

APPENDIX A
Species Profiles

PART THREE: REPTILES AND AMPHIBIANS

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SPECIES PROFILE

Black Racer

Coluber constrictor constrictor

Associated Habitat: Shrublands

Federal Listing: None

State Listing: None

Affected Species: NA

Global Rank: G5

State Rank: S3

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ELEMENT 1: DISTRIBUTION AND HABITAT

1.1 Habitat Description

The Northern black racer (*Coluber constrictor constrictor*) is a long, slender snake associated with a wide variety of early successional habitats, including: xeric and mesic forests; brushy areas; meadows; old fields; rocky ridges and ledges; and swamp and marsh edges (Hunter et al. 1999, Kjoss and Litvaitis 2000, Ernst and Ernst 2003). Additionally, wetlands may be important habitat components, as this species is extremely susceptible to dehydration (Ernst and Ernst 2003). Black racers appear to have a large (10-20 ha) but distinct home range, requiring fairly extensive patches of suitable habitat (Kjoss and Litvaitis 2000). Mammal burrows, rock crevices, rotting logs, and accumulated vegetation are required features within occupied patches, all of which serve as nest sites, retreats, and hibernacula (Ernst and Ernst 2003). High hibernacula site fidelity is common (Ernst and Ernst 2003). These sites are normally used communally, either in intra- or interspecific assemblages, during the months of September through May (Ernst and Ernst 2003). Juvenile prey consists primarily of insects whereas adult prey consists of frogs, toads, birds and their eggs, small mammals, and snakes, with mammals being the dominant food item (Ernst and Ernst 2003). Oviposition, which also may be communal, occurs during May or early June in loose

soil, litter, or hollow logs (Ernst and Ernst 2003). Hatchlings emerge in August or September (Hunter et al. 1999).

1.2 Justification

Based on historic reports of large populations of black racers, substantial population declines have likely occurred in New Hampshire. In Maine, black racers are considered Endangered. Early successional and shrub-dominated habitats are rapidly declining throughout the northeastern United States, largely as a result of commercial and residential development and forest maturation (Kjoss and Litvaitis 2000). In New Hampshire, remaining patches of early-successional habitat are small and patchily distributed (Kjoss and Litvaitis 2000). Severe habitat loss, alteration, and fragmentation throughout the species' distribution is exacerbated by the species' extensive habitat requirements (Kjoss and Litvaitis 2000).

1.3 Protection and Regulatory Status

There is currently no special protection for black racers in New Hampshire.

1.4 Population and Habitat Distribution

A total of 11 subspecies of black racers are recognized, all of which range north of Mexico (Ernst and Ernst 2003). The Northern black racer occurs from southern Maine and central New York, southwest to eastern Tennessee, northwestern Georgia, and northeastern Alabama (Ernst and Ernst 2003). In New Hampshire, this species is restricted to the southern half of the state, with the greatest number of verified records in the southeast. Within this region, black racers occur discontinuously, suggesting that populations may be confined to small pockets of optimal

habitat (Klemens 1993). The species distribution map associated with this profile is based on data synthesized at the time of its creation. Distribution maps are continually being updated as new reports are received.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

The University of New Hampshire (J. Taylor, Department of Zoology and S. Hale, Complex Systems Research Center) completed a potential habitat map for black racers within its New Hampshire range. These maps were primarily based on available GIS data layers including landcover, elevation, political boundaries, and element occurrences. Various query combinations can be performed to extract polygons matching user-defined criteria. An accuracy assessment has not been conducted on this model but maps should help prioritize areas to target for further surveys. Maps will need to be updated as new data layers become available.

1.7 Sources of Information

NatureServe (2005) provided status and ranking information. New Hampshire Reptile and Amphibian Reporting Program (RAARP) records and Taylor (1993) were the primary sources of locality records. Habitat and life history information was collected from scientific literature. Crother et al. (2000) was used for common and scientific names of reptiles and amphibians.

1.8 Extent and Quality of Data

The distribution, habitat use, and condition of black racer populations in New Hampshire are not well documented. This assessment was limited to those records included within the scientific literature or as high quality observations (photographs, specimens, or expert observer) in the RAARP database.

1.9 Distribution Research

Target RAARP volunteers to produce verified reports of black racer locations, especially in those areas

where records are scarce. Systematic surveys and research are needed to provide more information regarding the condition and habitat requirements of populations. Black racers, and other rare reptiles and amphibians, should be incorporated into habitat inventories as well as management and restoration efforts. Specifically, the effects of disturbance-inducing management practices on both black racer abundance and overall early-successional herpetofaunal diversity should be evaluated (Greenberg et al. 1994), considering their association with a community type that is currently intensively managed for Lepidopteran conservation.

ELEMENT 2: SPECIES/HABITAT CONDITION

This species is widespread throughout southern New England, though little information is available to evaluate the condition of black racers in New Hampshire. In a historic report (1940-1950, specific date unknown), Donald Carle, professor of science at Keene Teachers College, noted that 112 black racers were found at one location in Keene. No observations of this magnitude are known more recently. Inventory and research are necessary to fully identify basic life-history info, habitat use, and condition of populations.

ELEMENT 3: SPECIES AND HABITAT THREAT ASSESSMENT

Habitat loss, fragmentation, road mortality, modification of ecological processes, as well as human exploitation are the primary factors threatening black racer populations in New Hampshire (Hunter et al. 1999, Kjoss and Litvaitis 2000). Refer to element 3 in the grassland and shrubland habitat profiles for a detailed discussion of threats.

ELEMENT 4: CONSERVATION STRATEGIES

In an urbanized setting, both habitat restoration and improved conductivity are essential to the long-term survival of black racers in the region (Kjoss and Litvaitis 2000). Early successional habitat is effectively restored using disturbance-inducing management treatments, including prescribed fire (Russell et al 1999). Maintaining clusters of early successional patches with minimal development is critical to the

far-ranging black racer (Kjoss and Litvaitis 2000). Refer to grassland and shrubland habitat profiles for further conservation strategies.

ELEMENT 5: REFERENCES

5.1 Literature

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- Taylor, J. 1993. The Amphibians and Reptiles of New Hampshire. Nongame and Endangered

Wildlife Program. New Hampshire Fish and Game Department. Concord, New Hampshire, USA.

5.2 Data Sources

New Hampshire Reptile and Amphibian Reporting Program (RAARP) database. Maintained by the New Hampshire Fish and Game Department, Nongame and Endangered Species Program, Concord New Hampshire (Accessed: February 14, 2005)

SPECIES PROFILE

Blanding's Turtle

Emydoidea blandingii

Federal Listing: Not listed
State Listing: Species of Special Concern
Affected Species: N/A
Global Rank: G₄
State Rank: S₃
Author: Michael N. Marchand, NHFG

ELEMENT 1: DISTRIBUTION AND HABITAT

1.1 Habitat Description

Blanding's turtles require large habitats consisting of a diversity of wetland types and hydroperiods, sandy open areas for nesting, and limited human disturbance (Joyal 1996, Jenkins and Babbitt 2003). Aquatic habitats include marshes, ponds, forested and shrub swamps, fens, shallow slow-moving rivers, backwaters, oxbows, and vernal pools (Ernst et al. 1994, Fowle 2001). Additional habitats include buttonbush basin swamps, highbush blueberry-winterberry shrub thickets, and deep emergent marsh-aquatic beds (Sperduto 2004, Jenkins and Babbitt 2003). Slow moving streams and rivers may be important for dispersal and travel between wetlands (Southwell 2002). Adults prefer clean shallow water with a soft organic bottom and abundant aquatic vegetation (Ross and Anderson 1990, Ernst et al. 1994). Duckweed (*Lemna*) is a common floating plant associated with Blanding's turtles (Ross and Lovich 1992).

Habitat use may shift seasonally and vary geographically. In some populations, vernal pools are used extensively in spring and summer (Joyal 1996), and when summer temperatures are high, Blanding's turtles may become relatively inactive. Turtles may estivate in vernal pools, shrub swamps, marshes, and ponds (Joyal 1996, Graham 1999, Fowle 2001).

Female turtles lay eggs in upland habitats, usually between late May and early July. Suitable nest sites

include an open canopy with sand, loam, or gravelly substrate (Graham 1999). Human-altered sites (e.g., pastures, road edges, yards, cornfields, gravel pits, and power line right of ways) may be used (Linck et al. 1989, Joyal 1996, Jenkins and Babbitt 2003). Hatchlings may rest in moss, leaf litter, and grass tussocks prior to migrating from nesting areas to aquatic habitats (Butler and Graham 1995). Juveniles may use marsh edges and shrubby wetlands that provide refugia from predators (Pappas and Brecke 1992).

1.2 Justification

Like most turtles, Blanding's turtles are long-lived (up to 77 years in the wild; Brecke and Moriarty 1989) and are characterized by a late age of sexual maturity (14-20 years for female Blanding's turtles; Congdon and van Loben Sels 1993), relatively low fecundity (average 13 eggs per year, DePari et al. 1987, Congdon et al. 1983), and high rates of adult survival. Small increases in annual adult mortality (as little as 2-3%, Congdon et al. 1993, Gibbs and Shriver 2002), especially among females, can have catastrophic effects on populations. Blanding's turtles require large mosaics of wetland and upland habitats with relatively limited development.

Blanding's turtles occur patchily and at low densities throughout much of their range (Power et al. 1994) and are listed as endangered in Maine, threatened in Massachusetts and New York, and a Species of Special concern in New Hampshire. In New Hampshire, Blanding's turtle habitat overlaps with the highest human population densities. Therefore, turtles are extremely vulnerable to rapid development, especially where road density and traffic volume is high.

Blanding's turtles were listed as a candidate (candidate 2) for federal listing because of concerns over range-wide declines. Following a change in federal policy that eliminated federal candidate species listing,

the Northeast Endangered Species and Wildlife Diversity Technical Committee developed a list of species of regional concern. The Blanding's turtle was included in this list and was identified as a species that warrants federal or threatened species listing considerations as well as prelisting status reviews (Therres 1999).

1.3 Protection and Regulatory Status

See Marsh and Shrub Wetland Profile for regulations regarding wetland impacts.

- NHFG Rule FIS 803.02. Importation. Blanding's turtles shall not be imported to New Hampshire
- NHFG Rule FIS 804.02. Possession. Blanding's turtles shall not be possessed in New Hampshire.
- NHFG Rule FIS 811.01 Sale of Reptiles. No person shall sell Blanding's turtles in New Hampshire

1.4 Population and Habitat Distribution

Populations range from southern Ontario, south through Wisconsin, to Michigan, Minnesota, Ohio, Indiana, Illinois, Iowa, and Nebraska. Peripheral populations exist in Missouri and Pennsylvania and isolated populations of Blanding's turtles occur in Nova Scotia, New York, and New England (Ernst et al. 1994). In New England, Blanding's turtles are restricted to eastern Massachusetts, southeast and south-central New Hampshire, and south-coastal Maine.

In New Hampshire, the majority of known Blanding's turtle locations are in the southeast, where many towns have at least one record (See section 1.5). However, NHFG has received one verified record for the town of Moultonborough (photograph) and another record for Holderness (specimen verified by NHFG staff). A third record in adjacent Sandwich was made by the same observer who documented the Blanding's turtle in Moultonborough. These observations appear to be isolated from southern New Hampshire Blanding's turtle locations by the large lakes of central New Hampshire (i.e., Squam and Winnepesaukee lakes). Although these observations are northerly compared with other New Hampshire records, they are south of reported observations in western Maine (Graham 1999).

Specimens were also observed in Auburn and near Cohas brook, Manchester (Huse 1901), Milford

(Babcock 1919), near Allenstown, and in Derry (Oliver and Bailey 1939). Of these towns, recent records have been received for Auburn, Milford, Allenstown, and Derry. Historic towns with no recent records include Manchester (1900), Nashua (1979), New Durham (1982), and Pembroke (1978).

1.5 Town Distribution Map

1.6 Habitat Map

Blanding's turtle records were buffered by 1 km (Inferred Extent, NatureServe Element Occurrence specifications), and overlapping buffers were merged. These areas were considered occupied. For each occupied area, the following variables were measured: size (ha), area of potentially suitable wetland habitat (ha), conservation land (ha, percent), road density, and amount of development (ha, percent).

1.7 Sources of Information

Distribution information came largely from the New Hampshire Reptile and Amphibian Reporting Program (RAARP). High quality records were submitted to NHNHBB and were incorporated in the New Hampshire Rare Species Database. New Hampshire studies included an assessment conducted by D. Carroll along the Lamprey River and a study focused on the Great Bay and Concord areas (Jenkins and Babbitt 2003).

1.8 Extent and Quality of Data

Location records incorporated into the Rare Species Database included high quality photographs, specimens, and expert observations. Although most towns where Blanding's turtles currently occur probably have been reported, several towns in the center and periphery of the New Hampshire Blanding's turtle distribution have not verified the species presence to date.

1.9 Distribution Research

RAARP volunteers should report observations in towns where historic observations have been recorded (Manchester, Nashua, New Durham, Pembroke), in towns where gaps exist in the known distribution (e.g., Bedford), and in towns at the edge of the spe-

cies' New Hampshire range (e.g., Brookline, Henniker, Warner) where occurrence is likely. The NHB rare species database should be updated with recent reports, including a photo-verified report that was received for Hooksett but has not yet been incorporated into the Rare Species Database.

Where the species is likely to occur, visual and trapping surveys should be conducted. The NHFG should coordinate this effort and should involve other state and federal agencies, universities, non-government organizations, and expert observers.

ELEMENT 2: SPECIES/HABITAT CONDITION

2.1 Scale

Initially, potential Blanding's turtle habitat was mapped throughout the distribution of the species in New Hampshire. However, because of the large area mapped as potential habitat, habitat quality was assessed based on known occupied sites (1 km buffer around locations; see element 1.6).

