site

The quality of wildlife habitat in a defined location will depend on the relationship among various interconnected habitats. Reviewing proposed wetland impacts separate from proposed upland impacts might not protect the most significant wildlife resources in the long-term. For instance, the functions and values of a wetland often are directly tied to the adjacent uplands, and most wildlife that use wetlands also use surrounding uplands. Therefore, an integrated review process will allow for the protection of the most significant natural resources.

NHDES currently regulates wetlands and requires mitigation for wetland impacts, but there is not an equivalent process for terrestrial habitats, some of which are considered globally rare (e.g., pitch-pine barrens). The structure for reviewing and requiring mitigation for wetland impacts would be a useful template for review of upland habitats. However, this objective will require input and coordination among a large number of individuals and organizations to be successful.

410 Objective: Increase biologist interaction on project reviews

Staff at NHFG, NHNHB, and NHDES should increase interaction with project designers, engineers, developers, and environmental consultants. This interaction would increase communication among natural resources agencies and developers, leading to a shared understanding of expectations and options for reducing impacts to wildlife habitat. Site visits are currently uncommon because of limited time and personnel. Funding is needed to conduct reviews, coordinate with NHDES, NHFG, and NHNHB, and develop an efficient review process.

STRATEGY 500

Habitat Management

Management and restoration can protect species and habitats that have languished due to historic and current development or natural processes such as succession. Intiatives could include everything from backyard landscaping to improve habitat for songbirds, to replacing culverts to restore stream flow and wildlife passage, to creating and maintaining early succesional stages, to allowing late-successional conditions to develop on selected tracts of forest. Habitat management will involve federal, state, non-government organizations, local, and private landowners. The goal of this strategy is to provide and maintain critical habitats for wildlife and natural communities via active restoration and management.

501 Objective: Reclaim or maintain grassland and shrubland habitats

This objective will involve identifying priority areas for grassland and shrubland management and working with landowners to assess landowner objectives and current management. Reclamation and maintenance of grasslands and shrublands will benefit a number of at-risk wildlife species such as northern leopard frog, American bitterns, New England cottontails, migratory songbirds, and wood turtles. Of greatest concern are the effects of high intensity agriculture (e.g., mowing during the breeding and nesting season), development, altered natural disturbance, and altered hydrology.

NHFG is currently identifying priority grasslands and is evaluating methods for mapping shrublands. For priority areas on state lands, NHFG staff should work with the appropriate agencies to conduct field assessments and recommend management objectives. Implementation will likely require the addition of at least one NHFG state lands staff member dedicated to maintaining grasslands and shrublands on state lands. Early efforts to implement this strategy could focus on critical species such as New England cottontails.

502 Objective: Generate early successional and young forest habitats

Some wildlife species that prefer early successional habitats—such as New England cottontail, American woodcock, and several species of migratory songbirds—are declining in New Hampshire due to habitat limitation. Early-successional aspen and birch stands and sapling-dominated forests are increasingly uncommon in New Hampshire because of silvicultural practices. However, current early successional habitat availability in northern New Hampshire is higher than prior to the 1600s. Even-aged management would help to create new stands and expand existing stands, thereby improving habitat for critical species and increasing foraging opportunities for game animals (such as moose, deer, bear, and turkey).

New Hampshire has many forest managers for both public and private lands that can help address this objective. UNH Cooperative Extension can provide workshops on forest management to benefit wildlife. An inter-agency forestry and wildlife team could assess how much aspen, birch, and young forest is desired to maximize wildlife health and develop management goals by ecoregion subsection (see Strategy 600, Interagency Regulation and Policy). This effort can coincide with the development of the state lands management plan and Forest Resources Plan coordinated by DRED. It would take one year to develop management goals and less than five years for education and technical assistance.

503 Objective: Restore and maintain late-successional forests

Late successional forests are not exclusively relied on by any vertebrates, yet are nevertheless important for other species such as mosses, lichens, and some invertebrates. Most of New Hampshire's rare forest plants inhabit mid- to late-successional forests. Reserves of

late-successional forest will eventually enhance overall habitat diversity through the addition of complex patterns of dead and downed wood, increased variation in forest canopies, and greater habitat complexity in forest streams. Many species would benefit from these conditions. American marten would benefit from the plethora of coarse-woody debris. Three-toed woodpeckers would benefit from abundant snags commonly found in late-successional high-elevation spruce-fir stands. Deer, moose, and bear would benefit from the protection and maintenance of spruce-fir and hemlock stands that provide winter shelter and old growth hardwood stands that provide hard mast.

Most late-successional forests in New Hampshire were lost during the extensive timber harvesting of the nineteenth century. Areas that are currently allowed to grow unimpeded are those that are largely inaccessible because of steep slopes or some other barrier to timber harvesting. The greatest amount of late-successional forestland is within the White Mountain National Forest, with smaller tracts owned by NHFG, SPNHF and TNC. An inter-agency forestry and wildlife team could assess how much late-successional forest is desired and develop goals by ecoregion subsection. Additional protection and management objectives can be based on the state lands management plan nd Forest Resources Plan currently being coordinated by DRED.

504 Objective: Develop and implement an urban wildlife management plan

The development and implementation of an urban wildlife plan would help provide long-term nesting habitat for common nighthawks that have adapted to nesting atop flat roofed buildings. It would also enhance habitat for migrating songbirds, wintering bald eagles, and pine barrens Lepidoptera. Migrating songbirds require suitable stopover areas for resting and foraging. In winter, bald eagles roost and forage along major rivers even in urban areas. Pine barrens Lepidoptera require certain plants for larval foraging and adult nectaring that would be suitable to incorporate in backyard landscaping.

An urban wildlife management plan should include detailed strategies for education, habitat management, and monitoring. It should also outline funding needs for implementation. Educational efforts should include developing resource guides that address rooftop and backyard habitat, geared toward landowners, building managers, developers, landscapers, and municipal officials. NHFG should collaborate to develop and implement the urban wildlife habitat plan. This objective could commence in less than two years, and educational efforts would be a long-term endeavor.

505 Objective: Restore rare habitats and natural communities

Some critical habitats and natural communities have become so rare and degraded that restoration is necessary to maintain associated wildlife. Restoration should focus first on pine barrens, lowland spruce-fir forests, salt marshes, and coastal dunes. Restoration of pine barrens would benefit a suite of rare Lepidoptera, common nighthawks, whip-poor-wills, and other species. Restoration of lowland spruce-fir will benefit marten, three-toed woodpecker, spruce grouse, and others. Successful restoration of salt marshes will improve habitat conditions for Nelson's sharp-tailed sparrow, saltmarsh sharp-tailed sparrow, seaside sparrows, willets, black ducks, and others. Restoration of sand dunes will benefit piping plovers.

TNC and NHFG are involved in pine barrens restoration in the Ossipee-Madison area and Concord airport. Prescribed burning is the primary tool needed to restore pine barrens habitat, and prescribed burning is primarily administered by NHDFL, USFS, TNC, and NHFG. A number of agencies and organizations will need to coordinate a statewide prescribed burn program to address limiting factors associated with that management tool (e.g., liability and training).

A number of organizations are involved with salt marsh monitoring and restoration, including the NHCP. Thus far, over 700 acres of salt marsh have been restored and more restorations are planned. NHCP is the lead agency on salt marsh and coastal sand dune restorations. NHFG should work with NHCP and its partners (NHEP, NRCS, county Conservation Districts, Ducks Unlimited, the Great Bay Estuarine Research Reserve, and local towns) to support salt marsh restoration and to prioritize and implement coastal sand dune restoration.

506 Objective: Develop and implement a terrestrial invasive species control program

The NHDES Exotic Plant Program is currently developing a comprehensive management plan for the prevention and control of aquatic nuisance species. Under this objective, a strategic plan would be developed to create and implement a comprehensive terrestrial invasive species control plan, primarily focusing on plants and invertebrates. In a separate but related effort, NHFG, NHA, and USDA-Wildlife Services should collaborate to develop a predator control plan for coastal islands and dune habitats. If successful, an invasive species control program would reduce the effects of invasive species in a variety of habitats and improve conditions for native species. A staff person dedicated to the development of a terrestrial invasive species control plan (e.g., plants, invertebrates) should be housed within the New Hampshire Department of Agriculture.

507 Objective: Restore or maintain natural flow regimes

Since European settlement, many aquatic habitats in New Hampshire have undergone alterations because of impoundments, hydroelectric production, seasonal lake drawdowns, water withdrawals, and impervious surfaces. Restoring natural flow regimes will benefit migratory and local fish populations, as well as many species of amphibians, reptiles, and invertebrates that depend on seasonal changes in water levels to fulfill critical life history functions.

The River Restoration Task Force regulates dam removals in New Hampshire. NHFG employs biologists capable of providing technical input on the impacts of altered flow regimes on habitats used by aquatic species. NHDES, along with other agencies, is conducting an instream flow pilot study to establish minimum flow regulations necessary for fish, wildlife, and other interests. TNC and the USACE are collaborating in the Sustainable Rivers Project to modify the way dams are managed to improve the ecological health of rivers. The NHDES Dams Bureau is currently working on a guidance document that will better protect water levels. Currently there is a gap between researchers working on ways to better manage flow, such as the Sustainable Rivers Project, and those responsible for dam management, such as the NHDES Dams Bureau.

In the short term, this gap must be bridged by better interagency communication and training sessions related to managing flow regimes. In the future, it would be extremely helpful to have a central program office in a single agency to coordinate all activities related to flow regimes in the state. There is an immediate need for personnel to provide input on flow-related issues and guidance documents, but restoring natural flow regimes will likely take a long-term effort of more than 10 years.

508 Objective: Restore and maintain watershed continuity

Stream crossings (e.g., bridges, culverts, railroads) and dams fragment aquatic ecosystems. Constricted flow and "perched" culverts can prevent passage of fish, amphibians, and other aquatic organisms, denying them access to certain habitats and isolating populations. Reducing fragmentation in a watershed will be especially beneficial for species such as migratory fish that require different habitats throughout their lives. Stream crossings may also alter the natural geomorphology of a river or stream, changing sediment deposition patterns above and below the crossing.

In 2004 the River and Stream Continuity Steering Committee, composed of representatives from state, federal, and non-government organizations, established technical guidelines for river and stream crossings in Massachusetts. The "River Continuity Assessment of the Ashuelot River Watershed" project, initiated by the Nature Conservancy, will incorporate volunteer-gathered data on dams, stream crossings, and culverts that impede fish passage or alter hydrology. This survey could be easily expanded to other watersheds and can be used to prioritize and evaluate potential restoration projects.

The NHDES Wetlands Bureau currently has the authority to regulate and mitigate the impacts of stream crossings. NHFG should work with the NHDES Wetlands Bureau, NHDOT, and non-government agencies to establish new guidelines for river and stream crossings in New Hampshire. A stream crossing assessment and guidelines could be completed within one year, but it would be a long-term endeavor to restore river continuity throughout New Hampshire.

STRATEGY 600

Interagency Regulation and Policy

Improved coordination among agencies removes obstacles and creates opportunites to maintain and restore wildlife health. To improve air and water quality, efforts should focus on reducing air and water pollutants through science-based decisions. An interdisciplinary, interagency risk assessment team can identify selected indicator species and habitats to monitor changes in water and air quality that may negatively impact sustainability of wildlife populations. Topics for additional working groups include development, transportation, recreation, and forest management.

