EASTERN HELLBENDER
STATUS ASSESSMENT REPORT

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DISCLAIMER

This document is a compilation of biological data and a description of past, present, and likely future threats to the eastern hellbender, *Cryptobranchus alleganiensis alleganiensis* (Daudin). It does not represent a decision by the U.S. Fish and Wildlife Service (Service) on whether this taxon should be designated as a candidate species for listing as threatened or endangered under the Federal Endangered Species Act. That decision will be made by the Service after reviewing this document; other relevant biological and threat data not included herein; and all relevant laws, regulations, and policies. The result of the decision will be posted on the Service's Region 3 Web site (refer to: http://midwest.fws.gov/eco_serv/endangrd/lists/concern.html). If designated as a candidate species, the taxon will subsequently be added to the Service's candidate species list that is periodically published in the Federal Register and posted on the World Wide Web (refer to: http://endangered.fws.gov/wildlife.html). Even if the taxon does not warrant candidate status it should benefit from the conservation recommendations that are contained in this document.

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SYSTEMATICS

Common Name
Eastern hellbender. Other common names include Allegheny alligator, Allegheny hellbender, alligator, alligator of the mountains, big water lizard, devil dog, ground puppy, leverian water newt, mud-devil, vulgo, walking catfish, and water dog (Nickerson and Mays 1973).

Scientific Name
Cryptobranchus alleganiensis alleganiensis (Daudin)

Taxonomy
The eastern hellbender (*Cryptobranchus alleganiensis alleganiensis*) belongs to the Order Caudata, family Cryptobranchidae. This family contains three extant species belonging to two living genera of salamander, *Andrias*, which live in the Orient, and *Cryptobranchus*, which inhabit parts of the eastern United States (Petranka 1998).

The genus *Cryptobranchus*, is monotypic, although two subspecies are recognized (*C. alleganiensis alleganiensis, C. alleganiensis bishopi*). However, the taxonomic differentiation between hellbender subspecies is not well agreed upon by experts and discussion continues on whether *C. a. alleganiensis* and *C. a. bishopi* are distinct species or subspecies. Grobman (1943) first designated the Ozark hellbender as a new species, *C. bishopi*, from 12 specimens collected from the Current River in Carter County, Missouri, based on phenotypic differences which showed no intergradation with *C. alleganiensis*. Dundee and Dundee (1965) later argued that, despite the absence of demonstrated intergradation, consideration of morphology, ecology, and the allopatric distribution warranted the subspecies designation for *bishopi*. More recently, arguments have been made for reviving the *C. bishopi* designation on the basis of non-intergradation (Collins 1991) and recent evidence of significant genetic distinctions between Ozark and eastern hellbenders (Routman 1993).

Subspecies are most easily identified by geographic range although some difference in color pattern also exists. The eastern hellbender occurs from southern New York to northern Georgia, Alabama, and Mississippi with a population in central Missouri (Nickerson and Mays 1973, Petranka 1998). The Ozark hellbender (*C. a. bishopi*) is restricted to southern Missouri and northeastern Arkansas (Nickerson and Mays 1973). The Ozark subspecies is described as having dark dorsal blotching and noticeably pronounced chin mottling as opposed to the dorsal spotting of the eastern subspecies which has a uniformly colored chin (Grobman 1943, Nickerson and Mays 1973, Petranka 1998). *C. a. bishopi* also differs from the eastern subspecies by having considerably reduced spiracular (gill-like) openings, smooth skin in the ventral canal system of the pectoral portion of the lateral line system, and smaller overall body size (Grobman 1943, Nickerson and Mays 1973).

Some confusion exists in differentiating larval forms of *Cryptobranchus* from mudpuppies (*Necturus maculosus*). Mudpuppies, which have four toes and retain conspicuous gills as adults, are sometimes misidentified as larval hellbenders. Grobman (1943) describes the misidentification of a four-toed specimen collected from Lake Champlain, New York. The fact that at 28 centimeters (cm) in length it still had gills (which *Cryptobranchus* lose at around 13.5 cm), led to the conclusion that the specimen was *N. maculosus*.

PHYSICAL DESCRIPTION AND CHARACTERISTICS

The eastern hellbender is a fully aquatic giant salamander characterized by a large, flat head; wide neck; dorso-ventrally flattened, heavily wrinkled body; and keeled tail (Green and Pauley 1987). A drawing is provided in Appendix 1. The body is elongated and the short limbs have four toes on the front feet and five toes on the hind feet (Bishop 1941, Green and Pauley 1987). A fold of skin extends from the outer digits of the limbs to the body, forming a wing-like fringe most prominent on the hind legs (Cope 1889). Their skin has highly vascularized longitudinal folds on the dorsal and lateral aspects of the body surface (Bishop 1941). Adults lack eyelids and, after having undergone incomplete metamorphosis, retain extremely reduced gills which appear as circular openings on the neck and may be missing from one or both sides of the head (Petranka 1998). Hellbenders average 50 cm in length (Green and Pauley 1987, Petranka 1998) with some individuals reaching up to 74 cm (Nickerson and Mays 1973, Petranka 1998). *Cryptobranchus* shows negligible sexual dimorphism although Bishop (1941) found males to be heavier and broader than females of a similar length. Males and females are similar in color (Bishop 1941). Coloration is variable, but can be generally described as dark green or gray dorsally and lighter on the underside. Irregular, dark spots, brownish or black in color, are often present on the dorsal surface (Cope 1889, Bishop 1941, Nickerson and Mays 1973, Green and Pauley 1987, Petranka 1998).

Hatchling larvae range from 27 to 33 millimeters (mm) in length (Bishop 1941). Larvae have a large, conspicuous yolk sac which they presumably rely on as an energy source for the first few months after hatching (Petranka 1998). Larvae hatch with two forelimbs with two lobes representing undeveloped toes as well as unlobed, paddle-shaped hind limbs, a large mouth, and prominent eyes (Bishop 1941). Patches of cilia are scattered over the body with a high concentration on the gills (Pfingsten and Downs 1989). Bishop (1941) describes newly hatched larvae in New York as well pigmented dorsally, darkest down the midline and between the eyes. Pigmentation is lighter laterally and absent ventrally. Larvae develop rapidly during the first few weeks after hatching (Bishop 1941, Taber et al. 1975). At one month external gills have become reduced and short hind limbs with three toes are now present (Pfingsten and Downs 1989). The yolk sac is also reduced and cilia are now limited to the gills. At six months, larvae are roughly 40 mm in length and have grown much more stout. Lateral line organs become conspicuous at this point (Pfingsten and Downs 1989).

After one year, larvae average 70 mm in length (Bishop 1941, Nickerson and Mays 1973, Pfingsten and Downs 1989). Gills are still present but reduced, though a gular fold is well developed (Nickerson and Mays 1973). Legs are also well developed and skin folding is conspicuous. Irregular, dark spots are scattered on the brownish dorsal and lateral surfaces and inconspicuous yellow markings may be present (Bishop 1941). Juveniles undergo incomplete metamorphosis at around 18 months (Taber et al. 1975). Two-year-old specimens collected by Bishop (1941) averaged 11.5 cm in length with a maximum of 13.7 cm. At this stage, gills are very reduced or absent and when present have a reduced gular fold (Bishop 1941). There is a much more developed keel on the hind margins of the legs than in earlier stages of development and skin folding is more prominent (Pfingsten and Downs 1989). Coloration is also different from younger specimens as the darkened spots are more numerous and well developed.

Hellbenders have survived as long as 29 years in captivity (Nigrelli 1954). Extrapolations from growth rate data suggest that some very large individuals may live as long as 30 years in nature (Taber et al. 1975, Petranka 1998).

The prominent lateral skin folds allow for cutaneous gas exchange, effectively acting as gills (Guimond 1970). Pulmonary contribution to gas exchange is minimal although hellbenders have the ability to survive five to 11 days in hypoxic conditions by utilizing pulmonary respiration (Ultsch and Duke 1990). The lungs are used primarily for buoyancy control (Danch 1996). Under low oxygen conditions, hellbenders will rock their body from side to side, increasing rocking frequency with a decrease in dissolved oxygen content (Harlan and Wilkinson 1981) thereby enhancing diffusion (Ultsch and Duke 1990). Harlan and Wilkinson (1981) found that non-rocking hellbenders were unable to maintain normal oxygen tension in hypoxic water conditions. The oar-like tail allows the hellbender to remain stationary in swiftly moving currents where oxygen tension is generally near saturation (Nickerson and Mays 1973), thus providing sufficient countercurrent gas exchange to meet respiratory requirements (Williams et al. 1981a).

Smith (1907) provides a detailed account of hellbender locomotion, described as similar to the gait of a trotting horse. Crawling on the stream bottom is their regular means of locomotion. However, hellbenders are good swimmers and generally exhibit a combination of both crawling and swimming with body and tail undulating horizontally, the later being their principle means of propulsion. Hellbenders can swim many meters quickly when disturbed (Nickerson and Mays 1973).

Hellbenders' bodies are covered in a mucus that is thought to aid in protecting the hellbender from abrasion and parasitic attack and secrete a milky, gelatinous slime when injured or grasped (Smith 1907). These secretions have been shown to be lethal when injected into white mice and are probably unpalatable to some predators (Brodie 1971). Nickerson and Mays (1973) have hypothesized that these skin secretions may have an antibiotic function although this has not been supported experimentally.

BIOLOGY AND NATURAL HISTORY

Nocturnal activity in the eastern hellbender is known to be positively correlated with stream depth, with the greatest amount of activity occurring in early summer (Humphries and Pauly 2000). Hellbenders will avoid light, seeking cover by day where they are concealed from both predator and prey (Smith 1907) emerging at night to feed (Prosen et al. 1998). Diurnal activity has been noted (Smith 1907, Bishop 1941), though usually only on cloudy days as the breeding season approaches (Siebert and Brandon 1960, Nickerson and Mays 1973). Smith (1907) observed daytime congregations of six to 12 individuals during the breeding season although hellbenders ordinarily remain secluded and solitary in crevices under rocks. Laboratory experiments showed biphasic activity rhythms under normal photoperiodic regimes with activity lowest at midday but indicate that hellbenders are not strictly nocturnal and may have an early morning peak of activity (Noeske and Nickerson 1979).

Hellbenders are found in habitats with swift running, fairly shallow, highly oxygenated waters

(Bishop 1941, Nickerson and Mays 1973, Conant 1975, Pfingsten and Downs 1989, Green 1933). The presence of riffle areas with flat rocks, logs and other cover is essential for feeding and breeding activities (see discussions below). Home range has been reported in various forms for several populations of hellbenders. Home range sizes for a Pennsylvania population during the summer months had a mean activity radius of around 10.5 meters (m), with an average inter-captured distance of 18.8 m for males, 18.7 m for females (Hillis and Bellis 1971). Average home range size was 28 square meters (m^2) for females, 81 m^2 for males in Missouri using minimum area convex polygon (Peterson and Wilkinson 1996). Coatney (1982) calculated an average elliptical home range of 90 m^2 for seven Ozark hellbenders radio-tracked nocturnally for two weeks. Linear distance between captures in Tennessee ranged from five to 60 m (Casey et al. 1993). Topping and Peterson (1985) provided evidence for size-specific movement in hellbenders in Missouri. They demonstrated a tendency for upstream movements ranging from 2.3 to 25.7 m per day. In contrast, Peterson (1987) detected no net movement upstream or downstream in the [redacted] River, Missouri. Mean linear movement of hellbenders in a West Virginia stream was 20.1 m, ranging from 0.8 to 70.2 m between captures at least one month apart (Humphries 1999). Alexander (1927) has suggested that some hellbenders may migrate distances on the order of miles to reach breeding sites prior to the initiation of reproduction in mid-August. This assertion has not been supported by recent research efforts, although most researchers agree that males may move short distances within their home range to brooding sites (e.g. Petranka 1998).

Some overlap in hellbender home ranges occurs (Peterson and Wilkinson 1996) with male territories overlapping more than those of females during the breeding season in a New York population (Blais 1996). However, individuals in adjacent territories generally avoid occupying the region of overlap simultaneously (Coatney 1982). During the non-breeding season, hellbenders remain somewhat solitary and will defend shelter rocks from other hellbenders (Peterson and Wilkinson 1996, Hillis and Bellis 1971); however, they have been observed in close proximity to each other at night without displaying aggressive behavior (Humphries 1999). During the breeding season intraspecific aggression is more common as nest defense increases in importance (Smith 1907, Peterson 1988).

In their study of food habits, Peterson et al. (1989) collected 54 male and 54 female hellbenders. Crayfish were present in 81 percent of the stomachs and fish were present in 20 percent. Other food items included freshwater snails (Meso-gastropoda), a horsehair worm (Gordioidea), a stonefly (Pteronarcidae) nymph, a damselfly (Calopterygidae) nymph, a larval alderfly (Sialidae), fish eggs, and hellbender epidermal slough. Other studies have found similar results indicating that crayfishes are the primary food source for hellbenders, although fish and other organisms will occasionally be consumed (Smith 1907, Netting 1929, Green 1935, Bishop 1941, Swanson 1948). In addition, both male and female hellbenders will consume the eggs and larvae of their own species (Smith 1907).
Hellbenders are often found concealed beneath rocks with only their head protruding (Smith 1907, Hillis and Bellis 1971) and will seize prey that swim within a few inches with a quick sideways movement, snapping as the food item passes. Smith (1907) speculated that striking distance could be related to poor visual acuity or simply better odds of catching nearby prey. Nickerson and Mays (1973) suggested that visual stimuli in addition to chemical and tactile stimuli are utilized in locating and capturing prey. Green (1933) showed that hellbenders will

fast for a period of months; however, others have shown no evidence of seasonal fasting (Peterson et al. 1989).