2.2 Relative Health of Populations

There is little information on the condition of Blanding's turtle populations in New Hampshire. Among 100 records (Element Occurrences) in the Rare Species Database maintained by the NHNHBB (as of 30 March 2005), 14 are considered historic (before 1985). Thirty-three records were of individuals found only on roads, 52 records consisted of only 1 individual, and only 3 records in the database had greater than 10 observations.

2.3 Population Management Status

There is little management of Blanding's turtles in New Hampshire. Possession of Blanding's turtles, including manipulation of individuals for research, requires a permit from the NHFG. Several population studies have been conducted in New Hampshire; D. Carroll conducted a field investigation for rare turtles (i.e., Blanding's, spotted, *Clemmys guttata*, and wood, *Glyptemys insculpta*) in the Great Bay and Lamprey River areas. Recently, an extensive multi-year Blanding's turtle research project was conducted in two areas of New Hampshire: central New Hampshire (Dunbarton, Weare, Hopkinton) and southeastern

New Hampshire (Lee, Durham, Newmarket; Jenkins and Babbitt 2003). The New Boston Air Force Station is currently investigating habitat use and movement of Blanding's turtles on their property (S. Najjar, New Boston Air Force Station, personal communication). Protective screening has been placed over Blanding's turtle nests to prevent predation in some areas, but this effort has not been practiced at a large scale.

2.4 Relative Quality of Habitat Patches

Ninety-one occupied habitat areas were mapped, ranging from 318 to 5,602 ha (mean 852 ha \pm 839 SD). A 1 km buffer around known Blanding's turtle records restricted the possible sizes of occupied areas. The presence and intensity of roads is a major threat and influences the quality of an area for Blanding's turtles. Total road density in these areas averaged 2.4 km/km² \pm 1.4 SD (range 0-8 km/km²; see element 3: Threats). Only 24 occupied areas lacked any state routes and interstates. In these areas, residential development was less than 10%.

2.5 Habitat Patch Protection Status

The percentage of conservation land in Blanding's turtle occupied areas was 16% (range 0-100%); fee ownership was 13% (0-100%), and conservation easement was 3% (range 0-25%). Sixty-nine occupied areas had less than 20% of land protected, 82 areas had less than 50% protected, and only 4 occupied areas had more than 70% protection. The total area protected in occupied areas ranged from 0 to 1,787 ha (mean = 147 ha).

2.6 Habitat Management Status

There is little habitat management in New Hampshire specifically for Blanding's turtles, although the species has been targeted for management on some lands protected by the Great Bay Partnership. Thirty-one wetland impoundments are managed, primarily for waterfowl, by the NHFG, and Blanding's turtles are known to occur in some of these areas. Artificial nesting areas have been created in some areas as part of mitigation during NHFG review of wetland impacts. Nesting areas have also been created on other lands, including some owned by the Army Corps of Engineers, but use of these nesting areas is unknown.

2.7 Sources of Information

Information on the condition of Blanding's turtle populations largely was a result of reports received from the RAARP and several localized research and inventory efforts (Carroll 1999, Jenkins and Babbitt 2003). Geographic Information Systems (GIS) were used to assess quantity and quality of known Blanding's turtle observations by using available data layers (e.g., University of New Hampshire Complex Systems).

2.8 Extent and Quality of Data

Most records consist of 1 or a few observations, many of which were encounters on roads (see element 2.2). Wetland occupation and habitat use at a fine scale (e.g., wetland polygons) is poorly understood for most of the New Hampshire range of Blanding's turtles, though several sites near Concord and Great Bay have been studied in greater detail (Jenkins and Babbitt 2003).

2.9 Condition Assessment Research

- Continue to add and update Blanding's turtle records in the New Hampshire Rare Species Database in accordance with Element Occurrence standards accepted by NHFG and the NHNHBB.
- Coordinate with other states in the New England Blanding's Turtle Working Group (Massachusetts, Maine, New York) to build on existing research. An assessment of each state's Blanding's turtle populations will be included in the Northeast Regional Conservation Plan that will be conducted as part of a Science Support Partner Program grant. A model developed by B. Compton at the University of Massachusetts, Amherst, will be applied to New Hampshire's Blanding's turtle populations as part of this effort. This model (WETCROSS) will help indicate the quality of wetlands based on the likelihood of individual Blanding's turtles crossing roads.
- Identify viable populations and assess demographics. This was the highest ranking research item identified by the New England Blanding's Turtle Working Group (August 2004 survey).
- Assess population viability and habitat use on

conservation land, in especially state parks and wildlife management areas. Short visual (e.g., basking and nesting) and trapping surveys should be used to assess relative condition of populations. Because multiple land uses in protected areas may threaten populations, longer surveys should be conducted at a sample of conservation lands (e.g., Bear Brook State Park, Pawtuckaway State Park, Hopkinton-Everett Flood Control Area, New Boston Air Force Station) to assess effects of land use.

- Assess isolation of populations in New England via genetics studies.

ELEMENT 3: SPECIES AND HABITAT THREAT ASSESSMENT

3.1.1 Development (Fragmentation, Habitat Loss and Conversion)

(A) Exposure Pathway

Blanding's turtles use a mosaic of wetland, aquatic, and upland habitats, often traveling a kilometer or greater among them. Thus, a large amount of land is required to protect a population. Reduction in habitat quality or availability may harm populations by causing direct mortality of individuals (construction and forestry equipment, drawdown while turtles hibernating) or indirect mortality due to increased dispersal across inhospitable habitat, increased predation, and increased desiccation.

Female turtles require bare ground and open canopies to lay eggs, and from late May to early July, they leave wetlands in search of suitable nesting habitat. If nesting habitat is not connected to occupied wetland habitat, adult mortality may occur. Humans and their pets may also disturb nesting females and their eggs, and although turtle populations are less sensitive to egg survival than to adult survival, high nest mortality or lack of nesting habitat may harm populations. Also, succession can reduce the quality of nesting areas and may result in reduced recruitment to local populations.

Blanding's turtles may use human-modified areas such as gravel pits, residential lawns, and agricultural areas, for nesting. Thus, adults in these areas are vulnerable to predation, road mortality, disturbance, and mowing equipment (Marchand and Litvaitis 2004a).

Nests near some ecological edges may also be more vulnerable to predation (Temple 1987).

(B) Evidence

An estimated 21,000 ha (51,000 acres) were required to maintain viable populations of Blanding's turtles in Maine (McCullough 1999). Although smaller areas may protect species where populations are denser (Fowle 2001), large blocks of connected habitat are needed to protect Blanding's turtles.

Because Blanding's turtles may use vernal pools and uplands, protection only of large wetlands is not adequate to protect Blanding's turtles (Southwell 2002). Southern New Hampshire is rapidly developing and lands are becoming more fragmented (SPNHF 2005). New Hampshire state regulations are currently ineffective at protecting species that use large wetland complexes, and building and disturbance setbacks from freshwater wetlands are not required under New Hampshire state wetland regulations (except for septic setbacks). Where they occur at the local level, they are not sufficient to protect wide ranging species such as Blanding's turtles without a larger scale planning effort.

As southern New Hampshire develops, wetlands will be threatened by myriad stressors (see Marsh and Shrub Wetland Profile). Although extensive marshes are not likely to be filled, small vernal pools can easily be overlooked during environmental reviews of dredge and fill permit applications (M.N. Marchand, personal observation). Likewise, landowners may remove beaver dams to protect their property with no approval or review process. Wetland drawdowns, especially those conducted in fall, may expose Blanding's turtles to predation, winterkill, and road mortality (Hall and Cuthbert 2000), especially where dispersing individuals are surrounded by dense development (Marchand and Litvaitis 2004a). The effect of managed wetland and lake drawdowns and other water manipulations on Blanding's turtles has not been evaluated in New Hampshire.

3.1.2 Transportation Infrastructure (Mortality, Fragmentation, Dispersal Barriers)

(A) Exposure Pathway

Human population density and development is rapidly increasing in southern New Hampshire (SPNHF 2005). Attendant increases in road densities and traf-

fic volume pose direct threats to turtles, which are slow to cross wide roads. Small annual losses of only a few adult Blanding's turtles may result in population extirpation.

(B) Evidence

Blanding's turtles are capable of dispersing long distances through upland habitats (Joyal et al. 2001, Jenkins and Babbitt 2003), and roads that intersect turtle home ranges or migratory pathways will increase the chance of individuals being killed on roads. Thirty-three of 100 Blanding's turtle records (Element Occurrences) known from New Hampshire consisted entirely of individuals observed on roads. Additionally, low population densities and skewed age and sex ratios have raised concerns over the effect of road mortality on some turtle populations in the region (e.g., Joyal et al. 2000, Marchand and Litvaitis 2004a, Gibbs and Steen 2005). Computer modeling suggests that road densities as low as 1 km/ km² with fewer than 100 vehicles per lane per day will cause excessive loss of semiterrestrial turtles (e.g., Emydoidea, Gibbs and Shriver 2002). Only 10 of 91 known occupied Blanding's turtle areas in New Hampshire had road densities less than 1 km/km². Although density may be a good initial surrogate for investigating habitat quality, factors such as road width, traffic speed and volume, and position in the landscape should also be considered. Road shoulders, because of the availability of bare soil and open canopies, may attract nesting turtles, increasing the opportunity for road crossings of adult and hatchling turtles. Also, steep-sloping granite curbing can trap turtles on roadways and can decrease the chance of individuals successfully crossing roadways (Najjar, New Boston Air Force Base, personal communication).

3.1.3 Unregulated Take

(A) Exposure Pathway

Individual turtles are removed from local populations, and because populations depend on high adult survival, removal can lead to local extinction.

(B) Evidence

Large-scale commercial collection of Blanding's turtles appears to be low and NHFG has no evidence of commercial collection of Blanding's turtles in New Hampshire. However, reptile dealers have advertised Blanding's turtles in New Hampshire in the past

(Levell 2000). The loss of adult turtles from natural populations can have devastating effects for all species of turtles. Therefore, commercial collection in New Hampshire is worth further investigation and enforcement. Casual collection and relocation of individual Blanding's turtles is probably more common. People may move turtles to distant wetlands, ponds, or lakes, and may occasionally adopt Blanding's turtles as pets.

3.1.6 Predation and Herbivory (Subsidized or Introduced Predators)

(A) Exposure Pathway

Young turtles and eggs are vulnerable to predators, and the risk of predation increases when subsidized predators such as raccoons are supported by human development.

(B) Evidence

High predation rates at turtle nests may affect long-term recruitment (Marchand and Litvaitis 2004b). In southern New Hampshire, raccoons are the most common predator of turtle nests (Marchand et al. 2002), and elsewhere predation rates have reached 93% (Congdon et al. 1983) and 94% (Butler and Graham 1995).

Short-tailed shrews (*Blarina brevicauda*, Standing et al. 2000) and eastern chipmunks (*Tamias striatus*) (Grgurovic 2003) may also prey on neonate Blanding's turtles, and although protected by their size and hinged plastron, adult Blanding's turtles are occasionally injured or killed by predators (Standing et al. 1999, Congdon et al. 2000). In Missouri, 31% of Blanding's turtles collected had injuries or missing body parts (Kofron and Schreiber 1985).

3.2 Sources of Information

Information on threats came from literature reviews, summary reports, expert reviews, New England Blanding's Turtle Working Group meetings and questionnaire, and available GIS data layers from various sources.

3.3 Extent and Quality of Data

Some threats have been studied more in Massachusetts and southern Maine, and these data are relevant

to New Hampshire. Although life span, age of maturity, and fecundity may vary, Blanding's turtles consistently mature late and depend on high adult survivorship. Road mortality and loss of contiguous habitat are known threats, and, though less understood, disease, invasive plants, genetic isolation, and effects of agriculture and forestry activities in New Hampshire are potential threats.

3.4 Threat Assessment Research

- The efficacy of Blanding's turtle management (e.g., water level management and agriculture), should be evaluated
- Populations that are isolated by anthropogenic barriers (e.g., high-traffic roads) should be identified, and options for increasing safe passage of traveling turtles should be considered
- Blanding's turtle populations should be monitored (e.g., with radio telemetry) in areas where underpass systems have been installed or are proposed

ELEMENT 4: CONSERVATION ACTIONS

- Protect large blocks of unfragmented habitat with a diversity of wetland complexes (see Habitat Protection Strategies).
- Work with towns to protect critical habitat through land acquisition, prime wetland designation, and wetland buffer regulations (see Habitat Protection Strategies).
- Maintain beaver flowages and their function in the landscape (see Marsh and Shrub Wetland Profile).
- Design and place roads and other transportation networks (e.g., railways, bike trails, sidewalks) to reduce threats to Blanding's turtles and other rare wildlife (see Roads strategies).
- Educate public about rules and regulations pertaining to Blanding's turtles and other reptiles and amphibians (e.g., sale and possession) through updated and improved NHFG website and other media (see Wildlife Collection strategies).
- Reduce anthropogenic food sources for predators (see Predator control strategies).

4.1.1 Identify Blanding's turtle habitat that will be crucial for protection through acquisition, easement, development restrictions, and mitigation (see Habitat Protection)

(A) Direct Threats Affected

All threats caused loss of extensive, interspersed, interconnected, and diverse wetland complexes

(B) Justification:

- Protecting and managing habitat for Blanding's turtle will reduce the opportunity for future development (especially road construction).
- Blanding's turtles depend on high annual adult survival rates. Removing threats that increase adult mortality is critical to long-term viability.
- Known Blanding's turtle habitat has been mapped, and future documentation will be incorporated into protection strategies. Priority habitats can be identified by GIS.
- Blanding's turtle require large blocks of relatively undeveloped land. These areas are rapidly disappearing, particularly in southern New Hampshire, and land protection for this species needs to start immediately.
- As new Blanding's turtle populations are documented, locations can easily be incorporated into land protection policy.