601 Objective: Integrated inter-agency risk assessment teams for air and water quality

Interagency risk assessment teams can work together for the common goal of high air and water quality in New Hampshire. Teams can further identify and prioritize pollutants, habitats, and species at greatest risk, measurable outcomes and endpoints, and milestones.

The National Atmospheric Deposition Program (NADP) operates air-monitoring stations in New Hampshire. Currently only one NADP site is in operation in New Hampshire (at Hubbard Brook Research Station) and includes collection of wet deposition of mercury as part of the Mercury Deposition Network. The USGS and NHDES operates many water quality and flow monitoring stations across New Hampshire. The New Hampshire Lakes Association monitors lake quality statewide.

The BioDiversity Research Institute tracks methlymercury availability in aquatic (i.e., Global Loon Mercury Monitoring and Research Program (GLMMR) and terrestrial (i.e., Appalachian Mountain Mercury Network) ecosystems. NHDES is providing resources for developing a statewide risk assessment for mercury in loons and some funding for aquatic system monitoring of mercury.

Formulating state regulations will require networking among various state and federal (EPA, USFWS, USGS, and NOAA) agencies and a strong commitment between NHDES and NHFG. Regional regulation and policy representation for New Hampshire are best met through the New England Governors and Eastern Canadian Premiers.

602 Objective: Incorporate reduced wildlife mercury levels as a priority endpoint for air and water quality assessments

By reducing methlymercury availability in New Hampshire's aquatic and terrestrial systems, mercury body burdens in fish and wildlife will also lower. Any decreases will be timely; a comprehensive analysis of air, water, fish, bird, and mammal data shows that mercury levels are high and pervasive in New Hampshire. Intelligent mercury management will use indicator species (e.g., long-lived species, or high-trophic level predators) to detect system-wide changes in mercury content.

603 Objective: Promote a Transportation Working Group

A New Hampshire transportation-wildlife working group can proactively identify opportunities to maintain or improve the ecological integrity of landscapes impaired by existing or proposed roads. Improved planning and coordination among state (NHDES, NHFG) and federal regulatory (EPA, ACOE) and transportation agencies (NHDOT, FHWA), conservation groups, researchers, and local planners would have a statewide benefit to wildlife, as well as broad project support, increased permitting predictability, and improved highway safety. A multidisciplinary working group should include biologists, land-use planners, engineers, transportation project managers, and technical assistance specialists. Goals of a transportation working group may include prioritiz-

ing research needs, identifying funding opportunities, improving data sharing and coordination, and increasing education and technical assistance. Also, the products from the WAP should be integrated into NHDOT's long-range project planning effort that is currently underway.

604 Objective: Promote a sustainable development working group

Promote a New Hampshire non-regulatory working group that proactively identifies opportunities to improve decisions on how and where development occurs. This would help maintain and improve the ecological integrity of landscapes and would promote a commitment to environmentally sustainable development. Many organizations and agencies in New Hampshire can help plan sustainable development and reduce impacts to wildlife. The working group may be best coordinated by a non-regulatory non-governmental agency, and would require a consistent long-term funding source. Any effort to develop a sustainable development working group should build off of the work of the Minimum Impact Development Partnership coordinated by the Jordan Institute and NHA.

605 Objective: Recreation Working Group

The state needs a better understanding of the effects of different forms of recreation on species and habitats of concern. New Hampshire's wildlife and habitats could greatly benefit from better planning and coordination among state and federal regulatory agencies, conservation groups and recreation groups. The state should coordinate a New Hampshire recreation-wildlife working group that identifies issues, trends, and solutions to potential impacts caused by recreational activities. NHOEP currently coordinates the Statewide Comprehensive Outdoor Recreation Plan that allows for input and prioritization about recreational issues and use, that is primarily implemented by DRED. Many other state, federal, and non-government organizations are involved in different ways and could contribute to a statewide working group.

606 Objective: Promote reactivation of the Forest Sustainability Work Team

The Forest Advisory Board assists the State Forester in carrying out the provisions of the forest resources education, promotion, and planning chapter. The New Hampshire Forest Sustainability Standards Work Team was created in 1997. It developed "Good Forestry in the Granite State: Recommended Voluntary Forest Management Practices for New Hampshire", which outlined voluntary actions that forestland owners could take to ensure forest and ecological sustainability. The Work Team is now defunct but could be reactivated with staff from NHDFL, NHFG, SPNHF, UNH Cooperative Extension, and others.

The team should review issues and prescribe actions to address threats to forests, natural communities, and wildlife health. Prescribed actions may include outlining further research, recommending and assisting with policy or regulations at the agency or state level (502, 503, 803) and recommending additional best management practices.

607 Objective: Explore a wildlife biologist licensing program

To provide increased opportunities for communities, developers, agencies, and others to access qualified wildlife biologists, we propose to explore the development of a wildlife biologist licensing program. We expect that this will increase access to qualified wildlife technical assistance. Relevant laws and regulations would need to be modified accordingly. UNH Cooperative Extension, ASNH, UNH, NHFG, NHDES, USFWS, private consultants, and non-government organizations have the expertise to educate wildlife biologists.

STRATEGY 700

Land Protection

New Hampshire requires a network of permanently conserved lands that effectively represents the state's wildlife and habitat diversity. Land protection through conservation easements and acquisition ensures the long-term protection of our wildlife resources. Approximately 25% of New Hampshire's land is currently in conservation ownership through fee ownership by natural resource agencies, conservation organizations, and municipalities, or by permanent conservation easement. The current system of conservation lands is not equitably distributed across the state's geography, ecological regions, and critical wildlife habitats. More than two thirds of the state's conservation land is located in or north of the White Mountains, and the elevation distribution of conserved areas is heavily skewed towards areas higher than 1,700 feet. Coastal areas, southern forests, sand plains, large river valleys, and floodplains—many of which are vital for wildlife conservation—are poorly conserved. Highly threatened and essential habitat resources should be priorities, such as riparian/shoreland habitat, larger unfragmented blocks, and wildlife corridors that connect significant habitat. Specific targets for land protection will be identified via analysis of habitat maps to identify critical areas that will support priority wildlife habitats and biodiversity (see Conservation Planning strategy).

701 Objective: Protect riparian/shoreland habitat and other wildlife corridors

NHFG and others involved in land protection should promote the protection or restoration of wildlife corridors, including riparian and shoreland habitats. Maps of prioritized wildlife habitat should be used as guides when selecting areas to protect or restore. Habitat management that is implemented in these areas should be held to the highest standards, especially when promoted or supported by state agencies. Additional protection could also be provided through environmental review of proposed development projects within the shoreland protection zone. This objective will retain and restore sufficient habitat to sustain populations of wildlife species that require or benefit from riparian and shoreline ecosystems, and from the landscape connectivity often provided by these features. Wildlife such as turtles, amphibians, common loon, bald eagle, terns, bear, bobcat, New England cottontail, and mussels will benefit.

Riparian and shoreline areas are among the most expensive lands in the state, and effective protection at meaningful scales will require multi-million dollar investments. With limited funds, it is important to prioritize areas for protection. The conservation community needs to continue advancing our understanding of how to conserve aquatic habitat through targeted riparian protection, and which riparian and shoreland areas to focus on for habitat and connectivity goals.

702 Objective: Protect unfragmented blocks and other key wildlife habitats

NHFG should use maps of prioritized unfragmented blocks and other key habitat information to review and identify land protection projects. These maps should also be distributed to the conservation community. There are a number of large unfragmented blocks in northern New Hampshire and in the Monadnock Highlands of southwestern New Hampshire, with far fewer unfragmented blocks of similar size in southeastern New Hampshire. Therefore, prioritization of unfragmented blocks in New Hampshire should consider in which part of the state they occur and the relative size of other blocks in the region. Virtually all wildlife and habitats will directly or indirectly benefit from habitat protection, and the land protection strategy should be viewed as one of the most important ways to ensure long-term wildlife protection.

SPNHF and TNC have led the identification and protection of unfragmented resources. Through the creation and dissemination of information about natural resource inventories, coarse filter wildlife habitat maps, and significant wildlife habitat, many partners have been engaged in implementing this objective. Land trusts, local conservation commissions, regional planning commissions, regional, state and national conservation organizations, and state agencies have all considered the importance of unfragmented blocks and key wildlife habitats when planning land conservation projects. Forest Legacy has been an important funding source for land conservation of unfragmented blocks. LCHIP is a good model for identifying and funding important land protection projects.

703 Objective: Develop a comprehensive land protection support program

NHFG needs to take on a statewide leadership role in the land protection strategy. Using maps generated during the WAP development process as a framework, NHFG should work with partners to incorporate other important natural resources such as aquifers and productive soils to create a plan for a statewide green infrastructure network that includes large blocks of unfragmented forest, protection for significant wildlife habitat areas, and landscape permeability for wildlife movement.

NHFG should more fully develop a land protection staff and budget. Much of the GIS infrastructure and knowledge to generate conservation planning maps exists in NHFG. UNH Cooperative Extension should be viewed as a strong education and technical assistance partner. Wildlife biologists, both at NHFG headquarters and in regional offices should have the responsibility and time to work with local landowners, land trusts, conservation commissions, regional land trusts, and other members of the conservation community to identify and contribute in a substantial way to land protection projects.

STRATEGY 800

Landowner Incentives

With over 80% of the land in New Hampshire under private ownership, the land use decisions of private landowners have an enormous effect on habitat quality and sustainability. Thus, it is imperative to work with landowners to protect, manage, and restore habitat on their property. Landowner incentives may include tax benefits, financial and technical assistance to private landowners to restore and/or manage at-risk species and critical habitats, or the purchase of conservation easements.

801 Objective: Financial and Technical Assistance for Habitat Management and Restoration

Develop new programs and better coordinate existing programs to manage and restore critical habitats and natural communities on private lands. Financial incentives would be provided in the form of cost sharing for implementation, management, and restoration plans with potential of payments for maintaining practices. Existing financial and technical assistance programs include the Wildlife Habitat Incentives Program and Environmental Quality Incentives Program administered by the NRCS, the Conservation Reserve Program administered by the Farm Services Agency, the Partners for Fish and Wildlife Program administered by USFWS, the Forestland Enhancement Program (FLEP) administered by NHDFL, and the Habitat Small Grants Program administered by NHFG. NHFG should work with partners to focus resources on the most critical habitats.

These programs are typically limited in funding and scope and therefore are unable to adequately address many relevant threats. Consistent long-term funding is critical for the success of financial and technical assistance programs. Regional and national efforts will be needed to help secure long-term funding for programs.

802 Objective: Financial Incentives to Maintain Private Land in Open Space

Development pressure and rising carrying costs (e.g., taxes, liability insurance, and workers compensation benefits for industrial forests) have created numerous disincentives for long-term forest ownership. Under this strategy, critical wildlife habitats and natural communities on private lands would be conserved through tax incentives that make owning land more affordable or through the purchase of conservation easements. Maintaining private land in open space will benefit many types of habitats and wildlife, and with careful planning, may help mitigate the effects of fragmentation and population isolation maintaining habitat linkages.

Existing incentives to maintain private land in open space include the Current Use Taxation program (RSA 79-A), which helps conservation-minded landowners maintain their land in open space by reducing their property taxes. However, in areas of the state where land values are high, the economic incentive is high to sell land for development. There are a number of local and state conservation organizations, municipalities, and state and federal agencies that will purchase conservation easements on private lands, but all are limited in funding.