Age at sexual maturity has been estimated at 3 4 years (Smith 1907) and 5 6 years (Bishop 1941) for eastern populations and 5 6 years (Dundee and Dundee 1965, Nickerson and Mays 1973) for Ozark populations (see Petranka 1998, for a review). Taber et al. (1975) and Peterson et al. (1988) reported that signs of sexual maturity were most common in individuals from 30 to 40 cm in length, with males maturing at a smaller size and younger age than females. Males of reproductive status can be identified during the breeding season by a swelling of a ridge of tissue, forming a ring around the cloaca. Gravid females exhibit a swollen abdominal region that grows larger as eggs are collected in the uteri (Smith 1907).

Breeding occurs in the fall although the length of the breeding season varies between populations. Only a few specific breeding dates are given in the literature. Smith (1907) reported egg-laying dates from 28 August 8 September in six consecutive years starting in 1906 in northwestern Pennsylvania. Swanson (1948) stated that egg-laying takes place about the first of September in Venango County, Pennsylvania. The release of milt from captured males and the presence of gravid females were documented between 7 September 11 October during two years of study of the [redacted] River population in Indiana (Kern 1986a). Nests with eggs have been reported in the [redacted] River, Missouri on 13 September (Nickerson and Mays 1973), and 28 October (Nickerson and Tohulka 1986). Dundee and Dundee (1965) noted a nest containing eggs in the [redacted] River, Missouri on 14 November and Johnson (1981) noted a clump of eggs in the same river on 19 September. Bothner and Gottlieb (1991) reported nests in the [redacted] River in New York on 10 and 11 September. Pfingsten (1990) reported a nest with 250 eggs on September 21 in The [redacted] Creek of Ohio. Green (1934) reported the spawning season of the hellbender in the vicinity of [redacted], West Virginia to be from the middle of August early September. The release of milt from captured males was reported from 20 August 11 September in the west fork of the [redacted] River in West Virginia (Humphries 1999).

In general, eastern hellbender populations have a short breeding season that begins in mid- or late August through mid-September (Smith 1907, Bishop 1941, Swanson 1948, Humphries and Pauley 2000). For Missouri populations of the eastern subspecies, the breeding season is less well defined and has lasted well into November (Dundee and Dundee 1965). Most Ozark hellbender populations have a 1:1 sex ratio (Nickerson and Mays 1973) while eastern hellbenders frequently show males outnumbering females (Hillis and Bellis 1971).

The beginning of the breeding season is marked by a change in behavior of hellbenders, especially males. They leave their routine hiding places and move around the stream bottom, even during daylight, exploring potential nest sites (Smith 1907). Nests are normally excavated beneath large, flat rocks, crevices or holes in bedrock, or similar structures with an entrance located away from direct current on the downstream side (Bishop 1941, Pfingsten and Downs 1989). Peterson (1988) also reported males using a hole in a mud-gravel bank for nesting. Excavation and nest preparation is performed by males who generally utilize nest sites as dens during the non-breeding period as well as for reproductive purposes in the fall (Smith 1907). Williams et al. (1981a) have suggested that this dependence on den sites may have an influence on the restricted home ranges observed in hellbenders.

Shortly before mating occurs, males move into their nest site with their heads protruding from the entrance and wait for females to approach. Females may enter nest sites voluntarily or they may be forced into the cavity by the male (Petranka 1998). Once eggs begin to emerge from the female's cloaca, the male takes a position alongside of and slightly above her (Smith 1907). As the female begins to lay the eggs, the male makes horizontal and vertical swaying movements of the posterior end of the body, raising and lowering the hind limbs (Petranka 1998). Two strings of eggs, analogous to a beaded necklace, are exuded from the cloaca, forming strands that twist together into a tangled mass and sink to the bottom of the nest excavation (Bishop 1941). It may take two to three days for the female to complete oviposition (Pfingsten and Downs 1989). During this time, seminal fluid containing sperm is expelled and dispersed into the egg mass (Pfingsten and Downs 1989). This external mode of fertilization is unusual among the salamanders. The round, yellowish eggs are approximately 6 mm in diameter and are surrounded by two transparent envelopes (Nickerson and Mays 1973). Once deposited, the eggs swell with water and eventually increase to 18 mm in diameter, at which point the female leaves the nest or is expelled by the male (Petranka 1998).

Males often remain near the egg mass. Smith (1907) documented the defense of eggs against other hellbenders thought to be attempting to consume the mass. Smith (1907) also found between 15 and 20 eggs in hellbender stomachs during the breeding season. The risk of egg predation is likely to last only a short time after oviposition since silt often covers the egg mass after a few days (Smith 1907).

Topping and Ingersol (1981) demonstrated that hellbender fecundity is a positive linear function of female body length. A single female may deposit between 200 and 400 eggs (Smith 1907, Bishop 1941, Nickerson and Mays 1973). However, the number of eggs deposited may be well below the total number of eggs produced. Retention of a portion of eggs produced, in the ovaries after deposition, is typical (Pfingsten and Downs 1989, Topping and Ingersol 1981). Topping and Ingersol (1981) found that on average, 24 percent of enlarged eggs are retained or resorbed. Males and females will consume their own eggs and females may later regurgitate the eggs to allow for continued development (Smith 1907). Several females may deposit eggs in the same nest (Pfingsten and Downs 1989); it is not uncommon to find upwards of 2,000 in any one nest (Bishop 1941).

The duration of the brooding period varies, but Smith (1907) found males attending nests that contained embryos about three weeks old. Bishop (1941) estimated the incubation period at 68 to 75 days for western New York and Pennsylvania. Peterson (1988) encountered hatchlings in the Niangua River, Missouri that he believed to be no more than 45 days old.

RANGE

Historically, eastern hellbenders were found in the Susquehanna system (Atlantic drainage) in New York, Pennsylvania, and Maryland; tributaries of the Savannah River (Atlantic drainage) in South Carolina and Georgia; the Tennessee system in Georgia, Virginia, Alabama, Mississippi, Tennessee, North Carolina, and Kentucky; the Ohio system in New York, Maryland, Pennsylvania, Virginia, West Virginia, Ohio, Indiana, Kentucky, and Illinois. A secondary cluster of populations inhabits portions of the Missouri drainage in south-central Missouri and the [redacted] (Mississippi drainage) in eastern Missouri. Cope (1889) listed a specimen in the

U.S. National Museum from Des Moines, Iowa and Firschein (1951) mentioned an unverified record from the Skunk River (Mississippi drainage) in southeastern Iowa. Others have referred to the hellbender's presence in Iowa (e.g., Hay 1892, McMullen and Roudabush 1936) suggesting that Iowa might be within the historic range. Firschein (1951) convincingly discredited a specimen from Vernon County, Missouri (Arkansas drainage). Two specimens from the Neosho River (Arkansas drainage) in southeastern Kansas (Hall and Smith 1947) have come under scrutiny. Based on the extreme hiatus between the Kansas records and the nearest verified records to the east, several authors have speculated that these specimens were either introduced (Smith and Kohler 1977) or are otherwise invalid (Dundee 1971). Records from the Great Lakes, Louisiana, and New Jersey are certainly invalid and represent introductions or confusion with other species (see summary in Nickerson and Mays 1973).

Because of the secretive nature of hellbenders and the confusion with mudpuppies (*Necturus maculosus*) the present range is not known with certainty. They are no longer present in Iowa (if they ever occurred there) and they are almost certainly extirpated from the Ohio drainage in Illinois, although there is a verified 1991 record from the [redacted] River in [redacted] County (per coauthor C. Phillips). Hellbenders have been eliminated from Indiana except for a small population in the [redacted] River and the lower portions of the [redacted] of the [redacted] River (Kern 1986b). In Ohio, Pfingsten (1989) spent 2,000 person-hours searching for hellbenders from 1985-88 and failed to find any in the Miami River or its tributaries, but did locate them in the other main drainages of the Ohio River. Populations in the remainder of the Ohio drainage are extant, as are most of those in the Tennessee drainage. Green (1934) reported hellbenders to be common in the Ohio River, but not so common in the tributaries near Huntington, West Virginia. Hellbenders were also reported from the Ohio River near Marietta, Ohio (Krecker 1916). Records for the hellbenders in the Ohio River have not been reported since these early sightings due to the construction of a series of high dams which eliminated riffle areas and changed the character of the river to a series of lakes (R. Pfingsten, pers. comm.). Humphries (1999) reported hellbenders to still be common in many high elevation streams in West Virginia. Bothner and Gottlieb (1991) studied the distribution and abundance of hellbenders in New York and found the species in both the Allegheny and Susquehanna drainages. The same is true for both systems in Pennsylvania and Maryland (Gates 1983). No recent data are available for the Savannah drainage populations in Georgia and South Carolina.

It is apparent from the information available in the published literature that the range of the eastern hellbender is quite extensive, covering areas from Pennsylvania south to northern Alabama and Georgia, and west to Missouri. Information obtained from personal communications with the scientific professionals was used to provide current, additional detail on the eastern hellbender's range (see Table 1). Summaries of these personal communications follow.

Jeff Briggler (Missouri Department of Conservation, pers. comm.) reported that eastern hellbenders occur in the [redacted] rivers. The majority of the records are from the first three of these rivers. A map is provided in Appendix 1.

Brant Fisher (Indiana Department of Natural Resources, pers. comm.) reported that historical distribution records indicate that the eastern hellbender at one time inhabited the entire length of the Ohio River and probably most of the larger, direct tributaries to the Ohio River along the southern boundary of Indiana. There may still be a small population of hellbenders inhabiting the Ohio River at [redacted] and the lower section of [redacted] which enters the Ohio River just downstream of [redacted]. There is some question over how far upstream on the Wabash River eastern hellbenders once lived and there is uncertainty regarding their current distribution there. Eastern hellbenders currently inhabit the [redacted] from near its mouth [redacted] counties, Indiana) upstream to near [redacted] ([redacted] County) and the [redacted] River for several miles upstream from where it enters the [redacted] County). Historical records from Indiana indicate hellbender occurrence in [redacted] County - [redacted] Creek (1955); [redacted] County - [redacted] River (before 1980); [redacted] County - [redacted] River (unknown date); [redacted] County - [redacted] Creek (1998); [redacted] County - [redacted] Creek (~1950); [redacted] County - Ohio River (1889); [redacted] County - [redacted] River (1947); [redacted] County - [redacted] River (1990); [redacted] County - Ohio River (unknown date); [redacted] County - Ohio River (unknown date); [redacted] County - [redacted] River (1983).

Ralph Pfingsten (Cleveland Museum of Natural History, pers. comm.) provided information on occurrences of the eastern hellbender in Ohio (see map in Appendix 1). Exact location details are not provided because the eastern hellbender is on the Ohio endangered list. He speculated that the [redacted] River and [redacted] Creek are systems where one could easily find specimens with very little effort.

Coauthor Chris Phillips (University of Illinois Museum of Natural History, pers. comm.) has analyzed the distribution data for the eastern hellbender in Illinois. Historical records exist for the Skillet Fork (Little Wabash), Wabash, Ohio, and Cache rivers. Aside from the 1991 specimen (housed at Southern Illinois University, Carbondale's Amphibian and Reptile Collection) taken by a commercial fisherman in the Wabash River (near [redacted], [redacted] County, Illinois) no specimens have been reported in the past 15 years. The probability that hellbenders still inhabit any of these rivers in Illinois is remote, although no surveys have been conducted.

Alison Sherman (Mississippi Museum of Natural Science, pers. comm.) provided documentation of historical presence in [redacted] Creek, [redacted], Mississippi. She also communicated that the Mississippi Museum of Natural Science has five specimens and four of these were collected at [redacted] Creek in [redacted] County between 1966 and 1968. The fifth was captured in the [redacted] in 1981. The Mississippi Natural Heritage Program has two additional records of individuals captured in [redacted] Creek, [redacted] in 1970 and 1980. These individuals were released at the site. Regarding the eastern hellbender's current distribution, Sherman indicated that three individuals were captured in 1996 and 2001 at [redacted] Creek in [redacted]. Two were released on site (1996) and the other is being kept alive in an aquarium at the museum. She speculated that it is possible that individuals can also be found in [redacted] Creek, although no surveys of this area have been conducted. Records maintained by Travis Hill Henry (Tennessee Valley Authority, pers. comm.) indicate three records of specimens detected in [redacted] in 1966, 1970, and 1980.