(C) Conservation Performance Objective

Protect and manage large blocks of habitat in southern New Hampshire to protect Blanding's turtles.

(D) Performance Monitoring

The area of land protected, and the type of protection afforded, can easily be summarized for a given year by ensuring that the conservation lands database is continually updated. Based on protection successes and failures, protection priorities can be adjusted. Statewide land protection efforts can be summarized into known, potential, and unlikely Blanding's turtle habitats.

(E) Ecological Response Objective

Protection of large unfragmented blocks of land

with wetland and upland habitat will maintain adult survival rates and thus contribute to the health of Blanding's turtle in New Hampshire.

(F) Response Monitoring

Long-term monitoring is needed at a sample of priority sites to ensure that protection is effective and worthwhile. A combination of mark-recapture, radio telemetry, and basking and nest site surveys should be conducted to monitor long-term trends in population. Viable populations would be indicated by the density and structure of Blanding's turtle populations, threats to annual adult survival, and the area of land protected.

(G) Implementation

Known occupied Blanding's turtle habitat has been mapped by NHFG. New reports will be updated as verified records become available. Occupied Blanding's turtle habitats will be used to prioritize unfragmented blocks identified by the Comprehensive Wildlife Strategy process. Specific land protection might include the following:

- Work with the Great Bay Partnership to protect important Blanding's turtle habitat in the Coastal Watershed
- Add protection to and linkage between areas adjacent to large protected areas in south-central New Hampshire (especially Bear Brook, Pawtuckaway, and North Meadows State Parks)
- Identify and protect other large areas that are likely to support Blanding's turtles, including those in south-central New Hampshire
- Protect wetlands and uplands adjacent to slow rivers in southern New Hampshire (e.g., Lamprey River)
- Protect corridors between viable populations in New Hampshire, Massachusetts and Maine

When land is purchased with conservation of mitigation funds, or when existing habitat is enhanced or restored, protecting Blanding's turtles should be a priority. Other uses should be considered only when they do not jeopardize the long-term viability of Blanding's turtle populations. Therefore, ownership and management authority must be considered when acquiring pieces of conservation land.

(H) Feasibility

Protection of large blocks of habitat with diverse wetland complexes is compatible with other large-scale land protection priorities. Land values in southern New Hampshire are high and rising, so protection must be prioritized. Long-term monitoring is labor intensive, and so can only be initiated at a few priority sites.

4.1.2 Evaluate Blanding's turtle protection status and develop guidelines for regulatory review of threats to known or potential habitat, Regulation and Policy

(A) List of Direct Threats Affected

All habitat-based threats affected

(B) Justification

- The Blanding's turtle is currently listed as a Species of Special Concern, and this designation provides less protection than the New Hampshire Endangered Species Conservation Act (RSA 212-A).
- Restricting activities that harm Blanding's turtles will minimize mortality
- Because turtle habitat is under heavy pressure from development, protection is urgent
- New information on known and new populations will be incorporated into the review process.

(C) Conservation Performance Objective

Minimize threats to the Blanding's turtle through regulatory processes (residential, commercial, transportation and trail networks, and habitat management).

(D) Performance Monitoring

Guidelines will be developed so that NHFG project reviewers can provide a consistent and adequate response, and project reviewers will be able to indicate whether regulations are having a positive effect on Blanding's turtle habitat.

(E) Ecological Response Objective

To reduce the destruction of Blanding's turtle habitat in southern New Hampshire and maintain viable, connected populations.

(F) Response Monitoring

Long-term monitoring will be conducted at a few

priority Blanding's turtle sites. Shorter sampling efforts (basking and nesting surveys) can be applied to a larger number of known or potential Blanding's turtle sites. If threats from development are possible and can't be avoided through the regulatory review, qualified individuals hired by developers should monitor local turtle populations.

(G) Implementation

The Blanding's turtle is currently listed as a special concern species in New Hampshire. This designation carries limited regulatory protection and the species may warrant additional protection under the New Hampshire Endangered Species Conservation Act (RSA 212-A). Therefore, Blanding's turtles should be considered for listing at the next revision. Meanwhile, NHFG has authority over wildlife and can review wetland dredge and fill applications submitted to the NHDES. NHFG biologists should develop standard guidelines so project reviewers at NHFG and DES have a consistent regulatory review and so that permit applicants can expect a consistent review. Although guidelines should provide consistency, further requirements may be required depending on the scope of the project and the viability of the local Blanding's turtle population.

(H) Feasibility

Sufficient information is available to consider Blanding's turtle for state protection under RSA 212-A. Standard guidelines could be developed based on other states' successes and failures and on recommendations from the New England Blanding's Turtle Working Group. Unfortunately, NHFG reviews projects through other state agency permitting processes (especially NHDES) and does not currently have a conservation permit process of its own. Thus, implementing strong regulations is likely to be challenging. Therefore, priority sites should receive the greatest regulatory review.

4.1.3 Coordinate a regional Blanding's turtle working group

In February 2004 the "Northeast Blanding's Turtle Working Group" was initiated with the goal of sharing resources and identifying regional priorities for conserving Blanding's turtles. In October 2004, the USFWS funded a grant proposal to produce a

regional status report and a conservation plan for Blanding's turtles in the Northeast, to assess road mortality and population viability through modeling, and to conduct population viability analyses for the entire Northeast region. Information gathered from this study will help determine if the Northeast Blanding's turtle population warrants federal endangered species listing as a Distinct Population Segment. In addition, results of this study will help focus future funding, identify common priorities, guide conservation groups to protect viable populations of turtles, and guide the development of future transportation projects (Science Support Partnership Program Study Plan 2004).

4.2 Conservation Action Research:

Work with the New England Blanding's Turtle Working Group to update and prioritize areas for protection based on models and results of ongoing Blanding's turtle research.

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ELEMENT 6: LIST OF FIGURES

Figure 1. Town distribution map of known Blanding's turtle locations in New Hampshire, March 2005. Town records reported included a photograph, specimen, or were reported by an expert observer. Most reports were received through the New Hampshire Reptile and Amphibian Reporting Program (RAARP).

SPECIES PROFILE

Eastern Box Turtle

Terrapene carolina carolina

Federal Listing: Not listed

State Listing: Not listed

Global Rank: G5

State Rank: SNA (Not Applicable)

Author: Michael N. Marchand, NHFG

ELEMENT 1: DISTRIBUTION AND HABITAT

1.1 Habitat Description

Eastern box turtles are terrestrial generalists that use a variety of habitats including mesic forests, xeric uplands, open woodlands, pastures, old fields, thickets, and powerline clearings (Klemens 1993, Ernst et al. 1994, DeGraaf and Yamasaki 2001, Mitchell 2003). Although considered a terrestrial turtle, box turtles may make extensive use of a variety of wetlands, shallow streams, or muddy seepages (Klemens 1993, Quinlan et al. 2004, Marchand et al. 2004) as relief from high temperatures, concealment from predators (Dodd 2001), and for additional foraging opportunities (Marchand et al. 2004). A diversity of habitats in close proximity is apparently favored (Madden 1975, Klemens 1993), and box turtles may adjust habitat preference depending on season and temperature (Madden 1975, Dodd 2001, Marchand 2004).

During periods of inactivity, box turtles may bury in litter or rest in brush piles or briar patches (Stickel 1950). Openings in the forest canopy are important for basking individuals (Stickel 1950), and well-drained open canopy areas are required for nesting (Ernst et al. 1994). As temperatures drop in the fall, box turtles dig progressively deeper into soil where they spend the winter. Portions of the carapace are sometimes visible even in northern climates (Dodd 2001).

1.2 Justification

The eastern box turtle is a species of concern in the northeast (Therres 1999). States reporting declines of box turtles include Connecticut, Florida, Illinois, Indiana, Iowa, Maryland, Massachusetts, Missouri, New Jersey, New York, Ohio, Oklahoma, Tennessee, Virginia, West Virginia, and Wisconsin (Stickel 1978, Williams and Parker 1987, Lieberman 1994). Massachusetts and Connecticut consider the eastern box turtle a species of special concern, and in Maine eastern box turtles are listed as endangered (Hunter et al. 1999).

Box turtles are a long-lived species with delayed ages of sexual maturity, relatively low fecundity, and dependence on high adult survival. Therefore, they may be extremely vulnerable to increased mortality associated with rapid development in New England. The current and historic status of box turtles in New Hampshire is not known and needs further consideration.

1.3 Protection and Regulatory Status

- NHFG Rule FIS 803.02. Eastern box turtles shall not be imported to New Hampshire.
- NHFG Rule FIS 804.02. Eastern box turtles shall not be possessed in New Hampshire.
- NHFG Rule FIS 811.01. No person shall sell eastern box turtles in New Hampshire.
- Fill and Dredge in Wetlands; NHDES (RSA 482-A, Wt 302.04): For all affected major (more than 20,000 sq ft) and minor (3,000 to 20,000 sq ft) wetland, applicants must consider threats to rare species. Because box turtles often are associated with terrestrial habitats, protection of box turtles from this regulation is likely limited.

1.4 Population and Habitat Distribution

In New England the box turtle's range includes southeastern Maine, southeastern New Hampshire, eastern Massachusetts including Cape Cod and the islands, the Connecticut River region, and much of Rhode Island and Connecticut (Klemens 1993, DeGraaf and Yamasaki 2001). Box turtles do not occur in Vermont (Hunter et al. 1999). In Maine, box turtles have been reported in at least 13 towns (Hunter et al. 1999). However, reports distant from south-coastal Maine were likely released pets. Records in Maine consist largely of single individuals and do not attest to a population (P. deMaynadier, Maine Department of Inland Fisheries and Wildlife, personal communication).

In New Hampshire, the distribution and abundance of box turtles is not well known. A specimen was collected in Pelham, Rockingham County historically (Huse 1901) and submitted to the Manchester Institute of Arts and Sciences, but has apparently since been lost (Natural Heritage Rare Species Database 2004). Specimens from Lee were also reported (Huse 1901), suggesting that box turtles occurred in southern New Hampshire historically. Recently, remains of a box turtle were found at a pre-colonial excavation site from Lake Massabesic, New Hampshire (Largy 2003). This report may suggest that a native population of box turtles existed in New Hampshire historically.

Use and trade of box turtles by Native Americans has complicated our understanding of the historic distribution of the species (Adler 1968). Box turtles were occasionally consumed (Dodd 2001), were commonly used as ceremonial objects (Klemens 1993, Dodd 2001), and were transported, often north of the species' current range (Bleakney 1958, Adler 1968). Therefore, it is possible that box turtles were traded to New Hampshire from other locations where box turtles are currently more abundant (e.g., southern New England). Box turtle shells recovered in Ontario, north of the current range, have been considered not native (Bleakney 1958). However, Adler (1970) reported that Native Americans (primarily Iroquois) may have been responsible for the elimination of box turtles in western New York and possibly in southern Ontario.

The NHFG Nongame and Endangered Species Program has received reports of box turtles from 12

towns between 1992 and 2004 (RAARP). Most of these reports have not been verified, and 1 of these town observations (Merrimack) was later confirmed as an Ornate box turtle (*Terrapene ornata*). A report from Amherst was confirmed to be of released individuals. Reports of box turtles from central and northern New Hampshire (Wentworth Location, Eaton, Moultonborough) were most likely the result of released pets. Box turtles were extremely popular in the pet industry (Ernst et al. 1994, Lieberman 1994), and in New Hampshire, it was not illegal to possess Eastern box turtles until 1996.

In 1985, a box turtle was reported from Hudson, adjacent to the historic record in Pelham. During a survey for NHNHBB, a recently deceased box turtle was discovered. Habitat surrounding the turtle was described as a dry oak forest with a power line right-of-way and a graminoid marsh (Korpi 1985). A follow-up survey has not been done. Taylor (1993) illustrates 2 additional locations in southeastern New Hampshire on the edge of Rockingham and Strafford Counties, and Dodd (2001) depicts 2 locations on the southern border of Maine and New Hampshire.

All known reports of box turtles in New Hampshire were of 1 individual, and there is no known evidence of breeding. Based on these reports and the distribution of eastern box turtles in Massachusetts and Maine, any box turtle populations that may occur in New Hampshire are likely to occur in the south central to southeastern portion of the State.

1.5 Town Distribution Map

No known populations.

1.6 Habitat Map

N/A

1.7 Sources of Information

Sources of information include the RAARP database, NHNHBB Rare Species database, Massachusetts Natural Heritage Element Occurrence Information, and Maine Reptile and Amphibian Atlas (Hunter et al. 1999).

1.8 Extent and Quality of Data

The historic and current distribution of box turtles in

New Hampshire is not well known. Many observations made by RAARP volunteers have not included photographs and cannot be verified.

1.9 Distribution Research

NHFG will continue to evaluate reports received from the RAARP and will alert volunteers to changes in species status. Sightings should be followed by on-site surveys, which should describe habitat condition and perhaps historic suitability. When warranted, dogs may be used to locate turtles (Schwartz and Schwartz 1991). Because individual box turtles can be difficult to locate, searching potential habitat without a lead would likely not be effective.

NHFG should search archaeological excavation reports, communicate with groups conducting archaeological excavations, and compile verified historic occurrences of eastern box turtles. Reports describing archaeological excavations must be submitted to the New Hampshire Division of Historical Resources in compliance with federal regulations (Section 106, 1966 National Historic Preservation Act).

ELEMENT 3: SPECIES AND HABITAT THREAT ASSESSMENT

Threats to eastern box turtles have been assessed in other areas of the Northeast. The most significant threats include habitat loss and fragmentation, roads as barriers and agents of mortality, and commercial and casual collection. In New Hampshire, cold winters might have limited the species potential and historic distribution. Currently, the greatest threat to eastern box turtles in New Hampshire is a lack of knowledge regarding the species' presence. The popularity of eastern box turtles as pets and the resulting release of those pets to the wild have increased the difficulty of assessing the historic and current range of the species in New Hampshire.