Options to consider include amendments to the Current Use Tax program, decreased capital gains taxes on timber harvested on land, the use of current use tax rates for valuating estate and inheritance taxes, and tax credits given to people or companies who invest in forestland.

803 Objective: Financial Incentives to Promote Sustainable Forestry Practices

Sustainable forestry will benefit many types of upland and aquatic habitats and associated wildlife. This strategy aims to provide financial incentives to

forestland owners who practice sustainable forestry. It would provide funding to landowners for inventories of critical resources (e.g., wildlife, natural communities, plants, etc.) so the information can be incorporated into forest management plans.

Financial and technical assistance programs include the Current Use program (see objective 802), FLEP, and EQIP. FLEP, administered by NHDFL and USFS, encourages long-term sustainability of non-industrial private forestlands. Financial and technical assistance is provided to develop and implement management plans. Through an agreement with UNH Cooperative Extension and NRCS and EQIP funding, private lands are enhanced via the development of a forest management plan, wetland restoration and enhancement, tree and shrub establishment, and establishment of riparian forest buffers, among other projects. NHFG should coordinate with NRCS, UNH Cooperative Extension, and NHDFL to focus EQIP and FLEP efforts in areas with the most need and that will result in the most benefit to wildlife.

Options to consider include amendments to the Current Use program, decreased capital gains taxes on harvested timber, or deduction of forest management costs for lands that are managed sustainably.

804 Objective: Safe Harbor Agreements to Protect Habitat of Threatened and Endangered Species

Because many endangered and threatened species occur on private property, it is critical to involve the private sector in their conservation and recovery. Many property owners, however, are concerned about land use restrictions that may occur if listed species colonize their property or increase in numbers because of land management. Thus they often avoid or limit land and water management practices that could enhance and maintain habitat. A Safe Harbor agreement provides that private landowners will not face any further restrictions under the Endangered Species Act if they take actions to improve habitat of candidate, threatened, or endangered species that occur on their property.

This incentive requires landowners to enter into a legal agreement with USFWS. Safe Harbor agreements have yet to be enacted in New Hampshire, but have been applied in other states. NHFG would be able to enter into such agreements with private landowners if a statewide agreement is enacted between USFWS and NHFG. The USFWS would provide a permit to the state, which can then offer individual landowners authorizations through a "certificate of inclusion." NHFG would then assist landowners with habitat enhancements as outlined in objective 801.

STRATEGY 900

Monitoring

The monitoring strategy is discussed in Chapter 6: Monitoring, Performance Evaluation, and Adaptive Managment (page 6-6). The detailed strategy template was completed and included for this strategy as an example of the type of information collected that will be used in the next phases of prioritization and implementation.

STRATEGY 1000

Population Management

Protecting, enhancing, or augmenting scarce populations of wildlife may prevent their extinction, may perpetuate naturally scarce populations, or may increase populations to desired levels. Controlling disease, introduced wildlife, and over-population of certain wildlife is a way of protecting resources that are valued by human society. Responsible game harvesting promotes retention of wildlife populations while maintaining plant and animal biodiversity. Population management should be responsive and adapt to new information generated from monitoring and performance evaluations and changing biological conditions.

1001 Objective: Evaluate the viability of wildlife populations

For rare and declining species, assess long-term viability and potential management scenarios based on current knowledge of wildlife demographics. This will identify opportunities to enhance the health of wildlife populations, especially those listed as threatened or endangered (e.g., timber rattlesnake, piping plover, Karner blue butterfly, American marten) or those that likely will be considered for state listing status in the near future (e.g., Blanding's turtle, New England cottontail). Analyzing viability will inform decisions about the scarcity of wildlife populations and indirectly affect underlying causes for scarcity, such as unregulated take and loss of habitat to development.

NHFG will lead viability assessments, with contracted support from experts on individual species. Existing contracts with UNH may be negotiated to accomplish the objective for select species. Endangered species recovery teams may provide technical support.

1002 Objective: Augment rare and declining populations

Augmentation can help to restore rare and declining populations to the size and genetic diversity needed for long-term viability and can help to maintain overall ecosystem diversity. Rare and declining populations should only be augmented when abatement of limiting factors is feasible. Direct forms of augmentation include translocation and release of captive-bred animals. Indirect forms of augmentation include management of factors that limit population growth, such as predation, forage scarcity, and lack of nest or den sites.

Implement protection and captive breeding in zoos for rare and declining populations when augmentation in the wild or abatement limiting factors are not feasible within the timeframe of potential extinction. This will counter factors, such as scarcity, genetic drift, and environmental caprice that threaten to extirpate some species. It will delay population extinction or catastrophic population losses so that other factors such as habitat loss and predation can be addressed.

Existing programs under the Association of Zoos and Aquariums are dedicated to supporting field conservation initiatives. Roger Williams Park Zoo (RWPZ) currently provides support for the Karner blue butterfly captive rearing program and is committed to developing support for other field conservation efforts. RWPZ has had success in captive breeding for other rare invertebrates and reptiles as well.

1003 Objective: Prevent and control wildlife diseases and overpopulation

New Hampshire should attempt to curtail the spread of wildlife diseases and damaging effects of overpopulated wildlife. Diseases of greatest concern include chronic wasting disease (CWD), avian cholera, and West Nile virus. A number of diseases impacting wildlife (e.g., amphibians) are under study elsewhere. Introduced wildlife, such as zebra mussels and feral cats, and some native subsidized wildlife such as gulls, corvids, and raccoons, often become overpopulated and threaten native wildlife populations and human health. Wildlife benefits from disease and popula-

tion control will be diverse and will include both at-risk (e.g., common terns, roseate terns, piping plovers) and harvested wildlife (e.g., deer). Control of herbivores (such as deer) will maintain plant and animal biodiversity in some forest ecosystems.

The existing partnership with USDA to control nuisance wildlife could be expanded. Authority to regulate introduced wildlife under existing legislative rules needs be evaluated (see Agency Regulation and Policy). A statewide plan should be developed to control introduced and overpopulated wildlife, as should a comprehensive management plan for predators that threaten rare and endangered species. Development of a statewide plan should be coordinated by NHFG, USDA and USFWS.

1004 Objective: Maintain an adaptive population management program for harvested species

Population management is most efficient and effective when it adapts to changing conditions and considers interactions among different species and habitats. Data on the response of populations to management will allow managers to improve and integrate management approaches. NHFG should continue and expand programs to assess the responses of wildlife populations to ongoing management (e.g., harvesting, augmentation and fish-stocking, control of diseases and over-population), identify negative interaction of management with non-target species, and adapt management to current conditions across multiple species and habitats. Adaptive population management allows NHFG to maintain wildlife diversity under changing ecological and social conditions.

STRATEGY 1100

Regional Coordination

Regional coordination builds consensus on the most critical conservation issues. The majority of wildlife species at risk in New Hampshire are not restricted to the state, and thus it is imperative that conservation efforts take into consideration their status in neighboring states. In addition, many regional planning documents identify threats that are common throughout the region. Given that many of the threats identified in this WAP occur over a large area (e.g., mercury, acid deposition, invasive species), these are best approached in a regional or multi-state manner. Species and habitats of regional concern have been identified by both the Northeast Endangered Species and Wildlife Diversity Technical Committee (ESWD) and North American Bird Conservation Initiative (NABCI).

1101 Objective: Develop and implement existing regional conservation plans

Conservation plans have been or are being developed for several species of conservation concern in the Northeast. These include plans created for species identified by the ESWD as being potential candidates for federal listing, including three species that occur in New Hampshire: Blanding's turtle, timber rattlesnake, and New England cottontail. NABCI has developed, or is developing, broad conservation strategies for birds across the two Bird Conservation Regions that include parts of New Hampshire. Such plans have the potential to conserve species at risk when implemented over a large region.

1102 Objective: Regional conservation planning for species and habitats at risk

While structures such as the ESWD and NABCI provide valuable fora for regional discussion, there are limited staff at the regional level to facilitate actual conservation activity within the states in the region. Dedicated regional staff could ensure that committed conservationists from different areas collaborate. In this way, many disparate conservation efforts and funding sources can be concentrated more effectively.

1103 Objective: Step down federal air and water quality policy

Mercury emission sources in New Hampshire are minor compared to sources within and outside of New England. New Hampshire's air and water quality will largely depend on regional and national standards. Regional and national mercury databases and policies should be adapted to New Hampshire. Establishing a formal link with scientists and policy makers within New England will increase leverage for improving water quality, particularly on the Connecticut River and along the coast.

The benefits of working together at a regional level are crucial to improving ecological condition in New Hampshire. Reductions in major pollutants, including nitrogen oxides, sulfur dioxide, carbon dioxide, and mercury need to be made outside of New Hampshire. Key participants outside of New Hampshire agencies are NESCAUM, NEIWPCC, NEWMOA, federal agencies such as the USEPA, USFWS, USGS, and NOAA, and university and other nonprofit research (such as BioDiversity Research Institute) and policy groups.

STRATEGY 1200

Research

The goal of the research strategy is to develop an ongoing research program in New Hampshire that identifies and facilitates funding of priority surveys, research, and monitoring. Species and habitat profiles (Appendix A and B) contain research recommendations for:

- Providing information on the distribution of poorly understood species and habitats
- Assessing the current condition of species and habitats
- Identifying threats to these species and habitats
- Clarifying whether a conservation action will lead to a change in the threat and whether a change in the threat will lead to a change in the current condition of the species or habitat

If a convincing, research-based case is made for conservation, social and political support will be more likely. Sound research will also make grant writing and donation requests more compelling and will make conservation more effective.

1201 Objective: Prioritize Research Needs

NHFG biologists should lead a group of conservation research partners to prioritize wildlife and habitat research needs identified in the WAP. The process of prioritizing research will be similar to and incorporated into the process of prioritizing conservation strategies and actions identified in the WAP. As part of this process, NHFG must develop an internal operational plan to identify where available resources (staff and money) can be most effectively allocated.

Funding is limited for the many research needs identified for species and habitats in the WAP. Therefore, it will be critical to identify which research is needed immediately and which partners can help implement the research. Also, collaboration with other states directly or through regional working groups (e.g., Northeast Endangered Species and Diversity Technical Committee, NEPARC) would be an effective way of sharing research objectives and addressing regional environmental issues.

1202 Objective: Facilitate funding of priority conservation research

To facilitate priority survey, monitoring, and research efforts, priorities (as determined in objective 1201) will be communicated to other entities that fund conservation research in New Hampshire. NHFG can facilitate the development of a process to disseminate conservation research money and encourage other conservation researchers and funding entities to focus their efforts on priority research. Substantial, yet limited, conservation research money at the federal level has come to New Hampshire from many sources (e.g., from the USFS, USFWS, USEPA, and congressional appropriations). Research funded by the NHFG should support the goals of the WAP. NHFG administrators and biologists must discuss the most efficient method to disseminate conservation research funds, while receiving a desired designated product (e.g., request for proposals).

STRATEGY 1300

Local Regulation and Policy

Municipalities have broad power to regulate land use, but broad policies and visionary statements are not always translated into meaningful planning or conservation. Communities should have a sound, scientific basis for developing and implementing innovative land use incentives, legislation, and other measures that conserve habitat and landscape connections, maintain ecological function, and protect water quality and quantity.