According to Michael Barbour (Alabama Natural Heritage Program, pers. comm.), the eastern hellbender occurs in the [redacted] River drainage in Alabama. He, along with T.H. Henry (pers. comm.), provided documented, historical records of occurrence for several counties. Eastern hellbenders were detected in [redacted] County - [redacted] County - [redacted]

[redacted] Creek (1973); [redacted] County - [redacted] Creek (1966), [redacted] Creek (1928), [redacted] Creek (1969), and [redacted] Creek (1969); [redacted] County - [redacted] Creek (1990); [redacted] County - [redacted] River (1967) and [redacted] Creek (1965); [redacted] County - [redacted] River (1951); [redacted] County - [redacted] Creek (1976). Information on the current range of distribution was reported to be limited.

John Jensen (Georgia Department of Natural Resources, pers. comm.) along with T.H. Henry (pers. comm.) provided the following summary of eastern hellbender records from Tennessee River drainage streams in the Blue Ridge, Ridge and Valley, and Cumberland Plateau physiographic provinces, Georgia: [redacted] County - [redacted] Creek (1980); [redacted] County - [redacted] Creek (last reported 1959); [redacted] County - [redacted] Creek (recently observed), [redacted] River (1995) and [redacted] Creek (1996); [redacted] County - [redacted] River (1993); [redacted] County - [redacted] Creek (1987), [redacted] Creek (1955), Lake [redacted] (1955), [redacted] Creek (1987), and [redacted] River (1987); [redacted] County - [redacted] Creek (1999), [redacted] Creek (1966), [redacted] Creek (1993), [redacted] Creek (1951), [redacted] Creek (recently observed) and [redacted] River (1997).

Steve Bennett (South Carolina Department of Natural Resources, pers. comm.) indicated that the eastern hellbender may not be native to South Carolina; e.g. it is likely an introduction. One record exists from an occurrence in Lake Tugaloo along the Georgia - South Carolina border. The specimen was caught by an angler in 1970 in the Sumter National Forest.

Wayne Van Devender (Appalachian State University, pers. comm.) has found eastern hellbenders in parts of the [redacted] River, North Carolina. He also indicated that juveniles and larvae can be found; however, locating them requires a lot of effort. Alvin Braswell (North Carolina State Museum of Natural Sciences, pers. comm.) added that eastern hellbenders are documented in the [redacted] rivers; i.e. all of the drainages west of the [redacted] John Finnegan (North Carolina Department of Environment, Health, and Natural Resources, pers. comm.) supplied detailed records of occurrence and A. Braswell (pers. comm.) provided a map (see Appendix 1). Occurrence is documented in [redacted] County - [redacted] River and [redacted] River; [redacted] County - [redacted] River; [redacted] County - [redacted] River (1968); [redacted] County - [redacted] River, [redacted] Creek (1973), [redacted] Creek (1997), and [redacted] River; [redacted] County - [redacted] Creek, [redacted] River, [redacted] Creek (1968), [redacted] River (1998), and [redacted] River (1908); [redacted] County - [redacted] Lake, [redacted] Creek, [redacted] Creek, and [redacted] Creek; [redacted] County - [redacted] Creek (1995) and [redacted] Creek (1995); [redacted] County - [redacted] River (1988); [redacted] County - [redacted] River (1983); [redacted] County - [redacted] River (2001); [redacted] County - [redacted] Creek, [redacted] River (1930), and [redacted] River (1994); [redacted] County - [redacted] Creek Gorge (1972), [redacted] River, and [redacted] Creek; [redacted] County - [redacted] River and [redacted] River; [redacted] County - [redacted] Creek (1936), [redacted] Creek (1936), and [redacted] River (2001); [redacted] County - [redacted] River, [redacted] River, [redacted] Broad River (1977), [redacted] Creek (1924), [redacted] River (1977), [redacted] River, and [redacted] Creek (1916); [redacted] County - [redacted] River (1988); [redacted] County - [redacted] (1965) and [redacted] River (1968).

Arthur Scott (Austin Peay State University, pers. comm.) provided eastern hellbender records from the Austin Peay State University museum and T. H. Henry (pers. comm.) contributed a significant quantity of records compiled by the Tennessee Valley Authority (TVA) for the state of Tennessee. Hellbenders were detected in [redacted] County - [redacted] River (1996), [redacted] Creek (1988), and [redacted] Reservoir (1976); [redacted] County - [redacted] River (1978); [redacted] County - [redacted] Creek (2000), [redacted] River (1980), and [redacted] River (1976); [redacted] County - [redacted] Lake (1977); [redacted] County - [redacted] River (1984), [redacted] River (1984), and [redacted] Creek (1976); [redacted] County - [redacted] River (1979) and [redacted] Creek (1978); [redacted] County - [redacted] River (1966); [redacted] County - [redacted] Creek (1982); [redacted] County - unknown location (1915); [redacted] County - [redacted] River (1939); [redacted] County - [redacted] Creek (1981); [redacted] County - [redacted] River (1987); [redacted] County - [redacted] River (1976); [redacted] County - [redacted] Creek (1983) and [redacted] River (1939); [redacted] County - [redacted] Creek (1980), [redacted] Creek (1978), and [redacted] Creek (2000); [redacted] County - [redacted] Creek (1993), [redacted] Creek (unknown date), and [redacted] Creek (1977); [redacted] County - [redacted] Creek (1979) and [redacted] River (1895); [redacted] County - [redacted] River (1979); [redacted] County - [redacted] River (1980); [redacted] County - [redacted] River (1979) and [redacted] River (1979); [redacted] County - [redacted] River (1991) and [redacted] River (1981); [redacted] County - [redacted] River (1980); [redacted] County - [redacted] River (1981); [redacted] County - [redacted] Creek (1952); [redacted] County - [redacted] Creek (1954) and [redacted] Creek (1981); [redacted] County - [redacted] Creek (1977), [redacted] Creek (1976), and [redacted] River (1987); [redacted] County - [redacted] River (1968), [redacted] Creek (1982), and [redacted] River (1967); [redacted] County - [redacted] Creek (1996); [redacted] County - [redacted] River (1994); [redacted] County - [redacted] River (1989) and [redacted] Creek (unknown date); [redacted] County - [redacted] River (1968) and [redacted] River (1936); [redacted] County - [redacted] River (1964); [redacted] County - [redacted] (unknown date); [redacted] County - [redacted] Creek (unknown date) and [redacted] Creek (1977); [redacted] County - [redacted] Reservoir (1984) and [redacted] River (1991); [redacted] County - [redacted] Creek (1975) and [redacted] Creek (unknown date); [redacted] County - [redacted] Lake (1967).

Brainard Palmer-Ball (Kentucky State Nature Preserves Commission, pers. comm.) reported that the Kentucky Natural Heritage Program database contains 30 records for the eastern hellbender (less than ten with data as recent as the 1990s, but about half for which there is no reason to expect that populations are not extant). Just over half are considered "historic" (no update in 20 years). The most robust populations are likely present in [redacted] River (east Kentucky), [redacted] River (east Kentucky) and [redacted] River (south-central Kentucky).

Jeff Humphries (Clemson University, Department of Forest Resources, pers. comm.) and Jennifer Wykle (West Virginia Natural Heritage Program Zoologist, pers. comm.) provided a thorough discussion and detailed records of eastern hellbender distribution in West Virginia. There are 46 known occurrences of the hellbender in West Virginia, from 31 different streams and rivers. Twenty-three of the records are from prior to 1980 and one does not have a date recorded. From 1997 to 2000, Humphries conducted 21 surveys (total of 11 streams) on streams with historical records and on streams that appeared to have adequate habitat for the hellbender. Historical and recent records include [redacted] County - [redacted] Creek (1998); [redacted] County - [redacted] River (1959); [redacted] County - [redacted] River (1963); [redacted] County - [redacted] Creek (1974); [redacted] County - [redacted] River (1967) and [redacted] Creek (1997); [redacted] County - [redacted] (1951); [redacted] County - [redacted] Creek (2000) and [redacted] Creek (1955); [redacted] County - [redacted] Creek (1955); [redacted] County - [redacted] River (1937) and [redacted] River

(2001); [redacted] County - [redacted] River (1994) and [redacted] River (1998); [redacted] County - [redacted] (1932); [redacted] County - [redacted] Creek (1995); [redacted] County - [redacted] (1987), [redacted] (1983), [redacted] River (1997), [redacted] (2001), and [redacted] River (1935); [redacted] County - [redacted] River (1998) and [redacted] River (1969); [redacted] County - [redacted] River (1967); [redacted] County - [redacted] (unknown date), [redacted] River (1936), and [redacted] Run (1998); [redacted] County - [redacted] Creek (1968); [redacted] County - [redacted] River (1986), [redacted] (1998), [redacted] River (1938), [redacted] River (1980), and [redacted] River (1996); [redacted] County - [redacted] Creek (1970); [redacted] County - [redacted] River (1966); [redacted] County - unknown location (1949); [redacted] County - [redacted] River (1983).

Mike Pinder (Virginia Department of Game and Inland Fisheries, pers. comm.) summarized the eastern hellbender's range in the New and Tennessee River drainages ([redacted] River, [redacted] River and forks of the [redacted] River) in Virginia. A map is provided in Appendix 1. Detailed documentation of eastern hellbender occurrences within these drainages was provided by Steve Carter-Lovejoy (Virginia Department of Conservation and Recreation, pers. comm.) and T. H. Henry (pers. comm.). Hellbenders were located in [redacted] County - [redacted] Creek (1982) and [redacted] Creek (1982); [redacted] County - [redacted] River (1964) and [redacted] River (1969); [redacted] County - [redacted] Creek (1974), [redacted] Creek (unknown date), [redacted] Creek (1974), and [redacted] Creek (1994); [redacted] County - [redacted] Creek (1967); [redacted] County - [redacted] River (1960); [redacted] County - [redacted] River (1967); [redacted] County - [redacted] Creek (1969); [redacted] County - [redacted] Creek (1958), [redacted] River (1989), [redacted] Creek (1971), and [redacted] River (2001); [redacted] County - [redacted] Creek (1993) and [redacted] River (1989); [redacted] County - [redacted] River (1951) and [redacted] River (2000); [redacted] County - [redacted] River (1998) and [redacted] Creek (1973); [redacted] County - [redacted] River (1984) and [redacted] Creek (1970).

Arthur Hulse (Indiana University of Pennsylvania, pers. comm.) reported that in Pennsylvania eastern hellbenders can currently be found in [redacted] Creek, [redacted], [redacted] and [redacted] creeks, [redacted] Creek [redacted] and [redacted] creeks, [redacted] Creek, [redacted] Creek and tributary [redacted] Creek, [redacted] Creek, [redacted] Creek, and recently impounded [redacted] and [redacted] creeks. His summary of past records in Pennsylvania reveal that eastern hellbenders were also found in [redacted] Creek, the [redacted] River, [redacted] Creek, [redacted] Creek ([redacted] County), [redacted] Creek, the (lower) Allegheny and the (mainstream) Ohio rivers, [redacted] Creek and the lower reaches of [redacted] Creek. His information also revealed that hellbenders were located in [redacted] County - [redacted] Creek; [redacted] County - [redacted] Creek and [redacted] Creek; [redacted] County - [redacted] Creek; [redacted] County - [redacted] Creek; [redacted] County - [redacted] Fork; [redacted] County - [redacted] Creek, [redacted] Creek, and the [redacted] Creek; [redacted] County - [redacted] Creek; [redacted] County - [redacted] Creek; [redacted] County - [redacted] Creek and [redacted] Creek; [redacted] County - [redacted] Creek; [redacted] County - [redacted] Creek; [redacted] County - [redacted] Creek and [redacted] Creek; [redacted] County - [redacted] Creek, [redacted] Creek, [redacted] Creek; [redacted] County - [redacted] Creek; [redacted] County - [redacted] Creek and [redacted] Creek.

Ed Thompson and Dan Feller (Maryland Department of Natural Resources, pers. comm.) reported that the eastern hellbender's historical range in Maryland included the lower [redacted] River, the [redacted] River, and the [redacted] River and its tributaries. Recent surveys indicate the species is still present in a 4 km section of the [redacted] River and perhaps in an 8 km section of the lower [redacted] River, but it is apparently absent from the Susquehanna River and its tributaries.

Alvin Breisch (New York State Department of Environmental Conservation, pers. comm.) reported that the hellbender occurs in two drainages: the [redacted] River drainage and the [redacted] River drainage. In 1990 a single adult hellbender was caught in an eel weir in the [redacted] River. It is believed this was a released animal or possibly the offspring of hellbenders released in the [redacted] River, north of [redacted] several decades earlier. Although resource managers have not defined what constitutes a single population, there are approximately 11 locations within the [redacted] River system and 18 locations within the [redacted] River system where eastern hellbenders occur.

Table 1. Distribution of the eastern hellbender.