ELEMENT 5: REFERENCES

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SPECIES PROFILE

Fowler's Toad

Bufo fowleri formerly *Bufo woodhousii fowleri*

Federal Listing: Not listed

State Listing: Special concern

Global Rank: G5T

State Rank: S3

Author: Kimberly, J. Babbitt, University of New Hampshire

ELEMENT 1: DISTRIBUTION AND HABITAT

1.1 Habitat Description

Fowler's toad occurs mainly in habitats with loose, well-drained sandy or gravelly soils including riverbanks, lake margins, beach and coastal dune systems, and sandy or scrubby woodlands (Wright and Wright 1949, Smith 1961, Minton 1972, Green 1989, Breden 1987, Klemens 1993). Fowler's toads can be found along roadsides, near homes and gardens, and in fields and pastures (Wright and Wright 1949). Breeding habitat is generally the shallow margins of permanent water bodies, including lakes, farm ponds, rivers, and slow-moving streams (Wright and Wright 1949, Smith 1961, Breden 1988, Klemens 1993). Fowler's toads are facultative users of vernal pools (Wright and Wright 1949, Green 1989). Where the species co-occurs with the American toad (*Bufo americanus*), the Fowler's toad is often found in dryer areas than the American (Klemens 1993).

1.2 Justification

New Hampshire constitutes the northeastern limit of the range of the Fowler's toad. Little information on the Fowler's toad exists in New Hampshire and it is possible that the species occurs in low numbers. However, both historical and current written descriptions of the species distribution and numbers suggest that the species is abundant in some parts of New

England. Thus, the lack of evidence of a robust population in southern New Hampshire may be cause for concern. Lack of information on this species in the state is the most serious threat, as it currently cannot be assessed whether the species is locally abundant but not widespread, or is rare. This information is crucial for informing habitat protection and species management guidelines.

1.3 Protection and Regulatory Status

There is no special protection for Fowler's toad. See Marsh and Shrub Wetlands habitat profile and Vernal Pool habitat profile for protection and regulatory status of breeding habitats.

1.4 Population and Habitat Distribution

The Fowler's toad range is southern New England westward through southeast New York, New Jersey and northern parts of Pennsylvania, the Midwest (parts of Michigan, Illinois and Ohio), and southern Ontario, Canada. Throughout its range in New England and New York, the species has an irregular or spotty distribution, although it is often described as being "widespread". The species occurs throughout the south, with the exception of coastal plain areas of Georgia and South Carolina and peninsular Florida. Fowler's toads are limited to the southern portion of the states of Vermont and New Hampshire and may reach the Atlantic Coast almost into Maine (Stewart and Rossi 1981, Krauss and Schuett 1982, Shaffer 1991, Harding 1997, Klemens 1993). It is the only native *Bufo* on Long Island, New York. Limited records exist for the species in New Hampshire.

The distribution pattern of this species in the state is poorly documented. However, it is likely that the species occurred irregularly or patchily in areas with appropriate habitat upland and breeding

habitat. There are a limited number of Fowler's toad records in the state (see Town Distribution Map). The documented historic sitings (more than 20 years old) are from the towns of Boscawen, Canterbury, Amherst, Hanover, and Milford (Oliver and Bailey 1939). Observations considered verified within the last 20 years are from the towns of Grafton, Concord, and Pembroke. Overall, available data suggest that either the species suffers from poor monitoring and documentation or that it is rare and therefore constitutes a very small proportion of the regional Fowler's toad population.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

1.7 Sources of Information

Information was obtained from an extensive literature search and from Michael Marchand, Wetlands Biologist, Nongame and Endangered Wildlife Program, NHFG.

1.8 Extent and Quality of Data

The collective published works on Fowler's toad provide little insight into the species in New Hampshire. There have been no systematic surveys for Fowler's toads in the state. The quality of the existing data on Fowler's toad distribution in the state is extremely poor.

1.9 Distribution Research

As there have been no systematic surveys conducted in the state, the first priority is to conduct such a survey to document the location of breeding populations. There is no evidence that the species occurred historically in the northern portion of the state; thus, monitoring and survey efforts should focus on southern New Hampshire. Given that the species may not be widespread, it is important to determine sizes of any existing populations and to assess the threat (from development, pollution, or isolation) of continued persistence of the remaining populations. Although Fowler's toads breed in the shallow areas of permanent aquatic sites, they are facultative vernal pool breeders. Thus, it would also be important to

assess the location and type of breeding sites available in areas in which the species is documented. Because the species breeds later in the season than many other vernal pool breeding species, identification of appropriate vernal pool sites (e.g., long-hydroperiod vernal pools) is important.

ELEMENT 2: SPECIES/HABITAT CONDITION

2.1 Scale

2.2 Relative Health of Populations

There are not sufficient data available from which to make conclusions about population health or trends for this species.

2.3 Population Management Status

There are no population monitoring efforts for this species. The North American Amphibian Monitoring Program (NAAMP) is conducted annually in New Hampshire; however, no Fowler's toads have been reported.

2.4 Relative Quality of Habitat Patches

There are not sufficient data available to assess the quality of habitat patches for the Fowler's toads.

2.5 Habitat Patch Protection Status

There are insufficient data with which to assess protection status.

2.6 Habitat Management Status

There are no habitat management efforts being made for Fowler's toads. Because the distribution and abundance of the species is unknown, management efforts that might indirectly benefit this species cannot be assessed at this time.

2.7 Sources of Information

There are no sources of information beyond the RAARP and Natural Heritage databases.

2.8 Extent and Quality of Data

Although the literature can provide a general description of habitat associations for this species, distribution and population numbers are lacking for this species in New Hampshire. Because American toads are commonly misidentified as Fowler's toads, few records have been confirmed in New Hampshire (M. Marchand, NHFG, personal communication).

2.9 Condition Assessment Research

Basic distribution data for this species must be acquired. Understanding the location, size, and dispersal of existing populations will help protect the species. Areas for intensive, systematic surveys can be determined by an initial delineation of its potential habitat. Using remote sensing (e.g., aerial photography) and fieldwork, a GIS habitat layer could be created. Potential habitat could be determined by appropriate soil data layers with potential breeding site habitat. A list/formula should be developed that facilitates assessment of Fowler's toad population and habitat health. This list/formula could consider the following:

- Stability of the sub-population and/or metapopulation(s)
- Potential for genetic exchange between local populations
- Incidence of physical malformations or disease
- Water quality at breeding sites
- Proximity of the habitat patch to other potential habitat patches
- Proximity of the habitat to roads, development, and other disturbances
- Size and configuration of upland habitat

ELEMENT 3: SPECIES AND HABITAT THREAT ASSESSMENT

3.1.1 Development (Habitat Loss and Conversion)

(A) Exposure Pathway

Fowler's toads require sandy upland habitat near appropriate breeding sites. Many of these sites are along large river systems and lakes where development pres-

sure is high, thus Fowler's toads may suffer loss of habitat and fragmentation. Development could result in local extirpation if adjacent areas are unsuitable habitat and distances between suitable habitats are beyond dispersal capabilities of Fowler's toads.

(B) Evidence

Because we lack information on Fowler's toad distribution, there is no direct evidence that this threat is occurring. However, the most likely areas in which Fowler's toads may occur are in the southern part of the state and along riverine areas such as the Connecticut and Merrimack Rivers. Given current population growth and development trends (Sundquist and Stevens 1999), and the planned expansion of I-93, it is likely that there will be increasing development pressures in areas where Fowler's toads may occur.

3.1.2 Transportation Infrastructure (Mortality, Fragmentation, Dispersal Barriers)

(A) Exposure Pathway

Direct mortality of toads caused by vehicle traffic can be significant and may be particularly problematic for small populations. Roads fragment toad habitat and may act as partial barriers to migration. Thus, roads may decrease toad dispersal, resulting in decreased exchange of individuals among populations and consequently reduce colonization/recolonization and gene flow among local populations.

(B) Evidence

Although specific studies of road impacts on Fowler's toads are not available, there is substantial evidence in the literature that roads are a significant source of direct mortality for migrating amphibians (Fahrig et al. 1995, Ashley and Robinson 1996, Mazerolle 2004). Given current population growth and development trends (Sundquist and Stevens 1999), and the planned expansion of I-93, it is likely that there will be increasing developmental pressures in areas where Fowler's toads may occur.

3.2 Sources of Information

Because distribution and population size information on this species is not known, the threats to this species are hypothetical and are drawn largely from the general literature and knowledge rather than specific

evidence for this species in New Hampshire.

3.3 Extent and Quality of Data

No relevant data exist for this species in the state, and relatively poor data exist for this species in general.

3.4. Threat Assessment Research

A survey is needed to document the occurrence and abundance of the species, as well as to determine the number of remaining populations, the size of those populations and the degree of connectivity (i.e., likelihood of exchange among populations).

ELEMENT 4: CONSERVATION ACTIONS

4.1.1 Identify locations of Fowler's toad populations and protect their habitat; Habitat Protection

(A) Development (Habitat Loss and Conversion), Transportation Infrastructure (Mortality, Fragmentation, Dispersal Barriers)

(B) Justification

Given limited resources for habitat acquisition and protection, adequate data on population locations and status should be obtained so that the most appropriate parcels can be targeted for protection or management.

(C) Conservation Performance Objective

The initial performance objective is to survey all potential Fowler's toad habitats. If populations were found, the performance objective would be to protect the most significant (as measured through populations size, size or quality of the habitat patch, and other metrics) habitat parcels. Maintenance of extant Fowler's toad populations on those parcels would be the final performance objective.

(D) Performance Monitoring

Appropriate performance monitoring would be the number of parcels protected and the retention of extant Fowler's toad populations that are stable or increasing (however, see below).

4.2 Conservation Action Research

Existing knowledge of New Hampshire's Fowler's toad populations is poor and this precludes any attempt to assess the likely outcome of conservation actions. A systematic survey of potential Fowler's toad populations must be undertaken. This survey could most easily be accomplished during the breeding season through a combination of breeding call surveys (this species has a *very* distinctive call), egg mass counts, and larval surveys. Potential survey sites can be determined using GIS (see section 2.9). Once existence and location of populations have been established, the next step would be to determine the size of each population via a mark and recapture study. If potentially viable populations are identified, research should focus on the dispersal capabilities of the species, the degree to which populations are connected, and the areal extent of upland habitat that should be protected to ensure that habitat loss and fragmentation are minimized.

ELEMENT 5: REFERENCES

5.1 Literature

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SPECIES PROFILE

Hognose Snake

Heterodon platirhinos

Federal Listing: None

State Listing: Threatened

Global Rank: G5

State Rank: S3

Author: James Taylor, University of New Hampshire; Michael Marchand, NHFG

ELEMENT 1: DISTRIBUTION AND HABITAT

1.1 Habitat Description

Eastern hognose snakes are found in open woodland, grasslands, and fields with sandy soil derived from glacial outwash (Michener and Lazell 1989). Natural vegetation commonly occurring in these New Hampshire sandy soils include white pine (*Pinus strobus*), pitch pine (*Pinus rigida*), scrub oak (*Quercus ilicifolia*), and a mixture of hardwoods (Michener and Lazell 1989). Hognose snakes feed largely on amphibians, especially toads (*Bufo* spp.); however, other prey may be taken (Edgren 1955, Platt 1969). Therefore, wetlands that are suitable for amphibian breeding may be an important habitat component, but prey preference could potentially vary regionally or locally depending on prey availability. Eggs are laid in sandy soils, usually during June-July, and young snakes emerge from nests in August-September (Ernst and Ernst 2003). Hibernation occurs individually in mammal burrows, loose soil, or down logs (Plummer 2002, Ernst and Ernst 2003).

1.2 Justification

The eastern hognose snake was listed as Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as of January 1, 2001 and is considered a species of regional concern in the northeastern United States (Therres 1999). In New

England, the eastern hognose snake is listed as S2 in Rhode Island, S3S4 in Connecticut, and S4 in Massachusetts; it doesn't occur in Vermont or Maine.

New Hampshire's peripheral population of hognose snakes is state threatened (RSA 212-A, FIS 1000). Hognose snakes in New Hampshire probably have large home ranges (Plummer and Mills 2000, S. Najar, New Boston Air Force Base, personal communication) and are restricted to the Merrimack River corridor south of Concord, an area where development and human population increases are intense and remaining blocks of suitable habitat are becoming smaller and isolated (SPNHF 2005). In addition, the sandy, well-drained soils preferred by hognose snakes are easily converted to residential and commercial developments and are targeted for commercial sand extraction operations.

1.3 Protection and Regulatory Status

Listed as state threatened under RSA 212-A.

1.4 Population and Habitat Distribution

The eastern hognose snake is found from southern New England and Ontario south along Atlantic coast to Florida and west to Texas, Kansas, Nebraska, and South Dakota (Ernst and Ernst 2003). New Hampshire represents the northern limit of the species range on the east coast, where they are restricted to the sandy plain of the Merrimack River, extending from Concord on the north to the Massachusetts state line, as far east as Londonderry, and as far west as New Boston. In addition, 3 expert biologists have reported finding eastern hognose snakes historically in the Durham/Lee area of southeastern New Hampshire (Phillip Sawyer, formerly Professor of Zoology, University of New Hampshire; David Allen, formerly a biologist with the USDA Soil Conservation Service,

now known as the Natural Resource Conservation Service; John Litvaitis, Professor of Wildlife Ecology, University of New Hampshire. Sandy soils generated by glacial outwash, the critical habitat feature for hognose snakes, are common in the Durham/Lee area.