1301 Objective: Incorporate Habitat Conservation into Local Land Use Planning

Master plans, zoning ordinances, subdivision regulations, and other innovative land use tools that use scientific basis for addressing wildlife habitat will lead to greater protection of these habitats, will conserve water quality, and will maintain landscape connections. NHFG should provide technical guidance to New Hampshire municipalities on master plan goals and land use policies and regulations aimed at protecting significant or sensitive wildlife habitats. An integrated approach to land use decisions can maintain unfragmented blocks of upland forests and protect species of concern such as the Karner blue butterfly and common nighthawk. It will also protect functional connections that support wide-ranging species such as moose, bear, and deer. This approach will better protect the integrity of aquatic and wetland systems such as marsh and shrub wetlands, floodplain forests, and rivers, which are habitat for American bittern, common moorhen, spotted, Blanding's and wood turtles, cobblestone tiger beetles, and other species.

The critical gap that NHFG can address is the scientific basis for implementing land use policies and regulations that protect the ecological function and health of wildlife populations and their habitats. This technical assistance needs to be combined with an integrated approach to land use decisions among local decision-makers. NHFG should work with UNH Cooperative Extension and New Hampshire Office of Energy and Planning, key outreach partners to facilitate training for NHFG biologists on the integration of wildlife habitat information into local land use planning and regulation. Likewise, Cooperative Extension can facilitate training for town planners, planning boards, regional planners, and others involved in writing master plans and local ordinances, on how to integrate wildlife considerations into local planning. NHA and The Jordan Institute are other important partnering entities, through their Three Infrastructures Analysis with local communities.

1302 Objective: Advise Conservation Commissions and Open Space Committees

Many Conservation Commissions are permanently protecting lands using current use change tax revenues that accumulate in their conservation fund. In recent years many communities have passed multi-million dollar open space bonds through town warrant articles. Despite many successful individual land conservation efforts, most local efforts are not informed by conservation science. Moreover, other local land use decisions continue to fragment, degrade, and eliminate critical lands and waters. NHFG should guide municipal Conservation Commissions and Open Space Committees in identifying critical wildlife habitats in their communities for protection using conservation funds, open space bonds, and through engagement in land use planning decisions within their community. The Center for Land Conservation Assistance (CLCA) and regional land trusts are critical partners for NHFG and local communities.

1303 Objective: Promote Role of the Regional Planning Commissions in Landscape-Scale Conservation

Regional Planning Commissions (RPCs), established

by RSA 36, are required to "prepare a coordinated plan for the development of a region" and may assist their member or nonmember towns with implementing the plan and with other local planning issues. From a land use planning perspective, RPCs are in the best position to look beyond municipal political boundaries to advance landscape-scale conservation goals such as maintaining large blocks of forest, large wetland complexes, connectivity along river corridors, natural communities, and natural community systems.

Few professional planners in New Hampshire have any background in natural resource protection, ecological sciences, or wildlife biology. NHFG should collaborate with Regional Planning Commissions on opportunities to incorporate landscape-scale conservation goals and strategies into the comprehensive master plan and other planning efforts in their region. NHFG can also work with watershed coalitions and their partners at NHDES to ensure that watershed planning addresses aquatic habitats and associated species.

CHAPTER SIX

Monitoring, Performance Evaluation, and Adaptive Management

Overview

Element 5 of the NAAT Guidelines requires that the WAP propose plans for a) monitoring species of greatest conservation need and their habitats, b) monitoring the effectiveness of the conservation actions proposed, and c) adapting conservation actions to respond appropriately to new information or changing conditions. Chapter 6 describes New Hampshire's plan for addressing this required element.

Conservation Strategy 900, presented on page 6-6, is the full-length version of New Hampshire's monitoring strategy and also serves as an example of one of the complete strategy templates that are being used internally by NHFG. Table 6-1 (page 6-13) shows some of the criteria for selecting efficient indicators and cross-references technical monitoring objectives with species, habitats, and risk factors.

Many objectives in chapter 5 are directly related to monitoring, performance evaluation, and adaptive management. Species and habitat profiles (Appendix A and B) also contain strategic information about monitoring and detailed information about potential monitoring protocols, performance evaluation, and adaptive management.

Monitoring

The full version of Conservation Strategy 900 (Monitoring, page 6-6) outlines seven categories of monitoring that apply to New Hampshire's wildlife:.

- Conduct surveys to describe distribution (Objective 901)
- Detect changes in the condition of wildlife and habitats (Objective 902)
- Monitor population trends for threatened and endangered species (Objective 903)
- Measure direct effects of management (Objective 904)
- Monitor ecological responses to management (Objective 905)
- Select an efficient set of indicators by habitat (Objective 906)
- Report the condition of wildlife health by habitat (Objective 907)

Other strategies in chapter 5 that pertain to monitoring include:

- Provide technical guidance on monitoring protocols so the success of restoration and mitigation can be clearly demonstrated (408)
- Gather information about the locations of New Hampshire's wildlife and habitats and maintain a database to map populations and habitats (201, 202)
- Gather information about the condition of New Hampshire's landscape and maintain a database to assess the status of populations and habitats to help direct management actions (204, 205)

Within species and habitat profiles, monitoring needs were identified in several locations: distribution research (element 1.9), condition assessment research (element 2.9), threat assessment research (element 3.4), and conservation action research (element 4.2), conservation action performance monitoring (ele-

ment 4.1.X-D), and response monitoring (element 4.1.X-F).

Several important issues to consider when designing monitoring efforts include: existing monitoring programs and the scale and frequency of monitoring necessary to achieve objectives.

Overview of Existing Monitoring Programs

National and State Monitoring Programs

An early step to developing new monitoring protocols is to identify what currently exists. In some cases, existing monitoring may be sufficient for particular species, habitats, risk assessment, or management response. Some monitoring programs could be easily adapted or expanded to focus on priorities. For example, the North American Amphibian Monitoring Program (NAAMP) actively monitors amphibian populations at select sites ('routes') in New Hampshire annually. These routes do not adequately sample for several amphibians of conservation concern (e.g., leopard frog, mink frog, Fowler's toad) but this program could be expanded to include several priority species or habitats. In other cases, an entirely new monitoring scheme may be necessary.

The following list of monitoring efforts should provide readers with a sampling of ongoing monitoring and the relative level and scale of existing programs among taxonomic groups. It should be obvious that some taxonomic groups and species have been monitored far more intensely than others have.

Plant & Natural Communities

NHNHB conducts ongoing inventories for natural communities and plants.

Invertebrates

The Marine Division of NHFG conducts ongoing monitoring programs for lobsters and breeding horseshoe crab around Great Bay and coastal New Hampshire. The NHFG Nongame & Endangered Species Program, NHNHB, TNC, USFWS, and UNH have conducted occurrence surveys for several threatened or endangered invertebrates including but not limited to dwarf wedgemussels, brook floaters, ringed boghaunter, cobblestone tiger beetle, and pine barrens Lepidoptera. Intense population and habitat management monitoring occurs for Karner blue butterfly at the one extant population. Long-term population monitoring has been initiated for dwarf wedgemussels in the Ashuelot River.

Birds

Birds have traditionally been the most intensely monitored group of wildlife (other than perhaps game mammals). Major monitoring efforts have been initiated in New Hampshire by NHFG, USFWS, NHA, UNH, Dartmouth College, Vermont Institute of Natural Science, Biodiversity Research Institute, the Loon Preservation Committee, and others. New Hampshire participates in both nationally (Breeding Bird Surveys and Christmas Bird Counts) and state coordinated programs, as well as intense local surveys. NHBR is a state-reporting program for trained bird observations and is primarily used to collect distribution information. Long-term intense monitoring of occupied locations and population conditions has been conducted for several threatened and endangered species including common loon, piping plovers, bald eagle, osprey, and peregrine falcon. Habitat-based bird surveys have been conducted to varying extent for grassland, salt marsh, freshwater wetland, high elevation spruce fir, and floodplain forest habitats. Several game birds of conservation concern have been monitored annually as well (e.g., American black duck, ruffed grouse, American woodcock).

Fish

Anadromous fish species are monitored annually by NHFG and USFWS biologists at fishways during spring spawning runs. Atlantic Salmon populations are also monitored in cooperation with the USFWS and the USFS at designated salmon index sites. The Marine Division of NHFG has a number of ongoing monitoring programs as part of the multi-state management of marine fisheries administered by the Atlantic States Marine Fisheries Commission. Programs include a juvenile American eel survey and a juvenile finfish seine survey. The Marine Division also cooperates with the Maine Department of Marine Resources in the Inshore Trawl Survey, which has been monitoring marine fish populations in the Gulf of Maine since 2000. Surveys are conducted semi-annually by the NHFG Division of Inland Fisheries to monitor the populations of recreationally fished species such as brook trout. NHFG's Inland Fisheries also conducts surveys under the Fish Habitat Program to

assess the condition of fish habitats throughout the state. The Fish Habitat Program has recently initiated surveys to investigate the status of certain fish species of concern, including the bridle shiner, banded sunfish, redfin pickerel, swamp darter, and the American brook lamprey.

Reptiles and Amphibians

New Hampshire participates in the nationally coordinated NAAMP, designed to examine long-term trends of breeding frog populations. The Amphibian Research and Monitoring Initiative (ARMI) has conducted some inventory work in New Hampshire including the Lake Umbagog National Wildlife Refuge. The Reptile and Amphibian Reporting Program (RAARP) and the Vernal Pool Identification and Documentation program are coordinated by NHFG and are designed to gather statewide distribution information based on volunteer observations. Surveys of malformed frogs have been conducted by the NHDES and UNH. Local occurrence and condition surveys have been conducted for some rare, threatened, and endangered species, but have been limited.

Mammals

NHFG intensely monitors population trends of big game (e.g., white-tailed deer, black bear, Moose, turkey) and furbearer populations. Traditionally, small mammals (e.g., bog lemmings, shrews) have had minimal monitoring; the USFS has conducted some small mammal inventories on the WMNF. Known bat hibernacula are inventoried periodically to get a general species and numbers count. Recently, an intense inventory was conducted for American marten by the NHFG, in cooperation with the University of Massachusetts-Amherst.

Scale

Monitoring can occur at several scales. Three of these efforts reflect a hierarchical set of spatial scales (National/Regional, State, Local). The fourth is a one-time survey for inventory purposes that may not necessarily occur with any regularity, and which can occur at any of the three spatial scales (Surveys). The appropriate scale will differ depending on the objective.

The first step for monitoring is to determine regional/national and statewide distributions for species and habitats of conservation concern. Once statewide distributions are known, monitoring will be adapted to the condition of targeted local populations or habitat polygons. For habitats, we have assessed the statewide distribution by mapping predicted habitats. Following validation of habitat maps, target polygons will be identified to monitor habitat condition. Similarly, the distribution for many priority species is known, and monitoring will focus on identifying the condition of local target populations either directly or through indicators. As a population recovers, sampling intensity can decrease. Similarly, many monitoring efforts targeting challenging issues (e.g., climate change) may start at the regional level but intensify at the state or local level as specific issues are identified.

Some existing monitoring programs designed to detect long-term trends in species populations are coordinated nationally (e.g., NAAMP, BBS). However, many existing monitoring programs are specific to states (e.g., NHBR, RAARP), and wildlife obviously does not recognize these jurisdictional restrictions. Therefore, communication among states within a region will be critical for species and habitat conservation, and monitoring protocols should be designed or adapted to integrate with others. Monitoring of many priority species, especially those that are rare or locally distributed, often occurs at the local scale. Species that are difficult to detect will also require targeted local surveys.