US F&WS	State	Part of Range
Region 3	Minnesota	No
	Iowa	No
	Wisconsin	No
	Michigan	No
	Illinois	Yes
	Missouri	Yes (Ozark hellbender, also)
	Indiana	Yes
	Ohio	Yes
Region 4	Florida	No
	Louisiana	No
	Mississippi	Yes
	Alabama	Yes
	Georgia	Yes
	Arkansas	No (Ozark hellbender, only)
	South Carolina	Yes
	North Carolina	Yes
	Tennessee	Yes
	Kentucky	Yes
Region 5	West Virginia	Yes
	Virginia	Yes
	Pennsylvania	Yes
	Maryland	Yes
	New York	Yes
	Rhode Island	No
	New Jersey	No
	Delaware	No
	Connecticut	No
	Maine	No
	Vermont	No
	New Hampshire	No
	Massachusetts	No

Information supplied by K. Cieminski - Minnesota Department of Natural Resources, J. Bleser - Wisconsin Department of Natural Resources; C. Phillips - Illinois Natural History Survey; J. Briggler - Missouri Department of Conservation; B. Fisher - Indiana Department of Natural Resources, R. Pfingsten - Cleveland Museum of Natural History; G. Woodsum - Florida Natural Areas Survey; J. Carr - Department of Biology, University of Louisiana; A. Sherman - Mississippi Museum of Natural Science; M. Barbour - Alabama Natural Heritage Program; G. Krakow - Georgia Department of Natural Resources, Wildlife Resources Division, Georgia Natural Heritage Program; J. Jensen - Georgia Department of Natural Resources, Wildlife Resources Division, Nongame Endangered Wildlife Program; C. Osborne - Department of Arkansas Heritage, Arkansas Natural Heritage Commission; J. Holling - South Carolina Department of Natural Resources, Wildlife Diversity Section/Heritage Trust Program; S. Bennett - South Carolina Department of Natural Resources, Heritage Trust Program; J. Finnegan - North Carolina Department of Environment, Health, and Natural Resources, North Carolina Heritage Program, Division of Parks and Recreation;

A. Braswell - North Carolina State Museum of Natural Sciences; W. VanDevender - Department of Biology, Appalachian State University; D. Collins - Tennessee Aquarium; A. Scott - Department of Biology, Austin Peay State University; T. Henry - Tennessee Valley Authority Natural Heritage Project; B. Palmer-Ball - Kentucky State Nature Preserves Commission; J. Wykle - West Virginia Department of Natural Resources, West Virginia Natural Heritage Program; J. Humphries - Department of Forest Resources, Clemson University; M. Pinder - Virginia Department of Game and Inland Fisheries; S. Carter-Lovejoy - Virginia Department of Conservation and Recreation; A. Hulse - Department of Biology, Indiana University of Pennsylvania; K. Derge - Pennsylvania Fish and Boat Commission, Nongame and Endangered Species Unit; E. Thompson - Maryland Department of Natural Resources; A. Breisch - New York State Department of Environmental Conservation, Division of Fish, Wildlife and Marine Resources; E. Williams - New Jersey Department of Environmental Protection; R. Dutko - New Jersey Department of Environmental Protection; S. Cairns - New Hampshire Department of Resources and Economic Development. Contact information for these individuals can be found in Appendix 2.

POPULATION ESTIMATES AND TRENDS

Allegheny River Drainage

Swanson (1948) reported collecting (and permanently removing) over 650 hellbenders from a 4.8 km stretch of [redacted] Creek (Allegheny drainage) in [redacted] County, Pennsylvania from 1932 to 1948. Although several of the older records (pre 1990) indicate hellbenders were "abundant" in New York State, only one site has an extant population of at least 20 adults with all others ranging from one to 12 adults (A. Breisch, pers. comm.). These population numbers have been recorded as recently as 1991. Males and females were both described as "ripe" and "exuding eggs" but no nests were found during subsequent searches.

More rigorously documented abundance data are available for the Allegheny River drainage of New York State where Bothner and Goettlieb (1991) performed mark-recapture studies to estimate both abundance and density at eight sites along [redacted] Creek, [redacted] Creek, and the [redacted] River. Abundance estimates ranged from 3-58 individuals in study areas that ranged from 424 to 14,003 m^2 of streambed.

Hillis and Bellis (1971) surveyed [redacted] Creek in the Allegheny drainage of [redacted] They captured 152 adults and sub-adults with a sex ratio of 1.58 males to one female.

Missouri River Drainage

Eastern hellbender range in Missouri is limited to the [redacted] and [redacted] rivers (J. Briggler, pers. comm., Prosen et al. 1998). Peterson (1987) captured 110 adults in a 2,600 m^2 study site in the [redacted] River, [redacted] during 1985. Mark-recapture estimates of hellbender abundance ranging from 0.9-6.1 hellbenders/100 m^2 were reported for the [redacted] and [redacted] rivers during 1980 to 82 (Peterson et al. 1988). Prosen et al. (1998) surveyed ten sites along the [redacted] River and found only two hellbender specimens, although no historical hellbender data exists for the river. Quantitative evidence of negative trends in hellbender abundance has been recently corroborated in work published by Wheeler et al. (2003) whose 20-plus-year study of hellbender abundance shows an average decline of about 77 percent. This recent study focused on both the eastern and the Ozark hellbender and it was designed to yield independent sets of data that were both subspecies- and population-specific. Three distinct eastern hellbender populations in Missouri were evaluated in this study; from the [redacted] the [redacted] and the [redacted] rivers. Overall, these populations declined over 80 percent from 1971 to 1998. The declines were found to be statistically significant ($P \leq 0.05$) and consistent for all three populations. The decline of the [redacted] River population was immediately evident in the first decade of the study (between 1970 and 1980). The authors indicated that the declines were characterized by a shift in size (age) structure, with disproportionately decreased numbers of young individuals. The authors speculated that these declines in hellbender populations may be associated with common causative factors; however, they also note that distinct, population-specific factors could also elicit these responses.

Mississippi River Drainage
Green (1935) reported catching 34 hellbenders between the hours of 8 (PM) and midnight on June 21, 1934 in the headwaters of the [redacted] of the [redacted] (West Virginia). Hellbenders were detected using an acetylene light, but the number of observers or the length of the stream they surveyed was not specified.

Humphries (1999) conducted a mark-recapture study from 1998-99 in the west fork of the [redacted] River in West Virginia. An abundance estimate of 31 individuals was provided for a 216 m stretch of stream. The density in this section was 0.80 individuals per 100 m^2.

Tennessee River Drainage
Ferguson (1961) and students surveyed [redacted] Creek in the Tennessee drainage of [redacted] They caught nine hellbenders using hooks baited with crayfish and minnows between 1957 and 1961. All individuals were caught at night.

According to A. Sherman (pers. comm.), biologists at the Mississippi Museum of Natural Science believe that although population numbers for *C. alleganiensis* in [redacted] Creek are probably small, population numbers and trends are hard to estimate because of the difficulty in observing and capturing this species. Two surveys for *C. alleganiensis* have been funded by the Heritage Check-Off Grant Program. A survey conducted by Cliburn (1991) in Tishomingo County, Mississippi netted no results. A survey performed by Cash (1996) detected two individuals (one male and one female) from [redacted] in over 83 survey hours. Although a portion of sampling effort (9 hours) was dedicated to detecting hellbender larvae, none were found (Cash 1996).

Ohio River Drainage
Pfingsten (1989) caught 112 hellbenders over a period of three years (1985 to 1988) although none were discovered in the Ohio River or west of the Scioto River. Hellbender populations were discovered in four new Ohio watersheds: [redacted] Creek in [redacted] County, [redacted] River in [redacted] County, [redacted] River in [redacted] County, and [redacted] River in [redacted] County (Pfingsten 1988). Hellbender populations were also confirmed in three watersheds: [redacted] River in [redacted] County, [redacted] Creek in [redacted] County, and [redacted] Creek in [redacted] County (Pfingsten 1988). Four historical populations were located: two in [redacted] Creek in [redacted] County, [redacted] Creek in [redacted] County, and [redacted] River in [redacted] County (Pfingsten 1988). Seven new populations in rivers with known populations were also discovered: [redacted] Creek in [redacted] County, [redacted] River in [redacted] County, two populations in the [redacted] River in [redacted] County, [redacted] River in Coshocton County, [redacted] Creek in [redacted] County, and [redacted] River in [redacted] County (Pfingsten 1988). One nest, the first ever reported in Ohio, but no larvae were detected during the surveys (Pfingsten 1988). R.

Pfingsten (pers. comm.) mentioned that there have only been 200 specimens recorded in Ohio. Eastern hellbender larvae were never found and eggs were only noticed once in the waters surveyed.

Hellbenders have been reported from [redacted] Creek in [redacted] County, PA, although recent efforts to locate hellbenders both above and below the dam at [redacted] have failed to produce any animals (A. Hulse, pers. comm.). There are records of hellbender occurrence in [redacted] Creek, a tributary of [redacted] Creek. However extensive recent searches of [redacted] Creek have failed to document hellbenders in this stream despite sufficient habitat and food (i.e., crayfish exist in the streams; A. Hulse, pers. comm.). Hellbenders were reported from [redacted] Creek in [redacted] County, PA, however several excursions to this area have failed to produce any recent records of hellbenders in the stream (A. Hulse, pers. comm.). They had been reported from the lower reaches of [redacted] Creek, [redacted] County as well as near the headwaters, but now appear to be restricted to the headwater region of the stream (A. Hulse, pers. comm.). They have also been reported from Woodcock Creek prior to its impoundment, however now appear to be absent from the entire stream (A. Hulse, pers. comm.).

B. Fisher (pers. comm.) reported that Kern (1984) collected 130 hellbenders from the [redacted] IN, between 1982 to 1983. From one location, he estimated the population at 20.2 ± 7.7 hellbenders/100 meters of streambed. It is impossible to extrapolate this estimate for the entire river because hellbenders are habitat dependent; certain sections of the [redacted] seem to be unsuitable habitat for hellbenders. Of the 130 hellbenders examined by Kern (1984) between 1982 to 1983, only two were immature, and no larvae were found. One nest, containing 153 eggs, was found during the same time period. Recently, 67 individual hellbenders have been collected and Passive Integrated Transponder (PIT) tagged between 1999 to 2002 from the [redacted] with less effort than Kern (1984) and four nests have been discovered since 1997 (no more than one per year; B. Fisher, pers. comm.).

Coauthor C. Phillips (pers. comm.) is convinced that eastern hellbenders are probably no longer found in Illinois waters. The best probability for continued existence in the Ohio River drainage is in the large rivers (Wabash and Ohio), however it is extremely difficult to conduct surveys in these waters and none have been attempted to date.

Chesapeake Bay Drainage

Hellbenders were reported from the [redacted] as far upstream as [redacted] County [redacted]. The entire [redacted] is now effectively devoid of life as far down stream as [redacted], in [redacted] County (A. Hulse, pers. comm.). Surveys during the period when hellbenders are known to congregate there for breeding, failed to find any hellbenders in spite of over 50 person hours of search effort (A. Breisch, pers. comm.). Hellbenders had been reported from the mouth of [redacted] in [redacted] County, Pennsylvania. However, recent surveys of the area produced no hellbenders (A. Hulse, pers. comm.).

Gates et al. (1984) sampled 44 sites in the Susquehanna River system and other streams emptying into the northern Chesapeake Bay mostly through electro-fishing during 1979 to 1981. They found no evidence of hellbender occupation. E. Thompson and D. Feller (pers. comm.) revealed that current data suggest the eastern hellbender is extirpated from the Susquehanna

River and its tributaries in Maryland. In 1998-2002, additional stream surveys were conducted by lifting large flat rocks with a log peavey on sections of Deer Creek, Octoraro Creek, Rock Run, and Susquehanna River. Although a juvenile hellbender was reported from [redacted] in 1998 by the State Fisheries Division, subsequent survey of the site failed to confirm the record.

Regarding eastern hellbenders in the [redacted] River, E. Thompson and D. Feller (pers. comm.) report that the upper reaches in Maryland contain sections with good to very good habitat structure, and many locals have reported their historic presence there. However, no hellbenders were captured in the [redacted] River during a recent study (1997 to 2000), and no confirmed historic records exist south of the vicinity of US Route 40 (crosses the [redacted] at the town of [redacted]). The [redacted] River population in the lower reaches of the river appears to be isolated to a small section of the stream, and no evidence of reproduction has been detected. A total of 33 individuals were observed, all of which were adults. However, one individual estimated at 250 mm in length escaped. This was the only individual observed during the survey not classified as an adult. No egg masses were observed. In 1986 two nests were documented.

The [redacted] River population has certainly been stressed in the past, and the current amount of reproduction and recruitment is unknown (E. Thompson and D. Feller, pers. comm.). No recent hellbender surveys have been conducted in the main-stem of the [redacted] River, although the Natural Heritage Program is planning to do so. From 1980 to 1982, Gates et al. (1984) did not record any hellbenders within the main-stem of the [redacted]. However, eastern hellbenders are known to exist in this river as there have been reliable sightings recorded during the 1980s and 1990s. The most recent sighting occurred on June 8, 2002 when a fisherman caught an adult hellbender on a worm near [redacted] (E. Thompson, pers. comm.).