1.5 Town Distribution Map

1.6 Habitat Maps

The University of New Hampshire completed a potential habitat map for eastern hognose snakes within its New Hampshire range. These maps were primarily based on available GIS data layers including land-cover, soils, elevation, and distance to a known hognose snake occurrence. An accuracy assessment has not been conducted on this model but maps should help prioritize areas to target for further surveys. One limitation of this mapping procedure is that soils data was not available for Merrimack and Belknap counties. Maps will need to be updated as new data layers (especially soils) become available.

1.7 Source of information

The major source of distribution information for New Hampshire was from the Reptile and Amphibian Reporting Program (RAARP) coordinated by the Nongame and Endangered Wildlife Program at NHFG, the rare species database maintained by the NHNH, and literature reviews and professional knowledge of the authors. State and global heritage ranks were taken from NatureServe 2005. Habitat maps were completed by UNH, Complex Systems Research Center.

1.8 Extent and Quality of the Data

The extent of the eastern hognose snakes' current range in the state, given the clustering of records near the Merrimack River south of Concord, is fairly well known. Verified records in Manchester, Londonderry, Hollis, and Nashua are greater than 20 years old. More recently, unverified reports have been received for Londonderry and it is likely that a population still exists. Recent reports in Hudson are unverified but likely.

1.9 Distribution Research

Verify habitat suitability model by field surveying those sites likely to be most suitable for eastern hognose snakes (Fitzgerald 1994). Extensive time can be spent searching for hognose snakes with limited success. Therefore, surveys should be coordinated by the NHFG and could involve trained volunteers of the RAARP.

ELEMENT 2: SPECIES/HABITAT CONDITION

2.1 Scale

Abundance was evaluated throughout the New Hampshire range of eastern hognose snakes. Condition of specific locations can be evaluated by a GIS based on the habitat model described in Element 1.6 along with field surveys.

2.2 Relative Health

Information on the condition of hognose snakes in New Hampshire is not suitable to determine the viability of local populations. Several hognose snakes are reported to the NHFG annually; however, these observations largely consist of individual snakes, with very few locations having repeated observations. During the summer of 2002, the University of New Hampshire surveyed 6 sites for hognose snake presence but none were encountered (Oberkrieser and Litvaitis 2002). The New Boston Air Force Base incidentally encounters several snakes annually and densities appear low, but a systematic survey has not been conducted (S. Najjar, New Boston Air Force Base, personal communication).

2.3 Population Management Status

There is very little population management and or research occurring for hognose snakes in New Hampshire. The New Boston Air Force Base, in cooperation with the NHFG and a local veterinarian, implanted a transmitter in 1 adult hognose snake during spring 2005. This snake has been tracked on a regular basis and NHFG and the NBAFB intend to implant transmitters in several additional adult hognose snakes as they are encountered.

2.4 Relative Quality of Habitat Patches

Sandy glacial outwash is plentiful along the Merrimack River in Hillsborough and Merrimack counties, as well as the Lee/Durham area of New Hampshire. The abundance of the prey base (principally toads and frogs) has not been quantified, but several species, including American toads (*Bufo americanus*), spring peepers (*Pseudacris crucifer*), gray treefrogs (*Hyla versicolor*), and pickerel frogs (*Rana palustris*), appear to be common in this area of the state. The range of another native amphibian, the Fowler's toad (*Bufo fowleri*), coincides fairly well with that of the hognose snake, but this overlap may be a consequence of preference for similar sandy habitats, rather than a prey specialization to Fowler's toads. Development is intense and human population densities are rapidly expanding in southern New Hampshire. Many remaining fragmented blocks of habitat may be too small to support viable local populations of hognose snakes. The scarcity of hognose snake encounters may be a reflection of low habitat quality or of other factors not yet clearly understood.

2.5 Habitat Protection Status

Only a few eastern hognose snake records are on or near conservation land (University of New Hampshire Complex Systems GRANIT data layer). These areas are generally small and fragmented (Stevens, 1998) and it is not known whether management of conservation parcels is compatible for hognose snakes.

2.6 Habitat Management Status

No habitat management has occurred specifically for hognose snakes in New Hampshire to date. Restoration of Pine Barrens in south-central New Hampshire (e.g., Concord) should improve habitat suitability for hognose snakes, but it is unknown whether source populations exist in close enough proximity to become established. Potential impacts to hognose snake habitats are assessed during the Nongame & Endangered Species Program review of newly proposed developments projects.

2.7 Sources of Information

Condition of hognose snake locations was assessed

based on data from the RAARP and rare species database maintained by the NHNHBB. See Element 1.6 for details on habitat maps.

2.8 Extent and Quality of the Data

The condition of hognose snakes in New Hampshire is extremely poorly understood. Predicted habitat models for hognose snakes have some limitations based on available GIS data layers (See Element 1.6).

2.9 Condition Assessment Research

Habitat assessments should be conducted where hognose snakes have been reported and where hognose snake models predict suitable habitat (see Element 1.6). Systematic sampling of hognose snake, vegetative composition, and amphibian assemblages and abundance needs to be conducted at sites where hognose snakes have been documented. Because hognose snakes are difficult to locate, searching for snakes and monitoring individuals will require multiple years and will use the combination of experienced herpetologists and trained technicians and possibly volunteers. Volunteers are not authorized to handle state-protected species without a permit; therefore, a reporting protocol coordinated by NHFG will need to define roles of those involved. At highest priority sites, hognose snakes should be monitored (radiotelemetry) to assess viability as well as basic life history requirements (e.g., home range size, habitat use). Known locations should be evaluated in detail using a GIS and field surveys to assess size, location, and juxtaposition of remaining habitat blocks and conservation parcels.

ELEMENT 3: SPECIES AND HABITAT THREAT ASSESSMENT

3.1.1 Development (Habitat Loss and Conversion)

(A) Exposure Pathway

The corridor along the Merrimack River in Hillsborough and Merrimack counties is heavily urbanized and continuing to grow in human population and development. Continuing habitat conversion may degrade preferred habitat, fragment it into areas too

small to support the home range of an individual, increase encounters with humans and other generalist predators, and reduce the prey base of anurans that this species relies on.

(B) Evidence

Urbanization often converts hognose snake habitat to pavement and mown lawns. Eastern hognose snakes are also noted for having relatively large home ranges [in Arkansas, 21.4-72.8 ha, mean of 50.2 +/- 6.4 ha, and at times moving as much as 600 m at a time (Plummer and Mills 2000)]; conversion of habitat to standard New Hampshire 0.8 ha (2 acre) building lots thus has great potential to negatively affect this species. Amphibian populations, likely the primary prey for hognose snakes, are adversely impacted by wetland filling (especially vernal pools) and development of surrounding uplands, resulting from residential and commercial development. Other prey may be taken (Platt 1969) and it is not known to what extent eastern hognose snakes depend on amphibian prey in New Hampshire.

3.1.2 Transportation Infrastructure (Road mortality)

(A) Exposure Pathway

Hognose snakes probably have large home ranges in New Hampshire. Roads fragment habitat, increasing mortality as snakes are forced to cross roads on a more frequent basis. Hognose snakes are relatively slow moving and therefore vulnerable while crossing roadways.

(B) Evidence

Given the probable large home range requirements of this species and high road densities along the Merrimack River corridor, the opportunity for deadly encounters with automobiles is probably high. The number of snakes found dead on roads has been enumerated at other locations (Ashley and Robinson 1996, Enge and Wood 2002), but the degree to which road mortality threatens population viability in New Hampshire is largely unknown but expected for slow-moving species or those with large home ranges.

3.1.3 Unregulated take (killing and collection of individuals)

(A) Exposure Pathway

Many people have an irrational fear or hatred for snakes. The eastern hognose snake has an extensive threat display (Lazell and Michener 1976) and is a heavy bodied snake that is commonly misidentified as a dangerous species. Removal of individuals from an already small population can reduce population size. Small populations are subject to many problems that threaten viability including demographic and environmental stochasticity, genetic drift, and inbreeding depression (Meffe and Carroll 1997).

(B) Evidence

At least several individual hognose snakes have been killed and reported to the NHFG. However, there is no information on the frequency with which this species is killed or collected by humans.

3.2 Sources of Information

Literature reviews and knowledge/ experience with the eastern hognose snake and the Merrimack River region by the authors are the major sources of this information.

3.3 Extent and Quality of Data

Information regarding threats is based on literature reviews from other states or known condition of New Hampshire's rapidly changing landscape. Site-specific threats to hognose snakes in New Hampshire are unknown because of limited occurrence and condition information.

3.4 Threat Assessment Research

Developments proposed in known or potential hognose snake habitat should be assessed for the species presence. If a known threat is proposed or implemented near a known hognose snake location, the local population should be monitored to assess impacts (e.g., development, recreation, gravel/sand extraction). Also, a subset of hognose snake locations should be monitored to assess threat and viability.

ELEMENT 4: CONSERVATION ACTIONS

The most immediate step is to document the location and condition of existing hognose snake populations in New Hampshire. This information should be used to guide habitat protection and management and develop a detailed recovery/protection plan outlining specific research, management, land protection, and other potential actions (e.g., captive rearing). Conservation objectives and monitoring responses will be evaluated for this plan based on distribution and condition research. However, distribution and condition research can take many years. Therefore, it is critical that while this work occurs that known information is incorporated into current land protection and management and education and outreach.

4.1.1 Restoration, Management, and Habitat Protection

Increase coordination among those conducting restoration, management, and protection of Pine Barrens and other sandy outwash areas along the Merrimack River to ensure that habitat needs of hognose snakes are incorporated and threats are avoided. Land protection should focus on protecting large parcels within the range of hognose snakes and linking these areas with other suitable linear habitats (e.g., riparian, powerlines). Providing these linkages and large protected areas may be partially consistent with protection of other species of high conservation concern (e.g., New England cottontails, black racers).

4.1.2 Outreach and Education

People continue to kill snakes, including hognose snakes, out of fear and lack of knowledge of the species status. NHFG needs to increase education and outreach materials (newspaper articles, website development) to the public regarding the biology and status of this species. Also, the NHFG should promote maximizing native landscaping (rather than manicured mowed lawns) in residential developments (newly proposed and established).

4.1.3 Regulation and Policy

Avoid impacts to known hognose snake habitat (i.e., development, non-compatible recreational uses).

Proposed developments in potential hognose habitat should be evaluated based on habitat suitability (size and quality), and distance to other known hognose locations. NHFG evaluates projects potentially impacting hognose snake; however, there is currently no mechanism for reviewing projects where there are no wetland impacts. Because hognose snakes often occur in dry habitats, this is extremely problematic. Therefore, the NHFG should coordinate with other regulatory agencies to review impacts to terrestrial habitats in addition to the existing wetland review (i.e., NHDES site-specific review process).

4.2 Conservation Action Research

Investigate the possibility of reestablishing hognose snakes in restored or protected habitats within the historic New Hampshire range. Habitat management occurring at known hognose snake locations should include a hognose snake monitoring component.

ELEMENT 5: REFERENCES

5.1 Literature

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5.2 Data Sources:

NH Natural Heritage Bureau. 2005. Database of

SPECIES PROFILE

Jefferson Salamander and Blue-Spotted Salamander

Ambystoma jeffersonianum and *Ambystoma laterale*

Federal Listing: Not listed

State Listing: Special Concern (Jefferson), Not listed (blue-spotted)

Global Rank: G₄ (Jefferson), G₅ (blue-spotted)

State Rank: S₂S₃ (Jefferson), S₄ (blue-spotted)

Authors: Kimberly J. Babbitt and Jessica S. Veysey, University of New Hampshire

ELEMENT 1: DISTRIBUTION AND HABITAT

1.1 Habitat Description

Jefferson Salamander

Jefferson salamanders breed in palustrine wetlands, but spend most of their lives in nearby forested uplands (Klemens 1993, Faccio 2003). Jefferson salamanders can breed in several types of palustrine wetlands (i.e. grassy pasture ponds, small impoundments filled by seasonal stream, and vernal shrub swamps), but favor vernal pools (Klemens 1993). High breeding success in vernal pools is attributed to the absence of fish predators. To sustain a viable Jefferson salamander population, these pools must hold standing water until late summer in most years, so that the salamander larvae have sufficient time to develop and metamorphose (Harding 1997). This species attaches its egg masses to vegetation and dead branches within the water column of the vernal pool.

Jefferson salamanders prefer deciduous forest, but also occur in mixed deciduous-hemlock forest (Klemens 1993). This species also seems to prefer steep rocky areas with rotten logs and heavy duff layers (Klemens 1993). It seeks cover and hibernates in small mammal burrows, coarse woody debris, leaf litter, and stones (Faccio 2003, Klemens 1993). Jefferson salamanders have been observed at elevations ranging up to 1,700 feet (Klemens 1993, USFS 2002).

Blue-Spotted Salamander

Blue-spotted salamanders breed in fresh-water wetlands but spend most of their lives in nearby forested uplands (Downs 1989, Klemens 1993, Knox 1999). Blue-spotted salamanders use many wetlands types for breeding, including ephemeral and semi-permanent pools, swamps, ponds, marshes, ditches, and flooded sections of logging roads (Downs 1989, Klemens 1993, Knox 1999). In Connecticut, this species breeds frequently in acidic red maple/sphagnum moss swamps but also occurs in calcareous wetlands (Klemens 1993). Where the ranges of the closely related Jefferson salamanders (*Ambystoma jeffersonianum*) and blue-spotted salamanders overlap, Jefferson salamanders prefer ridge-top vernal pools, whereas blue-spotted salamanders seem to prefer lowland swamps (Klemens 1993). To sustain a viable blue-spotted salamander population, a wetland must hold standing water until late summer in most years so that the salamander larvae have time to develop and metamorphose (Harding 1997). Water depth in breeding wetlands is usually less than 40 cm (Knox 1999). This species sometimes attaches its eggs (singly or in small clusters) to grass and other wetland vegetation (Klemens 1993).