Local

- Monitoring of single populations (terns, Karner blue butterfly)
- Monitoring of specific sites (IBAs, WMAs)
- Response to management (pine barrens, grasslands)

State

- Statewide sampling of priority species
- Indicators of biodiversity
- Changes in habitat availability or distribution (land use change)
- Status of statewide threats (mercury)

Regional/National

- Large-scale population trends (BBS, NAAMP)
- Monitoring of cross-border threats (acid deposition, mercury)

Surveys (small to large scale applications)
- Assessment of conditions before and after a perturbation (mortality at towers)
- Site inventories (IBAs)
- Validation of habitat models
- Snapshots of species' distributions (RAARP, Atlases)

Frequency
Frequent monitoring may be needed, especially when species are at immediate risk of extirpation from New Hampshire (e.g., Karner blue butterfly, timber rattlesnake). However, intense monitoring often is costly and may not be needed to ascertain a particular ecological response. Therefore, frequency of monitoring must be critically evaluated for any monitoring program initiated. Some programs will require consistent long-term annual monitoring to compare datasets and trends (e.g., BBS, NAAMP). However, as species begin to recover, monitoring often can be adapted to less intense methodologies or frequency. To initiate a discussion regarding the frequency of monitoring indicators, we identified three levels of monitoring frequency: annual, 2-5 years, and >5 year intervals (Table 6-1). Selection and monitoring of indicators will be reviewed before implementation.

Monitoring by Citizens
In some cases, monitoring by highly qualified scientists may not be necessary. Trained citizens can provide important information on the distribution of species and assist with monitoring of the condition of habitats. In addition to the cost-effective means of collecting valuable data, citizen science is a valuable tool in educating the public. Several groups have been actively studying the feasibility of using citizens to assist with scientific studies or monitoring (e.g., Ashuelot Valley Environmental Observatory, UNH). Trained citizens are already used heavily to collect distribution information for some groups of species (e.g., RAARP, NHBR).

Indicator Monitoring
It is not possible to intensely monitor every species and habitat listed in the WAP as well as those not listed. Therefore, in some cases effective monitoring requires an efficient set of indicators that are surrogates for species or habitat condition. The monitoring strategy prescribes a starting point for identifying an efficient set of indicators for each habitat. Our approach is to seek efficient variables. By "efficient", we mean variables that fit into more than one of the categories described above and represent many wildlife. Efficient also means that we can measure a variable and detect changes with minimal effort. When a variable meets these criteria, we consider it a useful indicator because it indicates changes that are happening for many variables. Our goal is to select efficient indicators for habitats and species listed in the WAP and to monitor them rigorously.

Indicators to monitor habitat
To identify species to serve as appropriate indicators of habitat conditions and risks factors, we created Table 6-1 with several monitoring metrics (scale and frequency of monitoring needed). This table will help facilitate discussions of appropriate and efficient indicators. During the first steps of implementation (chapter 7), a working group will be convened to refine species-specific monitoring needs based on details provided in species and habitat profiles (Appendix A and B). This information will be used to select a set of habitat indicators.

Performance Evaluation

Performance evaluation was built into the WAP planning process at several stages including statewide strategies (Chapter 5) and species and habitat profiles (Appendix A and B).

Statewide Strategies
Performance evaluation is built into each strategy's objective (chapter 5) by explicitly identifying affected threats, expected benefits, and critical inputs. Two monitoring objectives were developed to measure the first two aspects of performance: the direct effects of management (affected threats, objective 904) and ecological response (expected benefits, objective 905). Periodic summary reports will include baseline information, measured indicators, trends in threatened and endangered populations, changes in the level of managed threats, and a summary of inputs. This information will be used to adapt management to current conditions. The following are strategies that pertain to performance evaluation:

- Track and evaluate performance to determine

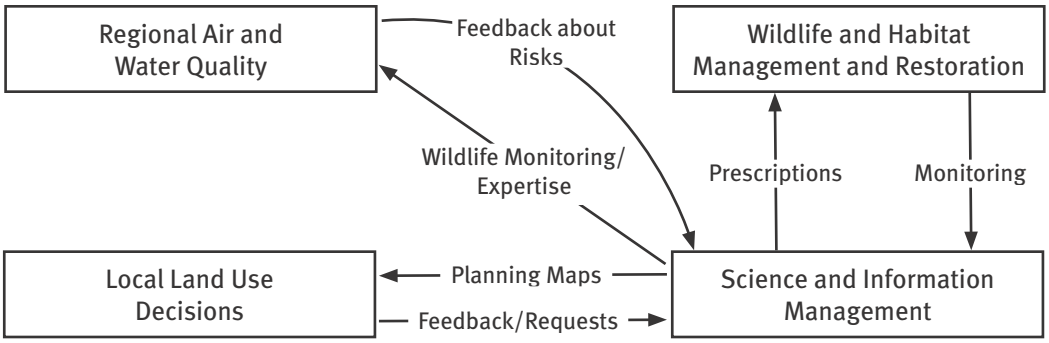

Figure 6-1 Adaptive management flow chart

the success of management actions. This entails measuring changes in the level of a risk factor, demonstrating a beneficial ecological response, and establishing a correlation between management and changes in threat levels (207, 904, 905)
- Monitor ecological health of under-surveyed taxa, indicators of condition, threatened and endangered species, effects of management, and ecological responses to management. Produce succinct, standardized periodic reports on wildlife health by habitat (901, 902, 903, 904, 905, 906, 907)

Conservation Actions for Species and Habitats

For each species and habitat, a profile template was completed to the extent that information was available (Appendix L). In element 4 of these profiles, priority Conservation Actions were identified. For each conservation action, we completed the conservation performance objective, performance monitoring, ecological response objective, and response monitoring. These objectives and monitoring will allow biologists to ascertain whether management is effective.

Adaptive Management

Adaptive management incorporates conservation planning, implementation, monitoring, performance evaluation, and most importantly the ability to learn and adapt between each phase. Formalizing adaptive management will help ensure that strategies and actions are ecologically effective, efficient, and cost-effective. We built adaptive management into the planning process and it will be an integral part of implementation (chapter 7). The adaptive management flow chart (Figure 6-1) shows the framework we developed to guide our decision-making. Identifying performance objectives for each strategy and action will be critical for evaluating performance and adapting when objectives do not meet expectations. Strategies listed in chapter 5 that pertain to adaptive management include:

- Research and comparatively analyze threats to the condition of wildlife populations and habitats (203, 204, 1001)
- Prioritize all proposed conservation actions before implementation to ensure that resources are targeted effectively (207, 1201, 1202)
- Refine and adapt all management activities to reflect new science (207, 904, 905, 1002)
- Manage information and develop media to disseminate to all levels in conservation (201, 202, 206, 401)

Monitoring Strategy (900)

900 Description

Monitoring entails the measurement of changes in ecological, spatial, or social variables over time. Traditionally, monitoring has included direct enumeration of species' populations, but also can include species' distributions, population productivity, genetic integrity, community analysis, habitat variables, and risks to wildlife health. Monitoring provides essential input and feedback for all kinds of wildlife conservation efforts, and is almost unilaterally prescribed when concern arises over a particular species or habitat.

It is not feasible to intensively monitor all species and habitats of concern. Certain species and other biological components that reflect pertinent ecological changes may serve as broad indicators of the health of natural systems. By tracking a subset of species or conditions, monitoring can elucidate the nature of threats and the effectiveness of restoration and management efforts prescribed to address those threats.

Monitoring programs must carefully evaluate statistical considerations to ensure that monitoring efforts provide useful information. The objectives presented in this monitoring strategy represent different levels of statistical rigor and monitoring intensity. Although there is some overlap between objectives, it is important to evaluate each to ensure that a monitoring program is comprehensive and adequately reflects the condition of species or habitats. Specific details about monitoring needs can be found in species and habitat profiles (Appendix A and B). Table 6-1 summarizes much of the information gathered during the planning process for priority species and habitats and indicates which monitoring objectives (901-905) are most appropriate for each species, habitat, and threat addressed in the WAP. Table 6-1 is an important first step in identifying an efficient suite of indicators (906).

900 Goal

The goal of monitoring is to provide wildlife managers with meaningful data on the status of wildlife populations and habitats. Monitoring will provide data and feedback for performance evaluation and adaptive management. In some cases, broad early-detection monitoring programs are necessary to inform managers about changes that may require more active management in the future. In other cases, it is necessary to monitor less tangible variables such as public attitudes, efficacy of regulatory enforcement, and economic values of natural resources.

901 Objective: Conduct Surveys to Describe Distribution

Assess the distribution of wildlife species and habitats by conducting presence/absence surveys that range from targeted confirmation of historic wildlife records to participation in coordinated statewide and regional surveys. Generally, distribution surveys occur at relatively coarse spatial and temporal scales, and have little or no statistical power to detect trends in abundance.

901(A) Expected Benefits

Determination of presence/absence is the simplest form of monitoring. For some rare or poorly known species, surveys provide the only data available to guide conservation efforts. Distribution information is critical for implementing a management strategy. Periodic assessment of distribution is also valuable for more common or widespread species, potentially showing range expansions and contractions that reflect the nature or distribution of broad scale threats. Poorly surveyed taxa (i.e., amphibians, fish, and invertebrates), and rare wildlife benefit most from distribution surveys.

901(B) Affected Threats

Threats are not directly affected by the implementation of any monitoring strategy, although distribution surveys form the baseline for all conservation efforts.

901(C) Existing Resources

Resources available for distribution surveys depend on taxa and scale, and are generally inadequate to obtain complete information about distribution. Models for distribution surveys exist in other states and in regionally coordinated efforts. Currently, the only distribution information that is consistently collected in New Hampshire is from volunteers par-

ticipating in the Reptile and Amphibian Reporting Program (RAARP) or New Hampshire Bird Records (NHBR), and via the Wildlife Sightings website. The information provided by these programs is not conducted in any standardized manner and thus only provide rough approximations of distributions in New Hampshire. NHNHB conducts relatively comprehensive localized surveys of natural communities and plants and maintains records of exemplary natural communities, rare plants, and animals. All wildlife records are tracked via the Wildlife Sightings website, and records for tracked species of conservation concern are maintained by NHB. Taxonomic expertise is a limiting factor for many taxa, especially invertebrates.

901(D) Critical Inputs

- Develop contracts to utilize existing taxonomic expertise to identify existing unidentified collections
- The Wildlife Sightings and NHB databases require enhancement and maintenance
- Evaluate the feasibility of statewide atlas efforts for broad groups of under-surveyed taxa (e.g. reptiles, amphibians, fish, and invertebrates); models exist for Lepidoptera and Odonata atlases in other states Integrate inter-agency survey results
- Repeat Breeding Bird Atlas at regular intervals
- Evaluate the need and feasibility of a mammal atlas
- Identify rare species requiring targeted searches.

901(E) Organization

NHFG needs to coordinate with independent consultants, university researchers, and other qualified individuals to ensure all wildlife sightings obtained during independent surveys are incorporated into the Wildlife Sightings database. All survey results conducted under this strategy also need to be incorporated into the database. NHFG can coordinate with RAARP volunteers and ASNH can coordinate with NHBR contributors to prioritize surveys. ASNH should repeat the Breeding Bird Atlas, which is now greater than 10 years old. Other distribution research should be assessed via discussions among interested partners including ASNH, TNC, universities, and others. Assessing compatibility of monitoring objectives within habitat types is described under 906, and reporting requirements are described under 907.