SUMMARY OF THREATS

The information available in the published literature concerning threats to hellbender populations lacks detail on quantification of responses and comprehension of hazards, and there is little evidence of effort to correlate observed population responses with potential threats. These research inadequacies make it very difficult to thoroughly elucidate the threats to eastern hellbenders. Personal communications with natural resource and conservation specialists helped to establish a more current and comprehensive list of potential threats (Table 2). Habitat alterations (i.e., siltation, water impoundment, and changes in water quality) were most frequently mentioned in personal communications as threatening to eastern hellbenders, followed by overutilization and predation. Among other threatening factors, there is some indication that hellbender populations suffer from low genetic variability, that recruitment is limited by endocrine disruption, and that adverse effects could result from a complex of interactions associated with global climate change.

A. The Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range.

As early as 1957 it was noted that the hellbender's range was rapidly shrinking as a result of human modification of stream habitats (Smith and Minton 1957). Indeed, destruction and modification of habitat is considered the main threat to hellbender population persistence (Williams et al. 1981a) and to amphibian populations worldwide (Wyman 1990). Dundee (1971) listed "siltation, general pollution, and thermal pollution"as being responsible for eliminating the hellbender from "much of the Ohio River drainage, and from other industrialized regions." Bury et al. (1980) mentioned channelization and impoundment of streams and rivers as an agent of decline specifically for Alabama, Maryland, Missouri, Tennessee, and West Virginia. They also cited Nickerson and Mays (1973) when implicating industrialization, agricultural runoff, and mine wastes as contributing factors in Ohio, Pennsylvania and West Virginia. Other authors have alluded to the range-wide decline in hellbender numbers (Williams et al. 1981a, Gates et al. 1985). However, rigorous quantification of effort is lacking in most hellbender surveys so there are few data to back up these claims. Exceptions to this circumstance, that of Trauth et al. (1992) and Wheeler et al. (2003) documented drastic declines in hellbenders along rivers in Arkansas (Ozark hellbender) and Missouri (Ozark and eastern hellbender). Although no data were collected to monitor potential causal factors in theses studies the authors speculated that the declines were attributed to factors such as habitat alteration and degradation, elimination of riparian habitats leading to an increase in the silt burden, and water pollution associated with anthropogenic activities.

Siltation

Evidence from studies of amphibian populations in the Pacific Northwest (Welsh and Ollivier 1998) link fine sediment accumulation to reduced densities of Pacific giant salamanders (*Dicamptodon tenebrosus*) which rely on coarse streambed substrates as larval habitat. Sediment deposition effectively fills interstitial spaces among coarse sediments reducing cover and foraging habitat. Although very little is known about the habitat requirements of larval hellbenders, it is reasonable to suspect that coarse bottom substrates are vital as refugia from predation and as foraging sites. Nickerson and Mays (1973) cite a personal communication from S. Minton in which sediment accumulation is suspected of destroying eggs and juvenile hellbenders (see also Jensen 1999). Prey abundance may also decline as a result of increased siltation. Siltation can also impede the movement of individuals and Routman (1993) speculates that colonization of new habitat will only occur when rivers have low silt loads. Erosion events associated with road construction, timber harvesting and other development activities in riparian habitats may therefore contribute to hellbender population declines by reducing the availability of potentially crucial microhabitat conditions.

Impoundment

Because hellbenders breathe primarily through the skin (Guimond 1970) they are dependent on cool, well-oxygenated, flowing water. Construction of dams stops swift water flow and submerges riffles; thereby reducing hellbender habitat and degrading the suitability of the lotic environment through declines of dissolved oxygen concentration and increased water temperature (Jensen 1999). Impoundments also act to fragment hellbender habitat, blocking the flow of immigration and emigration between populations in addition to preventing recolonization from source populations (Dodd 1997). Small, isolated populations are more susceptible to environmental perturbation and demographic stochasticity, both of which may lead to local extinction (Lande 1988, Wyman 1990).

Water Quality
Nickerson et al. (2002) cites a study by Huckabee et al. (1975) which implicated lowered pH levels and increased sulfate and metal concentrations as the likely contributor to salamander elimination from streams in the Great Smoky Mountains National Park. Salamander kills occurred downstream from road building projects (Huckabee et al. 1975). Dodd (1997) describes the environmental effects of mining which destroys and alters habitat through toxic pollution, decreased pH levels, and increased siltation. Both acid mine drainage (Humphries 1999) and streambed gravel mining are considered possible threats to hellbender populations. Since hellbenders' primary means of respiration is cutaneous (Guimond 1970), introduced toxins are readily absorbed (Jensen 1999) and can cause either direct mortality or interference with physiological processes, effectively reducing individual fitness and recruitment (see *Recruitment* section below).

B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes. The illegal pet trade is a likely threat to eastern hellbenders. Nickerson and Mays (1973) quote live hellbenders as selling for $15 to $35 dollars each in 1972. Although collection for commercial sale is illegal in several states (e.g., Missouri, Ohio, Indiana, Illinois, New York, North Carolina, Virginia, West Virginia), once removed, hellbenders can be legally sold to pet wholesalers in states where restrictions have not been enacted. In 2001 an advertisement in a Buffalo, New York newspaper was selling hellbenders for $50 each (A. Bresich, pers. comm.). Jeff Briggler (pers. comm.) provided an anecdotal report that a single group collected over 100 Ozark hellbender individuals during the 1980s in Missouri and that as recent as the 1990s, hellbenders were still being collected in Arkansas. Traugh et al. (1992) suggested that removal of specimens for "scientific or other purposes" in addition to habitat degradation has contributed to the decline of the Ozark hellbender in Arkansas. There is some indication that extensive scientifically motivated collections may have negatively impacted hellbender populations. Mike Pinder (VA Dept. of Game and Inland Fisheries, pers. comm.) described hellbender removal by a university teacher for sale to biological supply companies. Gates et al. (1985) suggest that recreational fishing may have a negative impact on hellbender populations due to an unfounded animosity towards hellbenders which are thought to be poisonous and/or to interfere with fisheries production. The extent and impact of this threat is difficult to gauge.

C. Disease and Predation. Nickerson and Mays (1973) contains thorough accounts of hellbender predators and parasites. They identify northern pike and muskellunge, turtles and water snakes, and humans as hellbender predators. Over one third of the state agencies contacted, speculated that introduced game fish may have detrimental effects on hellbender populations (Table 2). Nickerson and Mays (1973) include a brief discussion of cannibalism, suggesting that cannibalistic behavior may contribute to maintaining population stability. Documented observations of male and female hellbenders consuming eggs from their own nests indicate that, in addition to protecting nesting sites, male hellbenders may be defending food resources (Hillis and Bellis 1971, Green 1933). Nickerson and Mays (1973) describe various fungi, protozoans, nematodes, trematodes, cestodes, acanthocephalans, and annelids (leaches) as hellbender parasites. Krecker (1916) reported the worm *Filaria cingula* to be a skin parasite of *C. alleganiensis*. These factors can adversely affect individual eastern hellbenders although relative to the threatening factors associated with habitat degradation, it is doubtful that they have negatively impacted populations of eastern hellbenders, significantly. However, the cumulative effects of multiple environmental and biological stressors may increase hellbender mortality rates. For example, Kiesecker et al. (2001) describe how climate-induced changes in UV-B exposure increase susceptibility to pathogen outbreaks in western United States amphibian populations.

D. The Inadequacy of Existing Regulatory Mechanisms. Existing regulatory mechanisms merit some discussion here because they are coupled with most of the anthropogenic activities that manifest themselves as threats to the eastern hellbender. The Clean Water Act has provisions to address the water quality requirements of the eastern hellbender and the National Environmental Protection Act (NEPA) addresses land-use issues that affect eastern hellbender habitat. The provisions of the Federal Insecticide Fungicide Rodenticide Act (FIFRA) minimize the risks associated with pesticide use. In and of themselves, these regulatory mechanisms appear appropriately focused and sufficiently robust to prevent or control the human activities that are potentially hazardous to eastern hellbenders. However, given the threats to eastern hellbender populations presented above, implementation and enforcement of existing regulatory mechanisms appears to be problematic. Proving that a direct "take" will occur because of a specific land use activity is often difficult, but most certainly the cumulative effects of increased development, logging, and mining has made survival more difficult for hellbenders (E. Thompson, pers. comm.). Many states have afforded the eastern hellbender some level of protective status (see CURRENT PROTECTIVE STATUS section). However, the extent to which overutilization is reported in Table 2 indicates that implementation and/or enforcement of these protective measures is lacking.

E. Other Natural or Manmade Factors Affecting its Continued Existence.
Genetic Variation
Hellbenders display lower allozyme variation than other salamanders, suggesting a reduction in genetic variation in their evolutionary history (Merkle et al. 1977, Shaffer and Breden 1989, Routman 1993). Shaffer and Breden (1989) attributed this low allozyme variation to the non-transforming nature of hellbender life history and suggest that non-transforming species which are generally restricted to aquatic habitats are subject to genetic bottlenecks more often than more terrestrial, metamorphosing species. Routman (1993) found within-population mitochondrial DNA (mtDNA) to be less variable than variation in mtDNA between populations, possibly as a result of a severe genetic bottleneck followed by rapid mtDNA evolution with gene flow between rivers remaining lower than within a given river. Routman (1993) also hypothesized that high silt loading may be an impediment to gene flow since it prevents migration and reduces the availability of cover and breeding sites. This hypothesis is based on the logic that sedimentation and dissolved oxygen are negatively correlated and that because sedimentation tends to increase in downstream reaches of lotic systems, hellbender migration is impaired. These small, and increasingly isolated hellbender populations may continue to suffer from decreasing within-population diversity as inbreeding among close relatives, which can lead to problems such as reduced fertility and fitness, increases in likelihood (Noss and Cooperrider 1994). Similarly, the random loss of adaptive genes through genetic drift may function to limit the ability of hellbenders to respond to changes in their environment (Noss and Cooperrider 1994). Small population sizes and inhibited gene flow between hellbender populations may increase the likelihood of local extinction (Gilpin and Soulé 1986).

Recruitment

As previously mentioned, hellbenders are long-lived species capable of living up to 30 years (Nigrelli 1954, Taber et al. 1975, Petranka 1998) with sexual maturity estimated at around 4-5 years (Smith 1907, Bishop 1941). Negative aspects associated with delayed reproduction include the risk of death prior to reproduction and lengthened generation times (Congdon et al. 1993). Hellbender specimens less than five years of age are uncommon (Taber et al. 1975, Pfingsten 1990) and recent research has indicated that a shift in age structure has resulted in the prevalence of older individuals (Pfingsten 1990, Wheeler et al. 2003). For example, A. Bresich (pers. comm) reported that data complied by the Endangered Species Unit in the state of New York include approximately 150 records of eastern hellbenders from 1883 to present. Almost all of these were for mature adults and 20 reports include reference to eggs and three indicate that eggs were hatching into larvae. However, there are no reports of finding larvae in New York other than when associated with hatching eggs (A. Bresich, pers. comm.). Likewise, R. Pfingsten (pers. comm.) reported that larvae have not been detected in Ohio waters. He speculated that eastern hellbenders may not be highly dependent on recruitment in order for a population to remain extant, simply because of their longevity. However, empirical and theoretical evidence suggests that the amount of generation overlap within a population (i.e., high survivorship among juveniles) is necessary to maintain stable populations (Congdon et al. 1993, Ellner and Hairston 1994). Lack of sufficient recruitment may be limiting population stability as well as the ability of hellbender populations to maintain genetic diversity as alteration of habitat quality occurs within their range (Wheeler et al. 2003). However, Pfingsten (1990) also cautions that lack of larvae detection could mean that they occupy an unknown microhabitat that has yet to be surveyed. The disruption of endocrine system functions by anthropogenic chemicals may play a role in the near absence of recruitment observed in hellbender populations by causing developmental abnormalities in sexual organs (Colborn et al. 1993). For example, Guillette et al. (1994) found permanent modification of American alligator (*Alligator mississippiensis*) gonads as a response to estrogen mimicking compounds released into aquatic habitat. Guillette et al. (1994) suggest that these chemicals effectively alter sexual development and result in declining reproductive success. Dr. Yue-Wern Huang at the University of Missouri-Rolla is currently working to develop techniques for monitoring hellbender exposure to endocrine disruptors in Missouri waters (see http://web.umr.edu/~huangy/research.htm for proposal abstract).

Climate Change

Dodd (1997) has thoroughly reviewed threats to amphibians of the southeastern states. In addition to addressing the factors listed above, he presents discussions on other factors and activities that conceivably could impact eastern hellbenders; e.g. climate change, low pH (water), and UV-B radiation. Increasing air and water temperatures over the past 30 years are thought to have had serious influence on declines of amphibian populations worldwide (Pounds 2001). Reliance on cool, well oxygenated streams may inhibit the ability of eastern hellbenders to acclimate to higher water temperatures. Changing precipitation patterns have resulted in reduced water depths which may have dried up critical hellbender habitat or increased the amount of UV-B radiation penetrating the water column. Kiesecker et al. (2001) documented the connection between pathogen outbreaks in amphibian populations and climate-induced changes in water depth and UV-B exposure. Kiesecker et al. (2001) acknowledge the complex interactions between global climate trends and ecological responses at the local level to UV-B radiation. However, caution must be used when assigning causal relationships between climate change and amphibian declines since the pathways are not fully understood (Pounds 2001). Furthermore, the role of locally mediated interactions with global climate fluctuations must be considered when attempting to predict ecological responses such as population declines (e.g., Kiesecker et al. 2001).