For upland habitat, blue-spotted salamanders prefer damp, deciduous, or mixed woodlands with moderate shade (Downs 1989, Knox 1999). Blue-spotted salamanders are commonly found in water-saturated loamy soil and damp crumbly sand (Downs 1989, Klemens 1993). They seek cover under rocks, rotting stumps and logs, moss, vegetative debris, small mammal burrows, woodpiles, and human debris (Klemens 1993, Knox 1999).

General

The size and configuration of upland habitat needed to sustain Jefferson, blue-spotted, or hybrid populations are unknown. They may require large areas of

undisturbed upland forest connected by suitable dispersal corridors to maintain metapopulations (Semlitsch 1998, USFS 2002). Salamanders may migrate several hundred meters from their breeding pools into the adjacent uplands (Williams 1973, Faccio 2003, Carr Research Laboratory and Hyla Ecological Services 2003).

1.2 Justification

Blue-spotted salamanders and Jefferson salamanders are known to form hybrids. Populations of pure blue-spotted or Jefferson salamander populations are probably very rare; however, a pure male of either species (blue-spotted or Jefferson) is required for the production of viable offspring. Only a handful of individuals have actually been genotyped as pure blue-spotted in New Hampshire, and only one pure Jefferson salamander has ever been identified in New Hampshire. These species and their hybrids may be sensitive to habitat disturbance.

1.3 Protection and Regulatory Status

Jefferson salamanders, blue-spotted salamanders, and their hybrids are not specifically protected in New Hampshire, although their habitats receive some protection. See Vernal Pool and Marsh & Shrub Wetlands Profiles.

1.4 Population and Habitat Distribution

Jefferson Salamander

This “species” is limited to the eastern United States and Canada. It ranges from western New England to eastern Illinois, north to Ontario, and south to central Kentucky to Virginia to Maryland (Klemens 1993, DeGraaf and Yamasaki 2001). In New England, it occurs west of the Connecticut River in Vermont, Massachusetts, and Connecticut; and east of the Connecticut River in southwestern New Hampshire and Massachusetts (Klemens 1993, French and Master 1986). Despite the New England range, populations consisting only of pure Jefferson salamanders are known from Pennsylvania southward to Kentucky and West Virginia (NatureServe 2004, Conant and Collins 1998). The Jefferson genotype was found in hybrid individuals (carrying more blue-spotted than Jefferson chromosome sets) in central

Maine (Knox 1999).

In New Hampshire, only one pure Jefferson salamander has ever been identified (using DNA analysis). This was a pure male from Winchester in Cheshire County identified in 1984 (French and Master 1986, Bogart and Klemens 1997). It is unknown whether this male represented a pure or mixed pure-hybrid population (Bogart and Klemens 1997). Jefferson salamanders have been reported to the RAARP program for other towns in New Hampshire but it is not known whether these individuals represent pure Jefferson salamanders or hybrids dominated by either Jefferson or blue-spotted salamander genomes.

Blue-spotted salamander

This “species” ranges from the maritime provinces of Canada to southeastern Manitoba, southward to northern Illinois, east to New York, then north along the Atlantic coast through New England (Klemens 1993, DeGraaf and Yamasaki 2001). Disjunct populations are located in New Jersey, Long Island (NY), Iowa, and Labrador (Klemens 1993, DeGraaf and Yamasaki 2001). In New England, it occurs widely throughout eastern and central Massachusetts, southeastern New Hampshire, Maine, and the Lake Champlain lowlands in Vermont (Klemens 1993). Scattered populations occur in southwestern New England, but the species does not occur on Cape Cod (Klemens 1993). Only 2 populations of pure (non-hybrid) blue-spotted salamanders are known (one on Prince Edward Island, Canada; the other on Long Island, New York; Knox 1999), though 5 others are suspected in Massachusetts and Connecticut (Bogart and Klemens 1997).

In New Hampshire, pure blue-spotted salamanders have been documented in Hollis (1 female), Rockingham County (2 females and a male), and Strafford County (1 female) (Bogart and Klemens 1997). Additionally, hybrid blue-spotted salamanders (blue-spotted genotype dominant or equal to the Jefferson genotype) were reported in Hollis (4 females), Rockingham County (six females and an unsexed individual), and Strafford County (2 females) (Bogart and Klemens 1997). Taylor (1993) also reported several blue-spotted salamanders (pure or hybrid) observations from Strafford County, Rockingham County, and Hillsborough County, and 1 observation from Coos County. However, Taylor (1993) and Bogart and Klemens (1997) may have been reporting

some of the same individuals. Some of these individuals were museum specimens and may actually be historic records. Finally, RAARP has received several reports of blue-spotted salamander observations, but these reports do not distinguish between pure and hybrid salamanders. These reports are primarily from Rockingham and Strafford counties, but a couple of the reports are from Hillsboro, Cheshire, Coos and Merrimack counties.

Hybrids

Most of the individuals across the range of both species are likely hybrids (Klemens 1993). To produce viable offspring, hybrids must mate with a pure male of either parent species. Thus, pure diploid Jefferson salamander and blue-spotted salamander males are likely present throughout parts of New England, but the exact distribution of the pure genotype is unknown (Bogart and Klemens 1997).

Local populations of blue-spotted salamanders, Jefferson salamanders, and their associated hybrids, where they exist in New Hampshire, will be clustered in relatively undisturbed forest uplands around temporary and semi-permanent pools and other palustrine wetlands. Such a habitat mosaic, of palustrine wetlands embedded in forested upland, is common throughout New Hampshire but is increasingly fragmented by human development, especially in the southern portion of the state.

1.5 Town Distribution Map

1.6 Habitat Map

N/A

1.7 Sources of Information

Information relating to the distribution of this species was gathered during a literature review. Two primary sources of information and references were DeGraaf and Yamasaki (2001) and the "Species Data Collection Form" completed by the USFS (Wright and Marchand 2002); the latter included information from state databases, meetings, and expert reviews.

1.8 Extent and Quality of Data

No comprehensive survey has been conducted for these species in New Hampshire. Much of the exist-

ing distributional data for New Hampshire is unreliable because it does not distinguish between pure Jefferson salamanders, blue spotted salamanders, and their hybrids. The work of Bogart and Klemens (1997), which genetically identified 18 pure/hybrid blue-spotted salamanders from New Hampshire, is highly accurate, but of limited quantity. Regional distribution maps suggest that the species may be present throughout the state.

1.9 Distribution Research

Basic distribution data is lacking for Jefferson salamanders. Since this species is listed as imperiled/vulnerable in New Hampshire (i.e., state rank code = S2/S3) it may merit a statewide survey. Pure Jefferson salamanders may be present in southern Vermont and Ontario. Current distribution data are also lacking for blue-spotted salamanders. Blue-spotted salamanders may occur in relatively high densities in southern New Hampshire and have been documented in northern New Hampshire (Taylor 1993). It is present throughout Maine and is reported from southeastern Canada. Statewide surveys should be conducted for both species and their hybrids. This survey should distinguish (genetically) between pure and hybrid blue-spotted salamanders so that distribution maps can be drawn for pure populations, populations where pure forms and hybrids coexist, and hybrid populations that lack pure genotypes.

ELEMENT 2: SPECIES/HABITAT CONDITION

2.1 Scale

There are insufficient data from which to determine species condition.

2.2 Relative Health of Populations

There are insufficient data from which to determine the relative health of populations.

2.3 Population Management Status

Jefferson salamanders, blue-spotted salamanders, and their hybrids are not specifically protected or managed. No management plan exists for the population

from which the only pure Jefferson salamander was collected (see section 1.4).

2.4 Relative Quality of Habitat Patches

There are insufficient data from which to determine the relative quality of habitat patches.

2.5 Habitat Patch Protection Status

There are insufficient data from which to determine the habitat patch protection status.

2.6 Habitat Management Status

Salamander habitat is indirectly managed through wetland and water resource protection, forestry management regulations (i.e., New Hampshire RSA 482-A; New Hampshire Rule Chapters Wt 100-800; Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire), and through land preservation (e.g., conservation restrictions and land acquisitions).

These efforts are not specifically designed to manage for salamanders. Population growth and associated development will likely destroy or degrade potential habitat, despite measures aimed at slowing and redirecting development. Additionally, some forest management techniques (e.g., clear cutting) could also contribute to the fragmentation and degradation of potential habitat (deMaynadier and Hunter 1999, Pough and Wilson 1976 cited in DeGraaf and Yamasaki 2001, Faccio 2003).

Basic distribution and habitat use data for the species is needed to develop effective habitat management plans. In the absence of this basic data, habitat management efforts might focus on limiting disturbance in and around vernal pools that are embedded within a relatively large matrix of minimally disturbed forest. The goal of habitat management efforts should be to maintain habitat patches that allow for metapopulation dynamics (i.e., multiple pool/upland patches connected by dispersal habitat). Thus, the usefulness (to salamanders) of pool buffer zones and dispersal corridors between habitat patches needs to be evaluated.

2.7 Sources of Information

Information was gathered from published literature and New Hampshire laws and administrative codes. Two primary sources of information were DeGraaf and Yamasaki (2001) and Wright and Marchand (2002); the latter source included information from state databases, meetings, and expert reviews.

2.8 Extent and Quality of Data

See Section 1.8 above. Little is known about the extent and locations of Jefferson salamanders or blue-spotted salamanders in New Hampshire.

2.9 Condition Assessment Research

1. New Hampshire needs basic surveys to determine the presence and distribution of pure and hybrid Jefferson/blue-spotted salamanders. It may help to first delineate its potential habitat. A GIS habitat layer could be produced using remote sensing (e.g., aerial photography) and ground truthing. Potential habitat should be determined by comparing a vernal pool data layer to a forest cover data layer.

2. If pure populations are discovered, habitat, life history, and dispersal data should be collected. Scientists can then assess the effects of development, forest management, and other activity on local populations.

3. To assist in understanding habitat use and population health, surveys should record or consider the following:

- Stability of the sub-population and/or metapopulation(s)
- Potential for genetic exchange between local populations
- Incidence of physical malformations
- Water quality within the breeding wetlands
- Length and inter-annual variability of breeding wetland hydroperiods
- Real and potential fish presence/absence within the breeding wetlands
- Proximity of the habitat patch to other potential habitat patches
- Proximity of the habitat to roads, development, and other disturbances
- Size and configuration of upland habitat

ELEMENT 3: SPECIES AND HABITAT THREAT ASSESSMENT

3.1.1 Development (Habitat Loss and Conversion)

See Vernal Pool habitat profile, section 3.1.1

3.1.2 Transportation Infrastructure (Mortality, Fragmentation, Dispersal Barriers)

See Vernal Pools habitat profile, section 3.1.2

3.1.3 Development (Habitat Loss and Conversion)

See Vernal Pools habitat profile, section 3.1.3

3.1.4 Unsustainable Harvest (Forestry Operations and Management)

See Vernal Pool Habitat Profile, section 3.1.4

3.1.5 Non-Point Source Pollution (Chemical Contaminants, Nutrients (Eutrophication))

(A) Exposure Pathway

Chemical toxins include mercury, pesticides, herbicides, fungicides, gasoline, oil, cleaning products, and many other substances that are not naturally found, or are not naturally found in such high concentrations. These toxins reach wetlands via atmospheric deposition, surface or subsurface runoff, or direct deposition. Fertilizers can leach into soil and ground and surface water and eventually arrive in wetlands where it may cause algal and bacterial blooms.

(B) Evidence

A limited number of studies have explored the effects of toxins on ambystomatids that occur in eastern North America. Generally, studies show that toxins affect hatching success, growth and development, behavior, frequency of deformities, and mortality (Boone and Semlitsch 2001, Bridges 1997, Howard et al. 2002, Hatch and Burton 1998). These effects can vary with species and ecological context (Sparling et al. 2001). Through a variety of mechanisms, toxins and other threats (e.g., UV-B radiation and low pH), may act synergistically to amplify harm to amphibians (Kagan et al. 1984, Hatch and Burton 1998, Zaga et al. 1998, Monson et al. 1999, Blaustein et al. 2001). Toxins may also harm prey resources, which might also affect survival and fecundity.

Algal and bacterial blooms (as well as the fertilizers themselves) may be toxic to salamanders or cause anoxia, which affects salamanders or prey resources. Larvae often exhibit decreased feeding and swimming activity, and increased disequilibrium, paralysis, incidence of abnormalities and edemas, and mortality (Marco et al. 1999, Baker and Waights 1994). Terrestrial phases of these species may alter feeding behavior in the presence of nitrogenous fertilizers (e.g., Hatch et al. 2001). Fertilizers may have a synergistic effect with other threats, such as low pH (Hatch and Blaustein 2000). Farm fertilizer use, lawn-care fertilizer use, and human septic/farm animal manure disposal may affect salamanders differently based on the ratios of their component nutrients and their application rates.

3.1.6 Acid Deposition

(A) Exposure Pathway

Acid rain and contaminated runoff and discharge may increase soil and water acidity within salamander habitat.

(B) Evidence

Mole salamanders exhibited a decreased hatching success, larval survival, embryonic developmental rates, and abundance of egg masses at low water pH levels (Pough 1976, Rowe et al. 1992, Rowe and Dunson 1993, Horne and Dunson 1994a, 1994b). Swimming activity of blue-spotted salamanders decreased with decreasing pH (Kutka 1994). Similarly negative effects of low water pH have been observed in other ambystomatids and amphibian species (as summarized in Kiesecker 1996). Additionally, metal mobility, and hence toxicity of metals to salamanders, changes with pH (Rowe et al. 1992, Rowe and Dunson 1993, Horne and Dunson 1994b, Horne and Dunson 1995a, 1995b). Research with other amphibians has demonstrated a negative synergistic interaction between low pH and other threats (e.g., UV-B radiation; Long et al. 1995, Hatch and Blaustein 2000).