901(F) Feasibility: 2.19
901 (G) Initiation: 1 year
901 (H) Duration: <10 years

902 Objective: Detect changes in the condition of wildlife and wildlife habitats

Conduct monitoring to detect changes in the condition of wildlife populations and habitats. The purpose of this objective is to detect emerging risk factors (threats) and population declines before they become critical ecological problems. Variables that may be monitored include indicators of the extent or composition of habitats and natural communities, indicators of long-term trends in populations, and levels of risk factors that pose a potential threat to wildlife. Generally, indicators of condition will be monitored regularly across a network of fixed locations, with minimal statistical power to detect short-term local trends, and increasing power at broader spatial and temporal scales.

902 (A) Expected Benefits

Information on the current condition of indicator species or habitats can reflect broad patterns of distribution and abundance for all species and habitats. At a broad scale, monitoring programs such as the BBS generate trend information for many common species, and thus serve as an early warning system. Early detection of broad changes in condition will allow management to adapt incrementally, before species decline to threatened or endangered status, and before habitats are seriously degraded by emergent threats. Ultimately, this will preempt drastic and costly interventions.

902 (B) Affected Threats

Threats are not directly affected by the implementation of any monitoring strategy, although monitoring broad changes in condition will indirectly allow managers to address any potential threat that arises.

902 (C) Existing Resources

Several existing programs assess broad patterns of species and habitat condition. Many broad-based threats (atmospheric pollution, water quality, population growth, etc.) are extensively monitored. SPNHF regularly reports on the status of landscape-level threats that are relevant wildlife habitat condition.

Additionally, existing remotely sensed data can provide an efficient means of evaluating habitat health at broad scales (e.g., looking at trends in habitat abundance and distribution over time) using GIS. Even with these resources to evaluate habitat health, many programs are inadequate (e.g., we currently cannot accurately assess the abundance or distribution of shrubland habitats using existing remotely sensed data) and assessments of habitat health are often not tied to wildlife population health.

NHDES monitors stream macroinvertebrates to detect changes in stream quality. Several regional monitoring initiatives exist for birds, including the North American Bird Conservation Initiative (NABCI). Similarly, the BBS, and to a lesser extent the North American Amphibian Monitoring Program (NAAMP) is an important monitoring program in New Hampshire. *Keeping Track* is an international organization based in Vermont that teaches mammal tracking and survey skills to individuals so the information can be applied to local and regional conservation planning. Such information can also provide an indicator of ecological health at the landscape level. For other taxa, however, there is rarely the funding, organizational structure, or expertise to conduct regional monitoring.

902 (D) Critical Inputs

- Identify appropriate indicators of habitat and wildlife health (Objective 906)
- Integrate existing air and water quality and other landscape level assessments of broad threats into assessments of wildlife and habitat health
- Coordinate with and participate in regional monitoring efforts, including BBS, NAAMP, and Keeping Track

902 (E) Organization

Species monitored under existing programs (e.g. Partners in Flight, NABCI, RAARP, Christmas Bird Count, BBS, stream surveys, etc.) need to be catalogued to determine how they interact with identified monitoring needs. Assessing compatibility of monitoring objectives is described under 906, and reporting requirements are described under 907.

902 (F) Feasibility: 1.88

902 (G) Initiation: 1 year

902 (H) Duration: Indefinite

903 Objective: Monitor Population Trends for Threatened and Endangered Species

Monitor indicators of trends in population health for threatened and endangered species. Indicators of trends may include abundance, productivity, genetic diversity, or demographic structure. Trends will be used to assess the effectiveness of recovery efforts.
Generally, monitoring for population health should be able to detect local and relatively short-term trends with relatively high statistical power. For many species, it is feasible to achieve statistical power >0.8 with intensively surveyed fixed sampling units, but often, it is not feasible to achieve power >0.5. Decreasing intensity of monitoring (and power) is acceptable with increasingly stable populations.

903 (A) Expected Benefits

Intensive monitoring for threatened and endangered species helps ensure that inputs invested in recovery are effective, and definitive confirmation of recovery can lead to changes in listing status and potentially free resources for other threatened or endangered species. The species most likely to benefit may include timber rattlesnake, piping plover, roseate terns, cobblestone tiger beetle, Karner blue butterfly, Blanding's turtle, spotted turtle, lynx, American marten, White mountain arctic, White mountain fritillary, spruce grouse, New England cottontail, brook floater, dwarf wedgemussel, eastern pondmussel.

903 (B) Affected Threats

Threats are not directly affected by the implementation of any monitoring strategy, although the breakdown of population processes in small populations is, in itself a threat (see Scarcity). Accurate measurement of population parameters, as means of directing intervention, may help determine recovery.

903 (C) Existing Resources

Resources vary extensively depending on the species being monitored. Many species listed at the federal level (e.g., Karner blue butterfly, roseate tern, bald eagle, and peregrine falcon) receive regular funding and are the subject of extensive work throughout their ranges. Other federally listed species and the majority of state-listed ones are not adequately monitored, generally because of limited expertise and funding. Expertise frequently exists within the academic sci-

entific community, and there is high potential for collaboration among academic researchers, regional, and state recovery efforts. Resources and technical expertise exist within USFWS and USGS to evaluate monitoring protocols.

903 (D) Critical Inputs

- Develop monitoring protocols for listed species
- Collaborate with other states, federal agencies, and IAFWA to evaluate existing protocols to determine effectiveness
- Implement revised and existing protocols
- Evaluate opportunities for collaboration

903 (E) Organization

Threatened and endangered species monitoring is currently conducted via partnerships and contracts involving NHFG, NHA, USFWS, academic researchers, and private consultants. Existing contracts may be amended to implement new protocols. Contracts for rare amphibians, invertebrates, and fish need to be developed, most likely with academic researchers or consultants. Existing regional programs should be taken into consideration. Monitoring and reporting requirements need to be integrated with all recovery plans and incorporated into the scope of service for new contracts. Assessing compatibility of monitoring objectives within habitat types is described under 906, and reporting requirements are described under 907.

903 (F) Feasibility: 1.56
903 (G) Initiation: 1 year
903 (H) Duration: >10 years

904 Objective: Measure direct effects of management

Measure the magnitude of changes in threats as a direct result of management. Indicators that may be measured to quantify the direct effects of management are highly variable. Some examples include the level of duff or canopy reduction by fire or forestry, rate of survival of propagated plants, rate of recreational visits by a group targeted for education, or changes in the distribution of lead sinkers after restrictions are implemented. Generally, measuring the direct effects of management entails detecting local and relatively short-term changes with moderate power (0.5-0.8). Typically, change need only be measured over several intervals (i.e., before and after implementation), depending on the duration and frequency of management and the degree to which effects attenuate over time. Sample sizes and units will vary widely, and often statistical or quantitative methods are not applicable. For example, some types of management may be recorded photographically.

904 (A) Expected Benefits

Measuring whether management inputs have their intended direct effect is a critical component of performance evaluation and adaptive management. Together, information on the direct effect and the ecological response (see 905) allow managers to evaluate linkages between problems and solutions. Species and habitats under restoration or management will benefit most.

904 (B) Affected Threats

Threats are not directly affected by the implementation of any monitoring strategy, although measuring direct effects of management help determine whether management affects threats.

904 (C) Existing Resources

Resources available for threat monitoring vary in conjunction with the nature of a given threat. Many broad-based threats (atmospheric pollution, population growth, etc.) are already extensively monitored, while local threats (effects of a particular dam on stream conditions, human use of beaches, etc.) are poorly monitored or not monitored at all. Effects of department-level habitat management are monitored by NHFG, but need integration across programs. Habitat management projects completed under existing cost-share programs (e.g., WHIP, FLEP – see strategy 800) and other projects on private lands are rarely monitored.

904 (D) Critical Inputs

- Funding to adequately monitor effects on public and private lands is needed
- Existing cost-share programs should set aside a segment of funding to support monitoring of habitat management effects
- Appropriate indicators need to be identified by a group of stakeholders to make monitoring effective

and cost efficient (objective 906)
- Trained staff or contractors are needed to apply monitoring protocols, analyze data, and make habitat management recommendations based on principles of adaptive management

904 (E) Organization
Monitoring and reporting requirements need to be integrated with all NHFG management plans and incorporated into the scope of service for new contracts. NHFG and UNH Cooperative Extension should work with other conservation partners and land managers in monitoring the effects of their work. Regional coordination is needed to ensure appropriate levels of funding are provided for monitoring of existing cost-share programs that are funded by the federal government (e.g., WHIP, FLEP). Assessing compatibility of monitoring objectives within habitat types is described under 906, and reporting requirements are described under 907.

904 (F) Feasibility: 1.56
904 (G) Initiation: <1 year
904 (H) Duration: >10 years

905 Objective: Monitor Ecological Responses to Management

Conduct monitoring to determine whether the changes caused by management are having the desired beneficial effect on wildlife. Indicators that may be measured to quantify ecological responses to management are highly variable. For example, if captive breeding is proposed as a management tool, it is necessary to measure whether captive-reared individuals are successfully surviving and reproducing in the wild. See 904 for typical monitoring requirements.

905 (A) Expected Benefits
Follow-up monitoring of ecological responses to management is a critical component of performance evaluation and adaptive management, allowing managers to test the underlying assumption that management benefits targeted species or habitats. Together, information on direct effects (see 904) and ecological responses allow managers to evaluate linkages between problems and solutions (i.e., whether management is actually improving the health of wildlife and habitats, and whether the problem being managed is actually the cause of diminished wildlife health).

905 (B) Affected Threats
Threats are not directly affected by the implementation of any monitoring strategy, although monitoring ecological responses may allow for better understanding of how threats affect species and habitats or the extent to which management reduces any given threat.

905 (C) Existing Resources
Resources needed and available for monitoring under adaptive management vary extensively depending on the species or habitat being managed and the scale at which management is occurring. Ideally, indicators measured under 902, 903, and 904 will adequately reflect ecological responses (905) to evaluate management.

905 (D) Critical Inputs
See objectives 902, 903, 904, 906, 907 for additional inputs. Develop or evaluate protocols prior to implementation of management.

905 (E) Organization
See objective 904. Assessing compatibility of monitoring objectives within habitat types is described under 906, and reporting requirements are described under 907.

905 (F) Feasibility: 1.56
905 (G) Initiation: 1 year
905 (H) Duration: >10 years

906 Objective: Select an efficient set of indicators by habitat

Select an efficient set of indicators of wildlife health and management performance by habitat type. It is not feasible to monitor all species, risk factors, and management within a given habitat. Key components for monitoring within each habitat type includes under-surveyed taxa, indicators of condition, threatened and endangered species, effects of management, and ecological responses to management. Objectives 901, 902, 903, 904, 905 represent criteria for determining the collective adequacy of monitoring to provide

essential information on wildlife health and management performance. Existing monitoring programs, known threats, and proposed management will be systematically evaluated by habitat to identify compatible objectives and a set of efficient indicators.