Table 2. Potential threats to eastern hellbender populations in various states.

State	Habitat Impacts	Overutilization	Disease or Predation	Other Factors
Alabama	impoundments	no information	no information	pollution
Georgia	impoundments; siltation	incidental take by anglers; impacted by collection of bait salamanders	non-native trout	no information
Indiana	alteration for recreation (canoeing)	incidental take by anglers	catfish	water quality
Kentucky	impoundments; siltation	no information	no information	pollution
Maryland	impoundments; channelization; siltation; nutrient enrichment; temperature changes; low dissolved oxygen	incidental take by anglers	non-native trout	lack of prey; acid mine drainage; deforestation; agricultural runoff
Mississippi	impoundments	no information	no information	no information
Missouri	impoundments; siltation	illegal collection	non-native trout	pesticide runoff; gravel mining; endocrine disruption
New York	dams; siltation; low dissolved oxygen	illegal collection	exotic crayfish; non-native game fish	pollution; failing septic systems
North Carolina	dams	illegal commercial take	no information	pollution; residential development; municipal waste; road construction; agricultural runoff
Ohio	dams; siltation	no information	cannibalism (adults on eggs)	deforestation; acid mine drainage
Pennsylvania	impoundments; siltation	no information	no information	mining; pollution; deforestation
Tennessee	impoundments; siltation	no information	no information	water quality
Virginia	impoundments; siltation; nutrient enrichment; channelization	illegal collection; incidental take by anglers	no information	industrial pollution; mining
West Virginia	siltation	illegal collection	non-native trout	acid mine drainage; coal mining

Information supplied by J. Briggler - Missouri Department of Conservation; B. Fisher - Indiana Department of Natural Resources, R. Pfingsten - Cleveland Museum of Natural History; A. Sherman - Mississippi Museum of Natural Science; M. Barbour - Alabama Natural Heritage Program; J. Jensen - Georgia Department of Natural Resources, Wildlife Resources Division, Nongame Endangered Wildlife Program; J. Finnegan - North Carolina Department of Environment, Health, and Natural Resources, North Carolina Heritage Program, Division of Parks and Recreation; A. Braswell - North Carolina State Museum of Natural Sciences; A. Scott - Department of Biology, Austin Peay State University; T. Henry - Tennessee Valley Authority Natural Heritage Project; B. Palmer-Ball - Kentucky State Nature Preserves Commission; J. Wykle - West Virginia Department of Natural Resources, West Virginia Natural Heritage Program; J. Humphries - Department of Forest Resources, Clemson University; M. Pinder - Virginia Department of Game and Inland Fisheries; S. Carter-Lovejoy - Virginia Department of Conservation and Recreation; A. Hulse - Department of Biology, Indiana University of Pennsylvania; K. Derge - Pennsylvania Fish and Boat Commission, Nongame and Endangered Species Unit; E. Thompson - Maryland Department of Natural Resources; A. Breisch - New York State Department of Environmental Conservation, Division of Fish, Wildlife and Marine Resources. Contact information for these individuals can be found in Appendix 2.

CURRENT PROTECTIVE STATUS

The level of effort dedicated to documenting occurrences of the eastern hellbender and monitoring its numbers is generally minimal throughout its range and quite variable on a state-by-state basis. Each state has, therefore, established a specific level of protection to the eastern hellbender as they have seen fit. Table 3 presents the eastern hellbender's protective status and National Heritage ranking by state, as well as its global and federal protective status designation.

Table 3. Eastern hellbender's protective status at the global, federal, and state level.

Governmental Level	Protective Status	Heritage Status Rank
Global	none	G3G4T3T4
Federal (U.S.)	none	N3N4
Alabama	state protected	S3
Georgia	rare	S3
Illinois	endangered	S1
Indiana	endangered	S1
Kentucky	none	S3
Maryland	endangered	S1
Mississippi	none	S1
Missouri	endangered	S1
New York	special concern	S2
North Carolina	special concern	S3
Ohio	endangered	S2
Pennsylvania	none	S3S4
South Carolina	none	S?
Tennessee	deemed in need of management	S3
Virginia	species of concern	S2S3
West Virginia	species of concern	S2

G3G4T3T4 = species and subspecies vulnerable to apparently secure; N3N4 = nationally vulnerable to apparently secure; S1 = critically imperiled; S2 = imperiled; S2S3 = imperiled to vulnerable; S3 = vulnerable; S3S4 = vulnerable to apparently secure; S? = state status uncertain. Information obtained from NatureServe Explorer; M. Barbour - Alabama Natural Heritage Program; G. Krakow - Georgia Department of Natural Resources, Wildlife Resources Division, Georgia Natural Heritage Program; J. Jensen - Georgia Department of Natural Resources, Wildlife Resources Division, Nongame Endangered Wildlife Program; C. Phillips - Illinois Natural History Survey; B. Fisher - Indiana Department of Natural Resources; B. Palmer-Ball - Kentucky State Nature Preserves Commission; E. Thompson - Maryland Department of Natural Resources; A. Sherman - Mississippi Museum of Natural Science; J. Briggler - Missouri Department of Conservation; A. Breisch - New York State Department of Environmental Conservation, Division of Fish, Wildlife and Marine Resources; J. Finnegan - North Carolina Department of Environment, Health, and Natural Resources, North Carolina Heritage Program, Division of Parks and Recreation; A. Braswell - North Carolina State Museum of Natural Sciences; R. Pfingsten - Cleveland Museum of Natural History; B. Brilliger - Pennsylvania Dept. of Conservation; A. Hulse - Department of Biology, Indiana University of Pennsylvania; J. Holling - South Carolina Department of Natural Resources, Wildlife Diversity Section/Heritage Trust Program; D. Collins - Tennessee Aquarium; A. Scott - Department of Biology, Austin Peay State University; T. Henry - Tennessee Valley Authority Natural Heritage Project; M. Pinder - Virginia Department of Game and Inland Fisheries; S. Carter-Lovejoy - Virginia Department of Conservation and Recreation; J. Wykle - West Virginia Department of Natural Resources, West Virginia Natural Heritage Program; J. Humphries - Department of Forest Resources, Clemson University. Contact information for these individuals can be found in

Appendix 2.

Although the level of protection provided to eastern hellbender populations varies from state to state, most of the states within the eastern hellbender's range consider this salamander to be in some degree of peril. Of the 16 states comprising the eastern hellbender's range, nearly 88 percent consider populations to be "critically imperiled," "imperiled," or "vulnerable." Of these, about 33 percent have designated eastern hellbenders as endangered, thus providing legal protection.

Some degree of protection is sometimes afforded even in the absence of official, state designation as endangered. In Georgia, for example, a scientific collecting permit is needed to collect, kill, or possess hellbenders. However, the greatest amount of direct take probably comes from anglers who catch them incidental to trout fishing. The effectiveness of legal protection is limited by lack of enforcement and public knowledge (J. Jensen, pers. comm.). Although the protective status of the eastern hellbender in Missouri is pending elevation to state endangered, its current status of S1 (critically imperilled) requires a person to obtain a wildlife collector's permit from the Department of Conservation in order to possess or collect a hellbender (J. Briggler, pers. comm.). In New York, the status of special concern does not include a prohibition on collecting. However, even for unprotected species like the eastern hellbender, manner of take is regulated. If traps, nets, or seines are used a "license to collect and possess" is required. However, such a license is only issued for scientific, educational or exhibition purposes. A license need not be issued for collection for commercial purposes or for pets. Likewise, accidental take by anglers is not considered illegal (A. Breisch, pers. comm.). The special concern status in North Carolina dictates that hellbenders may be taken with a permit, where the number allowed is at the discretion of the person issuing the permit. There is a $100 minimum fine for the first offense; $500 minimum for the second offense. The law doesn't specify whether the fine is per animal or per taking (J. Finnegan, pers. comm.). For West Virginia, species of concern status provides no tangible form of protection (J. Wykle, pers. comm.). For general collection, a Class B fishing license is required for all aquatic life. To collect for scientific or educational purposes, a scientific collecting permit must be obtained through the West Virginia Wildlife Diversity program. West Virginia laws state that one can possess no more than 100 salamanders or other aquatic life unless obtained from a licensed dealer and accompanied by a bill of sale. Again, if collecting for scientific purposes a permit is necessary. However, if one has a West Virginia fishing license collection is unlimited. In Virginia, species of concern have no more special protection than most non-game amphibians (M. Pinder, pers. comm.). Anyone collecting hellbenders in Virginia for scientific purposes must have a scientific collection permit. Virginia regulations allow possession for private use of no more than five individuals of any single native or naturalized species of reptile or amphibian. Native and naturalized species cannot be bought, sold, liberated, exported, or imported unless specifically permitted by law or regulation.

In summary, a state protective status other than endangered typically requires that a permit be secured if specimens are to be collected for scientific purposes. However, unless designated as state endangered, a given state-specific protective status affords little to no protection against incidental take by anglers or collection for personal use. The other designations listed in Table 2 do not provide any level of protection but acknowledge that the population status of the eastern hellbender within several states is uncertain.

SUMMARY OF LAND OWNERSHIP AND EXISTING HABITAT PROTECTION

There is no comprehensive database or publication containing specific occurrence records that are thoroughly cross-referenced with site-specific ownership documentation for the entire geographic distribution of the eastern hellbender. Rather, each state maintains occurrence and location information in their own format and at their own level of detail. The Tennessee Valley Authority (TVA) maintains a useful regional database that includes several, but not all, of the states that define the eastern hellbender's distribution. The following state-specific summaries reflect the land ownership information obtained from scientific professionals that were directly contacted.

The TVA has recorded eastern hellbender occurrences in areas that they manage in Alabama, Georgia, North Carolina, Mississippi, Tennessee, and Virginia (T. H. Henry, pers. comm.). Their database is used to track populations of federal and state protected species throughout their seven-state power service area. The information is used during the environmental review process for development projects within their jurisdiction. When it is determined that a state-listed species such as the eastern hellbender could be affected by a project, commitments are placed in associated NEPA documents to reduce impacts to these populations. The TVA manages parts of [redacted], Mississippi (A. Sherman, pers. comm.). However, most of the remaining [redacted] area is privately owned. Most [redacted] streams containing hellbender populations are within the [redacted]. Other known streams of favorable habitat in Georgia are mostly surrounded by private lands (J. Jensen, pers. comm.).

The state of Indiana owns property along the lower section of the [redacted] as part of the [redacted] (B. Fisher, pers. comm.). Of the historic hellbender locations in Illinois, only the [redacted] River is bordered by significant quantities of state or federally protected land (C. Phillips, pers. comm.). Kentucky populations are completely surrounded by private property (B. Palmer-Ball, pers. comm.). Populations are scattered throughout central and western Pennsylvania, and ownership information for each population is not available. Several of the healthiest populations are in the [redacted] managed by the [redacted] The majority of the populations are most likely surrounded by private lands, though the waters themselves are public property (K. Derge, Pennsylvania Fish and Boat Commission, pers. comm.).

Hellbender habitat in the [redacted] River is largely within a Maryland state-legislated wild and scenic river so there are regulations in place to protect the view-shed from extensive development (E. Thompson, pers. comm.). There is also some degree of regulation on timber harvest within the view-shed of the main stem of the river. Unfortunately, this has not curtailed the rapid rate of resort/residential development occurring throughout the [redacted] watershed. This development is most evident in the vicinity of [redacted]. A major tributary [redacted] drains this lake near the upper reaches of hellbender habitation in the [redacted] River.

Eastern hellbender distribution in Missouri is primarily on private land with a few records from conservation areas managed by the Missouri Department of Conservation and U.S. Forest Service Lands in [redacted] (J. Briggler, pers. comm.). Populations occur in the [redacted], and the [redacted] (Bruce 1977, A. Braswell, pers. comm.).

There is one hellbender occurrence documented in waters flowing through [redacted] Creek in the [redacted] West Virginia (S. Lovejoy, pers. comm.). Most of the land surrounding hellbender habitat in West Virginia is owned by Public Lands Corporation (public property as navigable waters) with some records from lands managed by the USDA Forest Service and the West Virginia Division of Natural Resources (J. Humphries, pers. comm.).

BENEFICIAL CONSERVATION ACTIVITIES

To date, very few conservation activities specifically beneficial to the eastern hellbender have been conducted.