Low soil pH may lead to increased desiccation among terrestrial salamanders, and terrestrial salamanders may avoid habitat that has acidic soil. Jefferson salamanders experienced reduced whole body water and Na⁺ concentrations at increased soil acidity, and preferentially chose substrates with higher

pH (Horne and Dunson 1994a). In the same study, pH of pond water and adjacent soil were highly correlated (Horne and Dunson 1994a). Wyman (1988) also found that spotted salamander distribution was significantly influenced by soil pH.

3.1.7 Scarcity (Hybridization)

(A) Exposure Pathway

Jefferson-blue-spotted salamander hybrids may come to dominate salamander populations where pure Jefferson salamanders are also present (see section 1.4). Through competition with hybrids or with pure blue-spotted salamanders, or through local extinction events, pure Jefferson salamanders may be eliminated, and thus, the species as a pure lineage may go extinct.

(B) Evidence

Jefferson and blue-spotted salamanders hybridize throughout much of their range (Conant and Collins 1998), and other hybrid combinations occur at the western extent of the Jefferson range (Bogart and Klemens 1997). Changes in regional climate, caused by global warming, may facilitate future range overlap. Hybrid populations seem unsustainable without sexual stimulation from pure males, but the pure genome is either not, or only temporarily, incorporated into the lineage (Bogart and Klemens 1997). Hybrids are usually dominant where they are present (Bogart and Klemens 1997). Hybrids may be better adapted to a wider range of habitats and environmental conditions than either parent species.

Hybridization is viewed as a very serious threat by the research and conservation communities (see Wright and Marchand 2002). However, hybridization seems a natural evolutionary step for two species that recently diverged due to temporary geographic isolation (for evolutionary history, see Bogart and Klemens 1997). Were this evolution untouched by human influence, both or either species might still go extinct. Alternatively, they might re-merge into a single species, or survive as two species. The threat is more the potential for human influence to impact this process (i.e., through habitat destruction and fragmentation), than the hybridization itself.

3.2 Sources of Information

Information about threats was compiled from an

extensive literature review and from personal communications and observations.

3.3 Extent and Quality of Data

The genetic and reproductive mechanisms of hybridization and the effects of low pH on ambystomatid salamanders are well documented. The impacts of other threats are less well documented. However, some threats (e.g., road effects, logging) have been well documented for other similar species.

3.4 Threat Assessment Research

Additional research is needed to establish and thoroughly detail the specific effects of most of these threats (except effects of low pH). Yet foremost, New Hampshire needs a systematic survey to determine the distribution of blue-spotted and Jefferson salamanders.

ELEMENT 4: CONSERVATION ACTIONS

Refer to the Vernal Pools habitat profile for a complete list of conservation actions that are intended to protect vernal pools and vernal pool wildlife.

4.1.1 Amphibian Migration Facilitation, Restoration and Management/Education and Outreach

(A) Direct Threats

Transportation Infrastructure (Mortality, Fragmentation, Dispersal Barriers)

(B) Justification

Roads may often cut across major amphibian migration routes, although often in small, spatially discrete areas. In this context, “amphibian” refers to species such as spotted salamanders, Jefferson salamanders, blue-spotted salamanders, marbled salamanders, wood frogs, and spring peepers that migrate en masse from upland landscapes to vernal pools in the spring. Roads threats to amphibian populations are increasing in New Hampshire, as development in the state accelerates (Sundquist and Stevens 1999). Installing tunnels beneath roads that intersect amphibian migration routes will facilitate dispersal. Road signs may alert drivers to the possibility of migrating am-

phibians and lessen amphibian mortality caused by traffic. Community education may further decrease the threat of road traffic to migrating amphibians. Community members can help salamanders cross roads and witness the migrations at these locations (see Jackson 1996, 2003, Jackson and Tynning 1989).

(C) Conservation Performance Objective:

The objective is to reduce the impacts of roads on amphibian population and metapopulation dynamics, and thus maintain viable populations of breeding amphibians.

(D) Performance Monitoring:

Potential indicators that can be easily monitored include:

- Number of road-killed salamanders where roads cross migration routes, before and after tunnels have been installed
- Nightly counts of migrating animals during peak migration (warm rainy nights during March-May)
- Number of salamanders and other amphibians observed crawling through installed tunnels
- Egg mass abundance before and after tunnels have been installed

Overall, road kills are expected to be negatively correlated with egg mass abundance, despite normal annual fluctuations in salamander breeding population size and egg production. Tunnels should increase migration success, leading to an increase in successful breeding.

(E) Ecological Response Objective

The short-term objective of installing tunnels and facilitating migration is to increase migration success and thus the breeding pool of amphibians. If new roads and tunnels are installed simultaneously, then the objective is to have no effect on breeding populations.

(F) Response Monitoring

If feasible, baseline population growth rates of target species could be established prior to migration facilitation, and then changes in population growth rates following migration facilitation could be used as a response indicator. However, amphibian populations

fluctuate naturally from year to year, so monitoring efforts should continue for several years (five or more) to try to differentiate actual response from natural variation. Comparison of growth rates, counts of road mortality, nightly migration surveys, and use of tunnels should elucidate the effect of the conservation action.

(G) Implementation

- Locate intersections between roads and amphibian migration routes
- Determine pre-facilitation road kill frequencies and growth rates (i.e., conduct road kill and egg mass surveys)
- Implement migration facilitation program (i.e., migration tunnels, road signs, volunteer observers).
- After facilitation implementation, determine annual road kill frequencies and growth rates
- Monitoring growth rates and road kill frequencies until they have stabilized or are consistently positive
- Continue migration facilitation unless it is deemed unnecessary ineffective

Facilitation activities could be coordinated at the state level by a government, non-profit, or consulting group. Facilitation could alternatively be implemented and monitored at the municipal level. Volunteers should be trained and utilized to perform much of this conservation action.

(H) Feasibility

It is possible to implement this conservation action wherever volunteers are willing to help amphibians cross roads. Installation of tunnels and signs will require funding. This action is likely to improve the success of amphibian road crossings.

4.2 Conservation Action Research

Critical holes exist in knowledge of blue-spotted and Jefferson salamanders in New Hampshire. This general lack of knowledge bars the confident prescription of conservation actions. The first step is to conduct a statewide survey. Survey sites can be selected using aerial photographs and GIS data layers (as has been done in Massachusetts; contact the Massachusetts Natural Heritage Program at: natural.heritage@state)

.ma.us), as well as local knowledge. Surveys should target adults, eggs, or larvae. Genotypes must be analyzed to confirm the genetic identity of individuals; thus, surveyors must clip toes of captured animals or gather eggs for DNA analysis.

Maintaining vernal pool habitat, upland habitat, and dispersal corridors will be the most effective way to protect Jefferson salamanders, if populations exist in New Hampshire. Research should address:

- Dispersal capability in both undisturbed and variously disturbed (e.g., suburbia, forest clearcuts) habitats
- Degree of isolation and regional persistence mechanism of local populations in New Hampshire and neighboring states
- Threats to the species

Research should be used to develop specific conservation actions and best management practices for this species. Such a conservation management plan should be developed in cooperation with those neighboring states and provinces that also contain the species.

ELEMENT 5: REFERENCES

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SPECIES PROFILE

Marbled Salamander

Ambystoma opacum

Federal Listing: Not listed

State Listing: Endangered

Global Rank: G5

State Rank: S1

Authors: Kimberly J. Babbitt and Jessica S. Veysey, University of New Hampshire

ELEMENT 1: DISTRIBUTION AND HABITAT

1.1 Habitat Description

Marbled salamanders breed in seasonally flooded, palustrine wetlands, but spend most of their lives in the forested uplands surrounding these wetlands (Noble and Brady 1933, Bishop 1941, Petranka 1989, Klemens 1993). Marbled salamanders use several types of palustrine wetlands (e.g., ephemeral pools and streams, fishless swamps, ponds with low water levels) for breeding and nesting (Noble and Brady 1933, Bishop 1941, Petranka 1989). Eggs are laid along the exposed edges of the wetlands, and wetlands must flood in the late fall or early winter in order for eggs to hatch (Bishop 1941, Petranka 1989). Salamanders hide nests, usually in bare mineral soil, beneath leaf litter, grass clumps, or logs, or within root complexes (Jackson et al. 1989, Petranka 1990, Figiel and Semlitsch 1995). To sustain a viable marbled salamander population, a wetland must hold standing water for about 10 months in most years (approximately September to June), so that the salamander larvae have sufficient time to develop and metamorphose (Noble and Brady 1933, Bishop 1941).

For upland habitat, marbled salamanders seem to prefer deciduous or mixed-deciduous woodlands (Klemens 1993), especially oak-maple and oak-hickory woods (Minton 1972) and floodplain forests (Petranka 1998). Marbled salamanders also seem to favor dry, friable soils, including sand and gravel deposits

and rocky slopes (Bishop 1941, Klemens 1993). Marbled salamanders can inhabit somewhat drier areas than other *Ambystoma* species (Bishop 1941). Marbled salamanders use deeply imbedded rocks or logs (Klemens 1993) as cover objects, and probably use small mammal burrows as shelter throughout most of the year and as hibernacula in the winter (DeGraaf and Yamasaki 2001, Smyers et al. 2002). In Connecticut, this species was observed at elevations ranging from 30 to 335 m (Klemens 1993).

The area and configuration of upland habitat needed to sustain a marbled salamander population is unknown, but probably varies according to local site conditions. This species likely operates as metapopulations, which require a multitude of habitat patches (i.e., breeding wetland and adjacent upland forest) connected by habitat that is hospitable to dispersing salamanders, in order to persist (Semlitsch 1998). At the local population level, salamanders in Indiana migrated an average distance of 194 m (range 0- 450 m) from breeding wetlands into the surrounding uplands (Williams 1973 as cited in Semlitsch 1998).

1.2 Justification

The marbled salamander is at the northern periphery of its range in New Hampshire and is the rarest amphibian species in the state. Few documented occurrences of the species exist for New Hampshire; however, a systematic survey to determine the location of all potential populations has not been conducted. The southern distribution of this species in the state, together with intensive developmental pressure in the same area, places this species at significant risk of extirpation.

1.3 Protection and Regulatory Status

The marbled salamander is listed as Endangered un-

der the New Hampshire Endangered Species Conservation Act (RSA 212-A). See the vernal pools habitat profile for regulations of vernal pool habitat.

1.4 Population and Habitat Distribution

The marbled salamander is endemic to the eastern half of the United States. It ranges from southern New Hampshire, west through southeastern New England and Pennsylvania to the Lake Michigan region, and south to eastern Texas and northern Florida (Klemens 1993, DeGraaf and Yamasaki 2001, NatureServe 2004). In New England, this species occurs throughout Connecticut, Rhode Island, Massachusetts east of the Connecticut River, and in the Berkshire Hills of western Massachusetts (Klemens 1993, DeGraaf and Yamasaki 2001). One specimen was collected from western Vermont (DeGraaf and Yamasaki 2001).

Historically, marbled salamanders were reported from Milford (Hoopes 1938) and Hollis (NHNHB 1965), both in Hillsborough County south-central New Hampshire. Records from RAARP (2005) indicated that a marbled salamander was observed in Hinsdale, Cheshire County in 2000 (photo verified), and another was possibly observed in Hollis in 1997 (no photo or specimen but near location of historic report). A statewide survey and more recent documentation of this species are lacking.

Populations of marbled salamanders, where they exist in New Hampshire, will likely be clustered in relatively undisturbed forest uplands around temporary and seasonally flooded wetlands. Such a habitat mosaic, of seasonally-flooded wetlands embedded in forested upland, is common throughout much of New Hampshire, but is increasingly fragmented by human development, especially in the southern portions of the state, which is where this species is most likely to occur.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

Known sites were mapped (historic and recent). A potential habitat map was not created for this species.

1.7 Sources of Information

Information relating to the distribution of this species was gathered through an extensive literature review.

1.8 Extent and Quality of Data

No comprehensive survey has been conducted for this species in New Hampshire. The species was known to occur in southern New Hampshire historically (Hoopes 1938, Taylor 1993) and the New Hampshire RAARP has record of a possible sighting in 1997 and a vouchered sighting in 2000 from south-central and southwestern New Hampshire, respectively.

1.9 Distribution Research

Current distribution data are lacking for marbled salamanders, and it is necessary to determine whether and where the species persists in the state. Surveying for the marbled salamander should focus on appropriate habitat across the southern portion of the state. Using remote sensing (e.g., aerial photography, land cover), a potential habitat layer should be created in a Geographic Information Systems (GIS). Priority sites should be inventoried in the field. Since this wetland identification technique is somewhat limited by the size of vernal pools, by the season during which the photographs were taken, and by the tree species surrounding the pools, field surveys should also be conducted.

The surveying should be conducted in the fall to look for migrating adults and nests, and in the spring to look for larvae. During the spring, surveyors can dip-net for larvae; surveying prior to egg hatching by other vernal-pool breeding salamanders would help ensure likely capture of marbled salamander larvae (as accurate identification of larval ambystomatids can be difficult).

ELEMENT 2: SPECIES/HABITAT CONDITION

2.1 Scale

There are insufficient data from which to determine species condition.

2.2 Relative Health of Populations

There are no data on population number or population sizes from which to determine relative health of populations. However, as it is likely that the species occurs in low numbers, it may be in danger of extirpation.

2.3 Population Management Status

No specific management plans exist for populations at these observation locations. Confirmation of the existence of these populations is necessary. Additionally, a systematic survey, focused on southern New Hampshire, is needed to locate other potential marbled salamander populations. Population management plans can be created after populations have been identified.