906 (A) Expected Benefits
Choosing an appropriate set of indicators streamlines monitoring by reducing the number of species that need to be surveyed on a regular basis, allowing a finely-tuned system of detecting responses to changes in threats or management activity. For example, if available evidence indicates that a rare mussel is most sensitive to the availability of a fish host species, it may actually be more effective to monitor populations of the fish than the mussel. This would be even more appropriate if the fish was known to be a good indicator of several other environmental variables, such as stream temperature, sedimentation, or hydrologic alteration. Choosing indicators should not replace direct monitoring for the most threatened taxa, nor should it be assumed that threatened and endangered species are the best indicators.

906 (B) Affected Threats
Threats are not directly affected by the implementation of any monitoring strategy, although monitoring may allow for better understanding of how threats impact populations or the extent to which a given threat has been reduced through management.

906 (C) Existing Resources
Information on monitoring needs was gathered in species and habitat profiles completed for the WAP. Needs were tabulated and refined to reflect known threats and strategies (see Chapter 5). Within habitat types, the feasibility and efficacy of proposed indicators need to be evaluated. Criteria for assessing indicators are developed under the previous objectives, and during the *Assessing Biodiversity Indicators Workshop* (TNC 2005).

906 (D) Critical Inputs
NHFG should conduct a workshop or series of workshops to assess all indicators proposed in the WAP and identify other appropriate indicators by habitat. This will allow the termination of redundant monitoring for species and habitats, and reduce the intensity for over-surveyed or over-monitored taxa.

906 (E) Organization
NHFG will host a workshop or series of workshops to assess ongoing monitoring and indicators proposed in the WAP. TNC may serve as a partner in workshop organization.

906 (F) Feasibility: 3.28
906 (G) Initiation: 1 year
906 (H) Duration: 1 year

907 Objective: Report the condition of wildlife health by habitat

Produce succinct, standardized annual reports on the condition of wildlife health by habitat.

907 (A) Expected Benefits
Standardized reporting on a set of indicators selected by an informed process will provide critical information to summarize the status of ongoing monitoring and management, and serve as input to adapt management to current conditions. Funding invested in ineffective management may become available for more effective approaches. Reports may lead to changes in listing status and potentially free resources for other threatened or endangered species.

907 (B) Affected Threats
See above

907 (C) Existing Resources
Biometric expertise and data management resources to analyze and summarize monitoring data for most rare and declining wildlife are limiting. For instance, NHFG currently only has one biologist who works part time analyzing wildlife data for the entire department. Even when NHFG staff or partners collect rigorous data, data are often not summarized annually or for multiple years. Data collected on similar projects in different states are typically not integrated across state and regional programs to inform planning and management.

907 (D) Critical Inputs
Additional biometricians are needed for data analysis, interpretation, and reporting. Standardized reporting protocols are needed to guide NHFG staff and contractors. Technical assistance is needed for contractors

to collect and report data according to the developed standards.

907 (E) Organization
USFWS should coordinate sharing of data among states in the region for all threatened and endangered species. NHFG should coordinate data analysis and reporting of wildlife health within the state.

907 (F) Feasibility: 2.06
907 (G) Initiation: 1 year.
907 (H) Duration: >10 years

TABLE 6.1 Preliminary Criteria for Selecting Indicators. (in 9 sections, beginning on page 6-14).

For each species and habitat, potential monitoring needs were categorized according to the technical objectives (901-905) described in the Monitoring Strategy and species/habitat profiles. In the first column, each species and risk factor represents a factor or variable that needs to be monitored. Under objectives 901-905, letters signify the type of change that may need to be measured for each factor. The type of change measured varies among objectives, with intensity generally increasing from left to right. Often, objectives overlap. For a given species, all five objectives may be met with a single rigorous protocol. Many wildlife species, risk factors, and/or overall habitat condition may be highly correlated with a single species. Such species are considered 'efficient' indicators for a given habitat type. The next step in developing a WAP monitoring program is to evaluate potential indicators based on how well they represent all of the X's, whether programs exist already, and whether the necessary frequency and scale are cost effective. The goal is to identify one or a few indicators for each habitat that will reflect all of the X's in the table.

Footnotes Used in the Table:

1 Many species are associated with more than one habitat. For a complete list of species associated with each habitat, see Appendix D [species and habitat crosswalk].
2 Many possible indicators exist for the listed risk factors. Ideally, species with X's under one of the objective columns will serve to detect changes in the levels of risk factors.
3 Not all associated species are listed under each habitat. For a complete list of species associated with each habitat, see Appendix D [species and habitat crosswalk].
4 Objective 901 includes targeted and broad distribution surveys. Targeted surveys are likely to be prescribed for poorly studied rare species, and broad distribution surveys will be accomplished via atlas development or existing programs.
5 Objective 902 is intended for early detection of broad changes in the condition of habitats or the levels of risk factors.
6 Objective 903 is intended to address rigorous detection of population trends for the most imperiled species.
7 Objective 904 was developed to measure the direct effects of management in order to evaluate the performance of specific projects.
8 Objective 905 is intended to measure the ecological responses of wildlife to management activities. Ideally, objective 904 and 905 will serve to establish a correlation between management and response.
9 Existing programs will augment or serve instead of new monitoring programs.
10 1= annual, 2=2-5 years, 3=›5 years. Indicators that require frequent monitoring are undesirable.
11 A = Local, B = State, C = Regional/National, D = Surveys.

TABLE 6.1

Species[1] and Risk[2] Factors by Habitat[3]	Distribution (901)[4]	Detect Change (902)[5]	Population Trend (903)[6]	Management Effect (904)[7]	Ecological Response (905)[8]	Existing Programs[9]	Frequency[10]	Scale[11]
ALPINE		X					2, 3	A, B, D
American Pipit	X						3	A, D
White Mountain Fritillary	X		X			WMNF	2	A
White Mountain Arctic	X		X			WMNF	2	A
Acid Deposition		X						
Climate Change		X						
Scarcity		X	X					
GRASSLAND	X	X		X	X		2, 3	B
Upland Sandpiper	X	X	X	X	X	T&E, BBS	2	A, C
Northern Harrier	X	X	X	X	X	NHBR, BBS, T&E	2	A, B, C, D
Grasshopper Sparrow	X	X	X	X	X	T&E, BBS	2	A, B, C, D
Purple Martin	X			X	X	T&E, BBS	2	A, B, D
Eastern Meadowlark	X	X				BBS	1	B, C, D
Vesper Sparrow	X	X				NHBR, BBS	2	B, C, D
Horned Lark	X					NHBR, BBS	2	B, C, D
Northern Leopard Frog	X	X				RAARP	2	B, D
Black Racer	X					RAARP	3	B, D
Smooth Green Snake	X					RAARP	2	B, D
Agriculture				X	X			
Transportation Infrastructure		X		X	X			
Predation and Herbivory				X	X			
SHRUBLAND	X	X		X	X		2, 3	B
Ruffed Grouse	X	X		X	X	NHFG, BBS	1	B, C
Golden-winged Warbler	X					NHBR, BBS	1	A, B, C, D
New England Cottontail	X		X	X	X	UNH	2	A, B, C, D

TABLE 6.1

Species[1] and Risk[2] Factors by Habitat[3]	Distribution (901)[4]	Detect Change (902)[5]	Population Trend (903)[6]	Management Effect (904)[7]	Ecological Response (905)[8]	Existing Programs[9]	Frequency[10]	Scale[11]
American Woodcock	X	X		X	X	NHFG	1	B, C
Natural Succession				X	X			
Development		X						
Predation and Herbivory				X	X			
APPALACHIAN OAK PINE FOREST		X		X	X			
Timber Rattlesnake	X		X				1, 2	A
Development		X						
Transportation Infrastructure		X		X	X			
Scarcity		X	X					
Altered Natural Disturbance				X	X			
AQUATIC (7 watershed groups)		X		X	X			
Common Loon	X	X	X	X	X	LPC	1	A, B, C
Bald Eagle	X	X	X	X	X	T&E	1	A, B, C
Osprey	X	X				T&E, BBS	2	B
Brook Trout	X						2?	B, D
Burbot	X						3?	?
Lake Trout							?	?
Lake Whitefish	X	X					?	A, D
Round Whitefish	X	X					2, 3	A, D
Slimy Sculpin	X	X					2	A, D
Sunapee Trout	X							C
Atlantic Sturgeon	X						3	A
Swamp Darter	X						3	A, D
Banded Sunfish	X						3	A, D
Bridled Shiner	X						3	A, D

TABLE 6.1

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American Brook Lamprey	X						3	A, D
Finescale Dace	X						3	A, D
Northern Redbelly Dace	X						3	A, D
Redfin Pickerel	X						3	A, D
Tessellated Darter	X						3	A, D
Shortnose Sturgeon	X						3	A
Rainbow Smelt	X	X					2, 3?	A, B?
Atlantic Salmon			X	X	X			
Alewife	X	X					2?	B?
Blueback Herring	X	X					2?	B?
American Eel	X	X					2?	B?
Sea Lamprey	X						2?	B?
American Shad	X	X					2?	B?
Dwarf Wedgemussel	X	X	X				2	A, B
Brook Floater	X	X	X				2	A, B
Eastern Pond Mussel	X						2	
Recreation		X		X	X			
Introduced Species		X		X	X			
Development		X						
Non-point Source Pollution		X		X	X			
Altered Hydrology				X	X			
Mercury	X	X						
Agriculture		X		X	X			
CAVES and MINES		X		X	X		1, 2	A, B
Eastern Pipistrelle	X						2	A, B, D

TABLE 6.1

Species[1] and Risk[2] Factors by Habitat[3]	Distribution (901)[4]	Detect Change (902)[5]	Population Trend (903)[6]	Management Effect (904)[7]	Ecological Response (905)[8]	Existing Programs[9]	Frequency[10]	Scale[11]
Eastern Small-footed Bat	X						2	A, B, D
Indiana Bat	X						2	D
Northern Myotis	X						2	A, B, D
Recreation				X	X			
CLIFFS		X		X	X		2, 3	A, B
Peregrine Falcon	X	X	X	X	X	T&E	2	A, C
Golden Eagle	X					NHBR	3	C, D
Recreation				X	X			
Mercury		X						
COASTAL ISLANDS		X		X	X			
Common Tern	X	X	X	X	X	T&E	1	A, B, C
Roseate Tern	X	X	X	X	X	T&E	1	A, B, C
Arctic Tern	X		X			T&E	1	A, B, C
Black Guillemot	X					CBC	2	A, C
Purple Sandpiper	X	X				NHBR, CBC, PRISM	2	C
Scarcity		X	X					
Development		X						
Predation and Herbivory				X	X			
Oil Spills		X		X	X			
Introduced Species		X		X	X			
Unsustainable Harvest		X		X	X			
DUNES		X		X	X		1	A, B
Piping Plover	X		X	X	X	T&E	1	A, B, C
Least Tern	X					NHBR, T&E	2	C
Semipalmated Sandpiper	X	X				NHBR, PRISM	1	A, C