In the [redacted] River in Maryland, fishing pressure has dramatically increased. However, there is a restriction on use of live bait and this could reduce the potential for hellbender capture by fisherman (E. Thompson, pers. comm.). Other examples of beneficial actions include the acquisition of funding by the Maryland Bureau of Mines to review acid mine drainage re-mediation projects along the North Branch headwater tributary of the [redacted] River. This major tributary has a long history of acid mine drainage impacts. At the Natural Heritage Program's request the Bureau of Mines is studying this drainage with the goal of implementing more effective techniques to improve water quality (E. Thompson, pers. comm.). Efforts to improve water quality and fish habitat statewide in Pennsylvania, through stream enhancement projects funded by state and private organizations as well as habitat mitigation for river dredging and dock projects, are expected indirectly to improve water quality and in-stream habitats for the hellbender (K. Derge, pers. comm.). In Virginia, hellbenders are likely to benefit indirectly from stream restoration work within its range that is usually targeted towards endangered fish and mussels (M. Pinder, pers. comm.). The TVA has also implemented a variety of large-scale projects that benefit aquatic species including hellbenders. For example, in an effort to improve water quality throughout the Tennessee River system, TVA has placed weirs in tail water sections below several dams to increase dissolved oxygen levels at these sites. They have also begun working with private landowners to remove cattle from streams in a effort to improve water quality (T. H. Henry, pers. comm.).

MANAGEMENT ACTION AND RESEARCH NEEDS

A professional meeting on hellbenders is scheduled to be held in July 2003. The meeting will focus on the importance of management actions and research needs.

A. Monitoring and Surveys

The need for increased monitoring and surveying of populations dominates the research priorities. Contacts in nearly every state expressed the importance of increasing efforts to determine current distribution as well as searching for new populations. The importance of standardized protocols in order to determine range-wide trends is of great importance (M. Pinder, pers. comm.). Diurnal skin-diving surveys are strongly recommended for hellbenders, and when simultaneously surveying hellbenders and mud puppies (*N. Maculosus*) Passive Integrated Transponder (PIT) tagging coupled with branding of larvae is suggested (Nickerson et al. 2002). Nocturnal surveys proved to be very effective at documenting presence / absence in geographic areas, such as West Virginia, where there are seasonal trends in the hellbender's nocturnal activity (Humphries and Pauley 2000). Radio telemetry has been used to monitor eastern hellbenders in the [redacted] River basin in New York (Eastern Hellbender Fact Sheet 2002) and the [redacted] River in North Carolina (Ball and Van Devender 2000). Depending on stream habitat conditions, electroshocking in combination with dip nets or seine were shown to be effective and efficient (Williams et al. 1981b). Due to the near lack of larvae detection, it is also important to conduct frequent quantitative surveys designed to detect larvae and assess larval survival. A range-wide database of potentially suitable habitat could be developed to aid in prioritizing land acquisition for hellbender conservation as well as to identify potential locations for hellbender reintroduction.

B. Basic Research

Although increased monitoring is a dominant research priority, it is extremely naive and certainly not objective to simply request "more monitoring" (Pechmann and Wilbur 1994). As discussed in the SUMMARY OF THREATS section, there is a critical need for basic research efforts that feature experimental designs and hypotheses that encourage investigators to collect quantitative data on eastern hellbender population trends and integrate them with data representative of potential causal factors. It is only through well designed studies that direct mechanisms affecting eastern hellbender persistence will be identified. For example, research is currently underway to explore the effects of poor water quality, toxic chemical runoff (endocrine disruptors), and embryonic factors such as sperm viability, fertilization, egg development and hatching success in Missouri (J. Briggler, pers. comm.). Demographic, behavioral, and ecological studies are needed with particular attention paid to the minimum population size necessary to maintain genetic viability. Baseline demographic studies should be conducted in locations with known populations to provide a foundation for evaluating future changes in distribution and population status. In addition, specific research concerning the effects of sedimentation, toxicity and other factors influencing egg and larval survival is essential for understanding recruitment limitation (A. Breisch and M. Pinder pers. comm.). Dodd (1997) emphasizes the need for research to be scaled to the ecosystem, landscape and watershed level in order to understand the role of amphibians in imperiled aquatic ecosystems. Brant Fisher (pers. comm.) suggests that efforts to study hellbender life history be continued in the hope of understanding how to protect extant populations.

C. Best Management Practices

The state of Missouri has recommended various best management practices (BMPs) for the eastern hellbender. These focus on limiting impoundments, stream diversion, erosion and sedimentation, and in-stream gravel mining (MO Department of Conservation 2000). Best Management Practices are also used by the TVA to reduce the impacts of proposed activities.

Examples of TVA BMPs beneficial to eastern hellbenders include the placement of appropriate erosion control measures and re-vegetation of disturbed areas adjacent to streams, stream bank stabilization, and the establishment of stream management zones. These measures help control erosion and limit the alteration of critical stream characteristics such as dissolved oxygen, levels of turbidity and water temperature (T. H. Henry, pers. comm.). Management recommendations for hellbenders in West Virginia address siltation, damming, channelization, eutrophication and acid mine drainage (Humphries 1999). The preservation of forest buffer strips along streams, and the avoidance of stream impoundment, channelization, diversion, and bleaching were recommended by Jensen (1999). There is a need to implement buffer zones and other habitat preservation issues before predicted human population growth occurs (J Humphries and J. Wykle, pers. comm.).

D. Habitat Restoration

Water quality must be improved in much of the species' range (B. Fisher and B. Palmer-Ball, pers. comm.). A specific example of such efforts include the acquisition of funding by the Maryland Bureau of Mines to review acid mine drainage re-mediation projects along the North Branch headwater tributary of the [redacted] River which has a long history of acid mine drainage impacts (see BENEFICIAL CONSERVATION ACTIVITIES for more details). J. Briggler (pers. comm.) suggests that management actions focus on bank stabilization to decrease stream siltation thereby improving hellbender habitat. Continued efforts to improve water quality should focus largely on watersheds known to support hellbenders. Likewise, habitat enhancement in silt-impacted rivers and streams should be encouraged. Acid mine drainage and other causes for declines in water quality have impaired hellbender habitat, and any efforts to remediate such problems would likely benefit the species (K. Derge, pers. comm.).

E. Captive Breeding and Reintroduction

A. Breisch (pers. comm.) suggests that research should be conducted on captive breeding and reintroduction techniques. High quality habitat within the historical eastern hellbender range that does not currently support populations or which contains small populations should be assessed as potential reintroduction locations once the techniques of captive propagation are perfected. In cases of extreme isolation, human facilitated dispersion may be necessary to maintain a healthy degree of gene flow between populations. A captive propagation initiative is being jointly developed for the Ozark hellbender by the St. Louis Zoo, Mammoth Spring Fish Hatchery (United States Fish & Wildlife Service) and an Ozark Hellbender Working Group (J. Briggler, pers. comm.). Initiative goals are to: 1) establish a protocol for captive breeding and rearing (Ozark hellbenders have never been bred or reared in captivity); and 2) establish a captive stock in case an area needs to be re-stocked. Attaining these goals depends on the working group's progress on discerning why the Ozark hellbenders are declining and not reproducing (Ron Goellner, St. Louis Zoo pers. comm. with co-author C. Phillips). The working group also focuses on the status of current research, discusses future research needs and facilitates communication among biologists via a list server. Although the Ozark hellbender is the focal point, the eastern hellbender will likely benefit from these activities.

F. Public Outreach

The importance of outreach and education efforts targeting the fishing public has been noted (Gates et al. 1985, Eastern Hellbender Fact Sheet 2002). There is a need for public education, particularly for anglers to encourage them to return any captured hellbenders unharmed to the stream. In Maryland, the state fishing regulation guide includes a picture of a hellbender with a write-up to inform angles of its protected status (E. Thompson, pers. comm.). Calls for this type of education program targeting anglers has been echoed by natural resource managers in New York (A. Breisch, pers. comm.), Pennsylvania (A. Hulse, pers. comm.), and Missouri (J. Briggler, pers. comm.). In Missouri, grants have been written to acquire funding for producing educational outreach material for recreationists (especially anglers and bait store owners). Workshops on hellbender life history needs are being conducted at local stream team chapters and within the Missouri Department of Conservation (J. Briggler, pers. comm.). Information regarding the predatory effects of non-native species introductions (particularly trout) on eastern hellbender neonates in Missouri will be provided and recreationists in Missouri will be asked to report the illegal collection of eastern hellbenders for the pet trade (J. Briggler, pers. comm.). Educational programs in Virginia inform anglers and the general public of the hellbender's importance and their harmless nature (i.e., they are not venomous). Virginia game and fish department personnel have attended town and county fairs to disseminate information on eastern hellbender (M. Pinder, pers. comm.). Web sites have been established nationally (J. Humphries, pers.comm.) and in New York (A. Breisch, pers. comm.); e.g. http://hellbenders.sanwalddesigns.com and www.dec.state.ny.us/website/dfwmr/wildlife/endspec/hellfs.html. These present useful educational material concerning eastern hellbender natural history and conservation.

LITERATURE CITED

Alexander, W.P. 1927. The Allegheny hellbender and its habitat. Buffalo Society of Natural Science 7:13-18.

Ball, B.S. and R.W. Van Devender. 2000. Home range of eastern hellbenders. *Cryptobranchus alleganiensis alleganiensis*: A radiotelemetric study. Program Book and Abstracts, joint meeting of Ichthyologists and Herpetologists. La Paz, B.C.S., Mexico. Abstract only.

Bishop, S.C. 1941. Salamanders of New York. New York State Museum Bulletin 324:1-365.

Blais, D.P. 1996. Movement, home range, and other aspects of the biology of the eastern hellbender (*Cryptobranchus a. alleganiensis*): A radio telemetric study. M.S. Thesis, State University of New York at Binghamton, Binghamton, NY.

Bothner, R.C., and J.A. Gottlieb. 1991. A study of the New York State populations of the hellbender, *Cryptobranchus alleganiensis alleganiensis.* Proceedings of the Rochester Academy of Science 17(1):41-54.

Brodie, E.D., Jr. 1971. Two more toxic salamanders, *Ambystoma maculatum* and *Cryptobranchus alleganiensis*. Herpetological Review 3:8.

Bruce, R.C. 1977. *Cryptobranchus alleganiensis alleganiensis* hellbender. Pp. 316-317 In: J.E. Cooper, S.S. Robinson, and J.B. Funderburg (eds.), *Endangered and Threatened Plants and Animals of North Carolina,* N.C. State Mus. Nat. Hist., Raleigh, N.C.

Bury, R.B., C.K. Dodd, Jr., and G.M. Fellers. 1980. Conservation of the Amphibia of the United States: a review. Resource Publication 134, U.S. Fish and Wildlife Service, Washington, D.C., 34p.

Casey, T., G. Pritts, and B.T. Miller. 1993. Preliminary investigations on the movement of the hellbender (*Cryptobranchus alleganiensis*) in middle Tennessee. Journal of the Tennessee Academy of Science 68(2):55.

Cash,W.B. 1996. Population status of the hellbender, *Cryptobranchus alleganiensis*, in Bear Creek, Tishomingo County, Mississippi.

Cilburn, W. 1991. Status of *Cryptobranchus alleganiensis* in Mississippi. Final Report to the Mississippi Commission on Wildlife Conservation, Mississippi Natural Heritage Program.

Coatney, C.E., Jr. 1982. Home range and nocturnal activity of the Ozark hellbender. Unpubl. M.Sc. Thesis. Southwest Missouri State University, Springfield.

Colborn, T., F.S. vom Saal, and A.M. Soto. 1993. Developmental effects of endocrinedisrupting chemicals in wildlife and humans. Environmental Health Perspectives 101:378-384.

Collins, J.T. 1991. Viewpoint: a new taxonomic arrangement for some North American amphibians and reptiles. Herpetological Review 22:42-43.

Conant, R.A. 1975. A field guide to reptiles and amphibians of eastern and central North America, second edition. Pp240-241, PI 37.

Congdon, J.D., A.E. Dunham, and R.C. Van Loben Sels. 1993. Delayed sexual maturity and demographics of Blanding's Turtles (*Emydoidea blandingii*): implications for conservation and management of long-lived organisms. Conservation Biology 7:826-833.

Cope, E.D. 1889. The batrachia of North America. U.S. National Museum Bulletin 34:1-525.

Danch, J. 1996. The hellbender. Reptiles 4:48-59.

Dodd, Jr., C.K. 1997. Imperiled amphibians: a historical perspective. In: G.W. Benz and D.E. Collins (Eds.). *Aquatic Fauna in Peril: The Southeastern Perspective*. Southeast Aquatic Research Institute, Lenz Design and Communications, Deatur, Georgia, Special Publication 1, pp. 165-200.

Dundee, H.A. 1971. *Cryptobranchus alleganiensis.* Catalogue of American Amphibians and Reptiles 101.

Dundee, H.A. and D.S. Dundee. 1965. Observations on the systematics and ecology of *Cryptobranchus* from the Ozark Plateaus of Missouri and Arkansas. Copeia 3:369-370.

Ellner, S. and N.G. Hairston, Jr. 1994. Role of overlapping generations in maintaining genetic variation in a fluctuating environment. American Naturalist 143:403-417.

Ferguson, D.E. 1961. The herptofauna of Tishomingo County, Mississippi with comments on its zoogeographic affinities. Copeia 1961:391-396.

Firschein, I.L. 1951. The range of Cryptobranchus bishopi and remarks on the distribution of the genus Cryptobranchus. American Midland Naturalist 45(2):455-459.

Gates, J.E. 1983. The distribution and status of the hellbender (*Cryptobranchus alleganiensis*) in Maryland: I. The distribution and status of Cryptobranchus alleganiensis in Maryland. II. Movement patterns of translocated *Cryptobranchus alleganiensis* in a Maryland stream. Maryland Wildlife Administration.