TABLE 6.1

Species[1] and Risk[2] Factors by Habitat[3]	Distribution (901)[4]	Detect Change (902)[5]	Population Trend (903)[6]	Management Effect (904)[7]	Ecological Response (905)[8]	Existing Programs[9]	Frequency[10]	Scale[11]
Recreation				X	X			
Predation and Herbivory				X	X			
Development		X						
Scarcity		X	X					
Oil Spills		X		X	X			
FLOODPLAIN FOREST	X	X		X	X			
Red-shouldered Hawk	X	X				NHBR, BBS	2	C, D
Cerulean Warbler	X					NHBR, BBS	2	A, D
Wood Turtle	X	X				RAARP	2	B, D
Development		X						
Transportation Infrastructure		X		X	X			
HEMLOCK-HARDWOOD-PINE FOREST		X		X	X			
Development		X						
Introduced Species		X		X	X			
Altered Natural Disturbance				X	X			
HIGH ELEVATION SPRUCE-FIR FOREST		X		X	X		2, 3	B, C
Bicknell's Thrush	X	X				Mt. Birdwatch	1	B, C, D
Spruce Grouse	X	X				NHBR	2	B, C, D
American Marten	X		X			NHFG	2	B, C, D
Unsustainable Harvest		X		X	X			
Development		X						
Scarcity		X						
Acid Deposition		X						
LOWLAND SPRUCE-FIR FOREST		X		X	X			
Rusty Blackbird	X	X				NHBR, BBS	1	B, C, D

TABLE 6.1

Species[1] and Risk[2] Factors by Habitat[3]	Distribution (901)[4]	Detect Change (902)[5]	Population Trend (903)[6]	Management Effect (904)[7]	Ecological Response (905)[8]	Existing Programs[9]	Frequency[10]	Scale[11]
Three-toed Woodpecker	X					NHBR, BBS	2	B, C, D
Purple Finch	X	X				NHBR, BBS	1	B, C, D
Bay-breasted Warbler	X	X				NHBR, BBS	1	B, C, D
Spruce Grouse	X	X				NHBR, NHFG	2	B, C, D
Hoary Bat	X						2	B, C
Unsustainable Harvest				X	X			
Development		X						
Scarcity		X	X					
Non-point Source Pollution				X	X			
Altered Natural Disturbance				X	X			
MARSH AND SHRUB WETLANDS	X	X			X		2	B
Pied-billed Grebe	X	X	X	X	X	NHBR	2	B, C, D
American Bittern	X	X				NHBR, BBS	2	B, C
Sedge Wren	X	X				NHBR	2	C
Least Bittern	X	X				NHBR	2	C
Common Moorhen	X	X				NHBR	2	C
Great Blue Heron	X	X				NHFG, BBS	2	A, B
American Black Duck	X	X				NHFG, MWWS	1	B, C
Ribbon Snake	X					RAARP	3	D
Blanding's Turtle	X	X	X			RAARP	2	A, B, C, D
Spotted Turtle	X	X				RAARP	2, 3	B, D
Development		X						
Transportation Infrastructure		X		X	X			
Mercury	X	X		X	X			
Scarcity		X	X					

TABLE 6.1

Species[1] and Risk[2] Factors by Habitat[3]	Distribution (901)[4]	Detect Change (902)[5]	Population Trend (903)[6]	Management Effect (904)[7]	Ecological Response (905)[8]	Existing Programs[9]	Frequency[10]	Scale[11]
NORTHERN HARDWOOD-CONIFER FOREST		X						
Development		X						
Acid Deposition		X						
PEATLANDS	X	X				NHB	2, 3	B
Palm Warbler	X					NHBR, NWR, BBS	2	C, D
Ringed Boghaunter	X					T&E	2	A, D
Northern Bog Lemming	X						3	D
Mink Frog	X	X				RAARP, NAAMP	3	B, D
Development		X						
PINE BARRENS	X	X		X	X	NHB, TNC, NHFG		
Whip-poor-will	X	X				NHBR, PIF, ASNH	1	B, C, D
Common Nighthawk	X	X		X	X	NHBR	2	A, B, C, D
Eastern Towhee	X	X				BBS	1	B, C, D
Eastern Hognose Snake	X					RAARP	2	A, D
Fowler's Toad	X	X				RAARP, NAAMP	2	A, D
Box Turtle	X					RAARP	3	A, D
Pine Barrens Zanclognatha	X	X				NHFG, NHARNG, TNC	1	A, D
Karner Blue Butterfly	X		X	X	X	NHFG, NHARNG, TNC	1	A, D
Frosted Elfin	X	X				NHFG, NHARNG, TNC	1	A, D
Sleepy Duskywing	X					NHFG, NHARNG, TNC	1	A, D
Wild Indigo Duskywing	X					NHFG, NHARNG, TNC	1	A, D
Barrens Itame	X	X				NHFG, NHARNG, TNC	1	A, D
Barrens Xylotype	X	X				NHFG, NHARNG, TNC	1	A, D
Persius Duskywing	X	X				NHFG, NHARNG, TNC	1	A, D
Pine Pinion Moth	X	X				NHFG, NHARNG, TNC	1	A, D

TABLE 6.1

Species[1] and Risk[2] Factors by Habitat[3]	Distribution (901)[4]	Detect Change (902)[5]	Population Trend (903)[6]	Management Effect (904)[7]	Ecological Response (905)[8]	Existing Programs[9]	Frequency[10]	Scale[11]
Broad-lined Catopyrrha	X	X				NHFG, NHARNG, TNC	1	A, D
Phyllira Tiger Moth	X	X				NHFG, NHARNG, TNC	1	A, D
The Cora Moth	X	X				NHFG, NHARNG, TNC	1	A, D
Development		X						
Altered Natural Disturbance		X		X	X			
Scarcity		X	X					
Transportation Infrastructure		X		X	X			
Predation and Herbivory		X		X	X			
Introduced Species		X		X	X			
SALT MARSH		X		X	X	NHCP, DU	1	A, B
Nelson's Sharp-tailed Sparrow	X	X				UNH	2	A, C
Saltmarsh sharp-tailed Sparrow	X	X				UNH	1	A, B, C
Seaside Sparrow	X	X				UNH	2	C
Willet	X	X				UNH, NHBR, PRISM	2	C
Development		X						
Altered Hydrology		X		X	X			
SAND/COBBLE SHORES/BANKS								
Cobblestone Tiger Beetle	X		X				2	A, D
Puritan Tiger Beetle	X						3	A, D
Scarcity		X	X					
Altered Hydrology		X		X	X			
TALUS SLOPES AND ROCKY RIDGES	X	X		X	X			
Recreation				X	X			
UPLAND FORESTS		X						
Lynx	X					NHFG	3	C

TABLE 6.1

Species[1] and Risk[2] Factors by Habitat[3]	Distribution (901)[4]	Detect Change (902)[5]	Population Trend (903)[6]	Management Effect (904)[7]	Ecological Response (905)[8]	Existing Programs[9]	Frequency[10]	Scale[11]
Bobcat	X					NHFG	2	B
Eastern Red Bat	X						2	B, C
Silver-haired Bat	X						2	B, C
Cooper's Hawk	X	X				NHBR, BBS, CBC	1	B, C, D
Northern Goshawk	X	X				USFS, BBS	1	B, C, D
Development		X						
Scarcity		X	X					
VERNAL POOLS	X	X		X	X			
Marbled Salamander	X					RAARP	3	D
Jefferson Salamander	X	X				RAARP	2	B, D
Blue-spotted Salamander	X	X				RAARP	2	B, D
Development		X						
Transportation Infrastructure		X		X	X			
Acid Deposition		X		X	X			
NON-BREEDING BIRDS		X		X	X		1, 2, 3	A, B, C, D
Development		X						

CHAPTER SEVEN

Implementation

This chapter addresses Elements 6 and 7 of the NAAT Guidelines. Element 6 requires, "descriptions of procedures to review the strategy at intervals not to exceed ten years." Element 7 asks for, "Plans for coordinating the development, implementation, review, and revision of the plan with Federal, State, and local agencies and Indian tribes that manage significant land and water areas within the State or administer programs that significantly affect the conservation of identified species and habitats." Described here is our expected approach to implementing the New Hampshire WAP. Implementation will involve department staff, other agencies, and the many partners that assisted in the plan's development. Partners who have helped write, review, and edit the plan have a good understanding of its components and have a vested interest in its successful implementation.

We recognize that having the resources to implement the plan will be critical. We will need major support from future federal funding, such as the State Wildlife Grants that provided money to generate this Plan. While we will ask partners to support the WAP's goals in many ways, it will be difficult for NHFG to play the leadership role that is expected absent significant funding.

Years 1-2

To foster awareness and support for implementing the plan, initial actions will focus on internal and external outreach regarding plan strategies, and the prioritization of strategies and objectives into operational work plans. NHFG staff from many divisions and program areas will be engaged in these efforts to ensure a coordinated agency approach to strategy implementation.

The NHFG public affairs division will disseminate information about the WAP. A major public release of the plan will be developed for the early part of 2006, in coordination with national WAP promotion strategies. The intent is for target groups to understand how they can assist in strategy implementation to achieve conservation of species at risk. A component of this is likely to be a Wildlife Summit II, where partners from the conservation community, landowners, businesses, and agencies will be brought together to discuss the WAP and provide their input on implementation.

Internal discussions with NHFG staff will also be occurring. Many NHFG divisions, including wildlife, fisheries, marine, and law enforcement have important roles to play in the implementation of the WAP. Administrators and staff need to understand these roles, identify available resources, and commit to the successful implementation of plan strategies. Partners who participated in developing the WAP should also be engaged—their continued involvement and assistance is as important now as it was at the beginning of the planning process.

A principal need is the prioritization of WAP strategies and objectives. This task will be aided by the risk assessment scores and feasibility ranking forms developed as part of the WAP. Priority strategies and objectives will be reviewed by partners and revised as appropriate. Further, agencies and organizations need to be identified that have the interest and ability to

take on leadership roles in the four broad conservation focus areas: local land and water conservation, regional air and water quality, statewide biodiversity stewardship and conservation science, and information management. NHFG will be a leader on many strategies, but others may lend their leadership as appropriate. Specific coordinators should be established for the implementation and monitoring of conservation strategies.

Contact with state and federal agencies will be made to integrate the priorities and strategies of the WAP into their plans and operations. Agencies and their existing plans include but are not limited to:

State Agencies/Organizations

- NHDFL including the NH Forest Resources Plan due to be revised in 2006
- NH Estuaries Project Management Plan due to be revised in 2010
- Office of Energy and Planning including the Statewide Comprehensive Outdoor Recreation Plan (SCORP) to be updated in 2008
- NHDOT, including the Long Range Statewide Transportation Plan due to be completed Spring 2006

Federal Agencies

- USFS including the WMNF Land and Resource Management Plan due to be updated September 2005
- USFWS including all recovery plans for federally threatened and endangered species that occur in New Hampshire
- USFWS including conservation and management plans for all National Wildlife Refuges that occur in New Hampshire

Years 1-3

NHFG will work with lead implementation organizations and personnel to develop specific, measurable targets to monitor achievement of WAP goals. While some performance indicators were developed as a part of the WAP, additional detail is needed. Working groups may be organized at the level of the four focus areas or at the strategy level, to develop specific work plans and performance monitoring strategies. Work plans for top priorities will be developed in Year 1, while lower priority work plans may not be developed until Years 2-3.

Years 2-10

Progress toward WAP goals will be measured, and allowances will be made for adaptive management. Details on measuring and monitoring progress are described in detail in the Monitoring chapter.

Year 10

We will conduct a major plan review in 2015. The public will be involved in the review process through a "Wildlife Summit" type meeting, and other forums similar to those outlined in our public participation process described in this document. We will provide information on progress toward our goals to date, and facilitate a reassessment of WAP priorities and strategies.