Gates, J.E., C.H. Hocutt, J.R. Stauffer, Jr. 1984. The status of the hellbender (*Cryptobranchus* *alleganiensis*) in Maryland. Pp. 329-335 In: A.W. Norden, D.C. Forester, and G.H. Fenwick (eds.), *Threatened and Endangered Plants and Animals of Maryland*. Maryland Natural History Program, Special Publication 84-I, Annapolis, MD.

Gates, J.E., C.H. Hocutt, J.R. Stauffer, Jr., and G.J. Taylor. 1985. The distribution and status of *Cryptobranchus alleganiensis* in Maryland. Herpetological Review 16:17-18.

Gilpin, M.E. and M.E. Soulé. 1986. Minimum viable populations: the processes of species extinction. Pages 13-34 in *Conservation Biology: The Science of Scarcity and Diversity*, M.E. Soulé (ed.). Sinaur Associates, Sunderland, Mass.

Green, N.B. 1933. *Cryptobranchus alleganiensis* in West Virginia. Proc. W. Va. Acad. Sci. 7: 28-30.

Green, N.B. 1934. *Cryptobranchus alleganiensis* in West Virginia. Proc. W. Va. Acad. Sci. 7: 28-30.

Green, N.B. 1935. Further notes on the food habits of the water dog, *Cryptobranchus alleganiensis* (Daudin). Proceedings of the Academy of Science 9:36.

Green, N.B. and T.K. Pauley. 1987. *Amphibians and Reptiles in West Virginia*. University of Pittsburgh Press. Pittsburgh, Pa.

Grobman A.B. 1943. Notes on salamanders with the description of a new species of *Cryptobranchus*. Occasional Papers of the Museum of Zoology 470:1-13.

Guillette, L.J., Jr., T.S. Gross, G.R. Masson, J.M. Matter, H.F. Percival, and A.R. Woodward. 1994. Developmental abnormalities of the gonad and abnormal sex hormone concentrations in juvenile alligators from contaminated and control lakes in Florida. Environmental Health Perspectives 102:680-688.

Guimond, R.W. 1970. Aerial and aquatic respiration in four species of paedomorphic salamanders: *Amphiuma means means*, *Cryptobranchus alleganiensis alleganiensis*, *Necturus maculosus maculosus*, and *Siren lacertina*. PhD Dissertation. University of Rhode Island.

Hall, H.H. and H.M. Smith. 1947. Selected records of reptiles and amphibians from southeastern Kansas. Transactions of the Kansas Academy of Science 49(4):447-454.

Harlan, R.A. and R.F. Wilkinson. 1981. The effects of progressive hypoxia and rocking activity on blood oxygen tension for hellbenders, *Cryptobranchus alleganiensis*. Journal of Herpetology 15(4):383-388.

Hay, O.P. 1892. The batrachians and reptiles of the state of Indiana. Indiana Department of Geology and Natural Resources Annual Report 17:409-602.

Hillis, R.E. and E.D. Bellis. 1971. Some aspects of the ecology of the hellbender *Cryptobranchus alleganiensis alleganiensis*, in a Pennsylvania stream. Journal of Herpetology 5:121-126.

Huckabee, J.H., C.P. Goodyear, and R.D. Jones. 1975. Acid rock in the Great Smokies: unanticipated impact on aquatic biota of road construction in regions of sulfide mineralization. Transactions of the American Fisheries Society 104(4):677-684.

Humphries, W.J. 1999. Ecology and population demography of the hellbender, *Cryptobranchus alleganiensis,* in West Virginia. M.S. Thesis, Marshall University, Huntington, WV.

Humphries, W.J. and T.K. Pauly. 2000. Seasonal changes in nocturnal activity of the hellbender, *Cryptobranchus alleganiensis*, in West Virginia. Journal of Herpetology 34(4):604-607.

Johnson, T.R. 1981. Observations on hellbender, *Cryptobranchus alleganiensis alleganiensis,* eggs and early larvae. Transactions of the Missouri Academy of Science 15:248.

Jensen, J.B. 1999. Hellbender *Cryptobranchus alleganiensis*. *In* Protected animals of Georgia. Nongame-Endangered Wildlife Program, Georgia Department of Natural Resources, Social Circle, GA. Pp. 98-99.

Kern, W.H. 1984. The hellbender, *C. alleganiensis* in Indiana. M.A. thesis, Indiana State University. 48 pp.

Kern, W.H., Jr. 1986a. Reproduction of the hellbender, *Cryptobranchus alleganiensis*, in Indiana. Proceedings of the Indiana Academy of Science 95:521.

Kern, W.H., Jr. 1986b. The range of the hellbender, *Cryptobranchus alleganiensis alleganiensis*, in Indiana. Proceedings of the Indiana Academy of Science 95:520-521.

Kiesecker, J.M., A.R. Blaustein, and L.K. Belden. 2001. Complex causes of amphibian population declines. Nature 410:681-684.

Krecker, F.H. 1916. *Filaria cingula* parasitic in the skin of *Cryptobranchus alleganiensis*. Parasitology 2:74-79.

Lande, R. 1988. Genetics and demography in biological conservation. Science 241:1455-1461.

McMullen, D.B. and R.L. Roudabush. 1936. A new species of trematode, *Cercorchis cryptobranchi*, from *Cryptobranchus alleganiensis*. J. Parasitol. 22:516-517.

Merkle, D.A., S.I. Guttman, and M.A. Nickerson. 1977. Genetic uniformity throughout the range of the hellbender, *Cryptobranchus alleganiensis*. Copeia (3):549-553.

MO Department. of Conservation. 2000. Best Management Practices: Hellbender *Cryptobranchus alleganiensis*. Missouri Department of Conservation, Jefferson City, MO. 2 pp.

Netting, M.G. 1929. The food of the hellbender *Cryptobranchus alleganiensis* (Daudin). Copeia 170:23-34.

Nickerson, M.A. and C.E. Mays. 1973. The hellbenders: North American giant salamanders. Milwaukee Public Museum Publications in Biology and Geology 1, 106pp.

Nickerson, M.A. and M.D. Tohulka. 1986. The nests and nest site selection by Ozark hellbenders, *Cryptobranchus alleganiensis bishopi* Grobman. Transactions of the Kansas Academy of Science 89:66-69.

Nickerson, M.A., K.L. Krysko, and R.D. Owen. 2002. Ecological status of the hellbender (*Cryptobranchus alleganiensis*) and the mudpuppy (*Necturus maculosus*) salamanders in the Great Smoky Mountains National Park. J. North Carolina Acad. Sci. 118:27-34.

Nigrelli, R.F. 1954. Some longevity records of vertebrates. New York Academy of Sciences 16(6):296-299.

Noeske, T.A. and M.A. Nickerson. 1979. Diel activity rhythms in the hellbender, *Cryptobranchus alleganiensis* (Caudata: Cryptobranchidae). Copeia 1:92-95.

Noss, R.F. and A.Y. Cooperrider. 1994. *Saving Nature's Legacy: Protecting and Restoring Biodiversity.* Island Press, Washington, D.C.

Pechmann, J. H. K. and H. M. Wilbur. 1994. Putting declining amphibians populations in perspective: Natural fluctuations and human impacts. Herpetologica 50:64-85.

Peterson, C.L. 1985. Comparative demography of four populations of the hellbender, *Cryptobranchus alleganiensis*, in the Ozarks. PhD Dissertation. University of Missouri, Columbia. 158 pp.

Peterson, C.L. 1987. Movement and catchability of the hellbender, *Cryptobranchus alleganiensis.* Journal of Herpetology 21(3):197-204.

Peterson, C.L. 1988. Breeding activities of the hellbender in Missouri. Herpetological Review 19(2):28-29.

Peterson, C.L., D.E. Metter, and B.T. Miller. 1988. Demography of the *Cryptobranchus alleganiensis* in the Ozarks. American Midland Naturalist 119(2):291-303.

Peterson, C.L., J.W. Reed, and R.F. Wilkinson. 1989. Seasonal food habits of *Cryptobranchus alleganiensis* (Caudata: Cryptobranchidae). The Southwestern Naturalist 34(3):348-441.

Peterson, C.L. and R.F. Wilkinson. 1996. Home range size of the hellbender (*Cryptobranchus alleganiensis)* in Missouri. Herpetological Review 27(3):126-127.

Petranka, J.W. 1998. Salamanders of the United States and Canada. Smithsonian Institution.

Pfingsten, R.A. 1988. The status and distribution of the hellbender, *Cryptobranchus allegansiensis*, in Ohio. Unpublished report to the Ohio Department of Natural Resources. 25 pp.

Pfingsten, R.A. 1989. The status and distribution of the hellbender, *Cryptobranchus alleganiensis*, in Ohio. Ohio Journal of Science 89(2):3.

Pfingsten, R.A. 1990. The status and distribution of the hellbender, *Cryptobranchus alleganiensis* in Ohio. Herpetological Review 21(3):48-51.

Pfingsten, R.A. and F.L. Downs, eds. 1989. Salamanders of Ohio. Ohio Biol. Surv. New Series Vol. 7 No. 2.

Pounds, J.A. 2001. Climate change and amphibian declines. Nature 410:639-640.

Prosen, E., B. Wheeler, R. Wilkinson, A. Mathis, and B. Greene. 1998. Missouri hellbender survey: a progress report. Unpublished report for Southwest Missouri State University.

Routman, E. 1993. Mitochondrial DNA variation in *Cryptobranchus alleganiensis*, a salamander with extremely low allozyme diversity. Copeia (2):407-416.

Shaffer, H.B. and F. Breden. 1989. The relationship between allozyme variation and life history: nontransforming salamanders are less variable. Copeia (4):1016-1023.

Siebert, H. and R. Brandon. 1960. The salamanders of southeastern Ohio. Ohio Journal of Science 60(5):291-303.

Smith, B.G. 1907. The life history and habits of *Cryptobranchus alleganiensis*. Biological Bulletin 13: 5-39.

Smith, P.W. and S.A. Minton, Jr. 1957. A distributional summary of the herpetofauna of Indiana and Illinois. The American Midland Naturalist 58:341-351.

Smith, H.M. and A.J. Kohler. 1977. A survey of the herpetological introductions in the United States and Canada. Transactions of the Kansas Academy of Science 80(1-2):1-24.

Swanson, P.L. 1948. Notes on the amphibians and reptiles of Venango County, Pennsylvania. The American Midland Naturalist 40:362-371.

Taber, C.A., R.F. Wilkinson, Jr., and M.S. Topping. 1975. Age and growth of hellbenders in the Niangua River, Missouri. Copeia 1975:633-639.

Topping, M.S., and C.L. Peterson. 1985. Movement in the hellbender, *Cryptobranchus alleganiensis.* Transactions of the Missouri Academy of Science 19:121.

Topping, M.S. and C.A. Ingersol. 1981. Fecundity in the hellbender, *Cryptobranchus alleganiensis*. Copeia 1981(4):873-876.

Trauth, S.E., J,D. Wilhide and P. Daniel. 1992. Status of the Ozark hellbender, *Cryptobranchus bishopi* (Urodela: Cryptobranchidae), in the Spring River, Fulton County, Arkansas. Proceedings of the Arkansas Academy of Science 46:83-86.

Ultsch, G.R. and J.T. Duke. 1990. Gas exchange and habitat selection in the aquatic salamanders *Necturus maculosus* and *Cryptobranchus alleganiensis*. Oecologia 83(2):250-258.

Welsh, H.H. and L.M. Ollivier. 1998. Stream amphibians as indicators of ecosystem stress: a case study from California's redwoods. Ecological Applications 8:1118-1132.

Wheeler, B.A., E. Prosen, A. Mathis, and R.F. Wilkinson. 2003. Population declines of a long-lived salamander: a 20+ year study of hellbenders, *Cryptobranchus alleganiensis*. Biological Conservation 109:151-156.

Williams R.D., J.E. Gates, C.H. Hocutt, and G.J. Taylor. 1981a. The hellbender: a nongame species in need of management. Wildlife Society Bulletin 9(2):94-100.

Williams R.D., J.E. Gates and C.H. Hocutt. 1981b. An evaluation of known and potential sampling techniques for hellbender, *Cryptobranchus alleganiensis*. Journal of Herpetology 15 (1):23-27.

Wyman, R.L. 1990. What's happening to the amphibians? Conservation Biology 4:350-352.

INTERNET LITERATURE CITED

Eastern Hellbender Fact Sheet 2002. New York State Department of Environmental Conservation. Available: http://www.dec.state.ny.us/website/dfwmr/wildlife/endspec/hellfs.html (Accessed January 7, 2003).

NatureServe Explorer: An online encyclopedia of life [web application]. 2002. Version 1.6. Arlington, Virginia, USA: NatureServe. Available: http://natureserve.org/explorer. (Accessed: January 30, 2003).

APPENDICES

Appendix 1 - 11 pages, contains a drawing of the eastern hellbender and distribution maps
Appendix 2 - 12 pages, contains contact information for the individuals who were consulted for information