2.4 Relative Quality of Habitat Patches

There are not sufficient data available with which to assess the quality of habitat patches for the marbled salamanders.

2.5 Habitat Patch Protection Status

There are insufficient data with which to assess protection status.

2.6 Habitat Management Status

Marbled salamander habitat is indirectly managed through wetland and water resource protection, forestry management regulations (i.e., New Hampshire RSA 482-A; New Hampshire Rule Chapters Wt 100-800; Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire), and through land preservation (e.g., conservation restrictions and land acquisitions).

These efforts are not specifically designed to manage for marbled salamanders. Population growth and associated development will likely destroy or degrade potential marbled salamander habitat, despite measures aimed at slowing and redirecting development. Additionally, some forest management techniques (e.g., clear cutting) could also contribute to the fragmentation and degradation of potential marbled salamander habitat (deMaynadier and Hunter 1999,

Pough and Wilson 1976 cited in DeGraaf and Yamasaki 2001, Faccio 2003).

Basic distribution and habitat use data for the species are needed to develop effective habitat management plans. In the absence of these basic data, habitat management efforts might focus on limiting disturbance in and around vernal pools that are embedded within a relatively large matrix of minimally disturbed forest. The goal of habitat management efforts should be to maintain habitat patches that allow for metapopulation dynamics (i.e., multiple pool/upland patches connected by dispersal habitat). Thus, the usefulness (to salamanders) of pool buffer zones and dispersal corridors between habitat patches needs to be evaluated.

2.7 Sources of Information

Information relating to the condition of this species and its habitat was gathered during an extensive literature review, a review of New Hampshire laws and administrative codes, and a review of the New Hampshire RAARP.

2.8 Extent and Quality of Data

See element 1.8. No information is available on the condition of this species and its habitat in New Hampshire.

2.9 Condition Assessment Research

- Monitor populations for habitat patch occupancy and determine stability and growth rates of local populations.
- Determine potential for regional dynamics at metapopulation level (i.e., determine interaction of spatial arrangement of viable habitat, local threats, and dispersal capacity of the species).

ELEMENT 3: SPECIES AND HABITAT THREAT ASSESSMENT

3.1.1 Scarcity (Natural Rarity)

(A) Exposure Pathway

The current known distribution of this species suggests that it may be extremely rare in the state, and may occur as only 1 or 2 populations, putting it at

risk of demographic stochasticity.

(B) Evidence

There are no data available from which to analyze this threat. However, the generally increased risk of extinction for small, isolated populations is well established.

3.2 Sources of Information

Information on marbled salamander distribution was obtained from the RAARP database.

3.3 Extent and Quality of Data

Other than the records in the RAARP database, there are no data on this species in the state.

3.4 Threat Assessment Research

Because there is so little information about this species in the state, establishing a research program to assess threat is premature. The most important research is a systematic survey and mapping of the distribution of this species in New Hampshire and adjacent areas of Massachusetts. If populations are documented in New Hampshire, local threats can be assessed. The Jefferson salamander profile contains a more extensive examination of threats assessment research, and threats to the marbled salamander would be essentially the same (with the exception of hybridization).

ELEMENT 4: CONSERVATION ACTIONS

Since the current distribution of this species in New Hampshire is unknown, it is impossible to evaluate the urgency of threats to, and the impacts of prospective conservation actions on, specific salamander populations and habitat patches. See the Jefferson salamander profile for a more extensive list of conservation actions that would be appropriate for marbled salamanders if several populations are identified.

ELEMENT 5: REFERENCES

5.1 Literature

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5.2 Data Sources

- NH Natural Heritage Bureau. 2005. Database of Rare Species and Exemplary Natural Community Occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.
- New Hampshire Reptile and Amphibian Reporting Program (RAARP). Coordinated by New Hampshire Fish and Game's Nongame and Endangered Species Program.

SPECIES PROFILE

Mink Frog

Rana septentrionalis

Federal Listing: Not listed

State Listing: Not listed

Global Rank: G5

State Rank: S3S4

Author: Kim A. Tuttle, NHFG

ELEMENT 1: DISTRIBUTION AND HABITAT

1.1 Habitat Description

The mink frog inhabits the cold waters of lakes, ponds, stream edges, springs, and occasionally peatlands of northern New Hampshire. The mink frog is almost entirely aquatic. It prefers to forage, breed, and hibernate in shallow, permanently open water with abundant emergent vegetation, especially lily pads (*Nymphaea spp.*) and pickerelweed (*Pontedaria cordata*) (DeGraaf and Yamasaki 2001). Adults often feed from lily pads far from shore; adult and larval aquatic invertebrates are common prey (Conant and Collins 1998, Stockwell 1999). Mink frogs lay eggs in a globular jelly mass attached to submerged vegetation, especially the stems of spatterdock (*Nuphar spp.*) or water lily. Egg masses eventually fall from the stems and drop to the bottom where they develop (Stockwell 1999).

1.2 Justification

Mink frogs are seldom seen or recorded because of their shy nature and unique habitat preferences. Few data are available for this species in New Hampshire. Its preference for the combination of cold, oxygen rich water and lily pads may restrict the mink frog to few suitable habitats. Lily pads are associated with warmer water and are not common in cold, northern water bodies (A. Schafermeyer, NHFG, personal communication). Water temperature may restrict

mink frogs to northern regions because colder water has higher oxygen levels, which are required for embryo development (Stockwell 1999).

1.3 Protection and Regulatory Status

This species has no special protection in New Hampshire.

1.4 Population and Habitat Distribution

Mink frogs are restricted to areas north of the 43° N parallel in Maine, northern Ontario, Quebec, and Labrador, and west to Minnesota (Stockwell 1999). Historical locations of mink frogs in New Hampshire are clustered in the northern Connecticut River watershed towns of Coos and Grafton counties. This distribution is an artifact of the biological surveys conducted by Oliver and Bailey in 1938 and 1939 for the NHFG. Reptile and amphibian surveys, incidental to fish distribution surveys, were conducted in the Connecticut River watershed but not in the Androscoggin and Saco watersheds. More recent amphibian surveys have revealed occurrences of mink frog across Coos County to Wentworth's Location and Errol on the Maine border, and south to Livermore and Thornton in Grafton County. Mink frogs can be locally common in New Hampshire's North Country water bodies such as the Magalloway River in Wentworth's Location and marshes at the edge of Lake Umbagog (L. Wunder, Lake Umbagog National Wildlife Refuge, personal communication).

1.5 Town Distribution Map

1.6 Habitat Map

A habitat map was not completed for this species.

1.7 Sources of Information

Status and ranking information was taken from NatureServe (2005). New Hampshire Reptile and Amphibian Reporting Program (RAARP) records, Taylor (1993), and Oliver and Bailey (1939) were the primary sources of locality records. Habitat and life history information was taken from published literature. Michael Marchand, NHFG, provided comments on drafts.

1.8 Extent and Quality of Data

The distribution, habitat use, and condition of mink frog populations in New Hampshire are not well understood. This assessment was limited to records in scientific reports, records reported to the New Hampshire RAARP by an expert, and to reports that included a specimen or clear photograph.

1.9 Distribution Research

Continued efforts by RAARP volunteers are needed to identify and report mink frog locations, especially in the southern part of its range in Grafton and Carroll counties. In the North Country, Little Diamond Pond in North Stewartstown, and Back Lake and East Inlet, Pittsburg appear to be have suitable habitat for mink frogs and should be surveyed (A. Schafermeyer, NHFG, personal communication). Scotts Bog, Indian Stream, and the Connecticut Lakes in Pittsburg need to be rechecked to update 1985 occurrence records. Mink frogs and other reptile and amphibian species should be incorporated into comprehensive habitat monitoring efforts, particularly in northern New Hampshire where many species reach the edge of their range. North American Amphibian Monitoring Program (NAAMP) routes should be expanded to include more northern routes in New Hampshire. Mink frogs seem to be easily detected by call surveys during night sampling.

ELEMENT 3: SPECIES THREAT ASSESSMENT

The loss or degradation of cold, shallow water habitats with lily pads and pickerelweed in northern New Hampshire may pose the greatest threat to mink frogs.

ELEMENT 4: CONSERVATION ACTIONS

See Marsh and Shrub Wetlands, Peatlands, and Aquatic habitats for relevant conservation strategies. Maintaining natural emergent vegetation at the borders of ponds and wetlands, especially lily pads and pickerelweed, will help maintain the viability of mink frogs and other wetland dependent organisms.

ELEMENT 5: REFERENCES

5.1 Literature

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5.2 Data Sources

- NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. <http://www.natureserve.org/explorer>. (Accessed: March 11, 2005).
- New Hampshire Reptile and Amphibian Reporting Program (RAARP) database. Maintained by the New Hampshire Fish and Game, Nongame and Endangered Species Program, Concord New Hampshire. (Accessed: February 14, 2005).

SPECIES PROFILE

Northern Leopard Frog

Rana pipiens

Federal Listing: Not listed

State Listing: Special Concern

Global Rank: G5

State Rank: S3

Author: Kimberly, J. Babbitt and Nicole A. Freidenfelds, University of New Hampshire

Element 1: Distribution and Habitat

1.1 Habitat Description

Northern leopard frogs require 3 distinct habitats for breeding, foraging, and overwintering. Breeding (May to late June), egg deposition, and tadpole development occur in shallow standing water and emergent vegetation, such as lake inlets, slow streams, ponds, temporary wetlands holding water until at least July or August (e.g., long-hydroperiod vernal pools), overflows, or the backwater of rivers (Merrell 1977, Hine et al. 1981, Hunter et al. 1999, Alberta Sustainable Resource Development 2003). The best spawning habitat is marked by ample vegetation and a lack of fish (Merrill 1977).

During the summer, adult, juvenile, and young-of-the-year frogs are typically found near water (Alberta Sustainable Resource Development 2003). However, leopard frogs will travel 1 to 2 km from major waterbodies to wet meadows, pastures, hay fields, scrub vegetation, sedge meadows, drainage and irrigation ditches, or damp wooded areas (Hunter et al. 1999, Kendell 2002). Leopard frogs cannot withstand prolonged freezing and therefore overwinter in permanent waterbodies that do not freeze to the bottom (Schmid 1982, Costanzo et al. 1992, Layne 1992, 1993, Hunter et al. 1999, Russell and Bauer 2000, Alberta Sustainable Resource Development 2003). Hibernacula are most often located in springs, streams, spillways below dams, or in deeper lakes and ponds (Emery et al. 1972, Merrell 1977, Cunjak

1986). Within waterbodies, leopard frogs have been found hibernating under rocks, logs, leaf litter, vegetation, or in depressions in sand or mud (Emery et al. 1972).

1.2 Justification

Leopard frogs have apparently declined throughout much of New England. The decline is likely related to farm abandonment, forest regeneration, and decreases in grassland. The current distribution and abundance of northern leopard frogs, and the status of remaining populations in New Hampshire, are poorly known.

1.3 Protection and Regulatory Status

Leopard frogs are not specifically protected. Breeding wetlands are regulated through NHDES Wetlands Bureau (RSA 482-A and Administrative Rules). Uplands are generally not regulated.

1.4 Population and Habitat Distribution

The northern leopard frog (or, more specifically, the northern leopard frog complex) has a broad distribution in the United States and Canada. Northern leopard frogs range from New England to the mid-Atlantic to west of the Rockies, and in Canada, populations exist from southeastern British Columbia east to the Maritimes. The northern leopard frog is absent from most of the southeast. Throughout its range, the species often has a spotty distribution and is considered critically imperiled (S1) or imperiled (S2) in several states in the west and south and in British Columbia. In New England, the species is considered imperiled (S2) in Connecticut and Rhode Island, Vulnerable (S3) in New Hampshire and Maine, and apparently secure (S4) in Vermont and Massachusetts (Nature Serve 2001). Throughout New England, the species

has a very spotty distribution and is strongly associated with grassy riparian floodplains. For example, in Connecticut, Klemens (1993) found that the species is restricted mainly to the Housatonic and Connecticut drainage basins and their tributaries.

In New Hampshire, records submitted to RAARP database were verified for the following areas between 1992 and 2004: Coos County (Errol, Pittsburg), Merrimack County (Concord), Rockingham County (Portsmouth), and Sullivan County (Charlestown). Reports from a number of other towns have not been verified with a photograph or specimen. Most observations were from the Merrimack River, Connecticut River, Androscoggin River, and associated floodplains.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

N/A

1.7 Sources of Information

Information relating to the distribution and status of this species was gathered through a literature review and from NatureServe, as well as from the RAARP database.

1.8 Extent and Quality of Data

No comprehensive survey has been conducted for this species in New Hampshire, thus detailed distribution data are lacking. Because leopard frogs are commonly confused with pickerel frogs (*Rana palustris*), a photograph is required to verify records submitted to the RAARP. Many new populations are likely to be identified in the future (M. Marchand, NHFG, personal communication).

1.9 Distribution Research

Current distribution data are poor for northern leopard frogs. Surveys should focus on grassy riparian floodplains.

ELEMENT 2: SPECIES CONDITION

2.1 Scale

There are insufficient demographic data from which to determine species condition.

2.2 Relative Health of Populations

Data are insufficient to determine population health.

2.3 Population Management Status

There are no management efforts for any particular northern leopard frog population in New Hampshire at this time.

2.4 Relative Quality of Habitat Patches

Data are insufficient to determine relative quality of habitat patches.

2.5 Habitat Patch Protection Status

There are insufficient data to assess protection status for this species.

2.6 Habitat Management Status:

Northern leopard frog habitat is not specifically managed in New Hampshire.

2.7 Sources of Information:

No information was found pertaining to leopard frog status in New Hampshire.

2.8 Extent and Quality of Data:

No information was found pertaining to leopard frog status in New Hampshire.

2.9 Condition Assessment Research

- Acquire and map basic distribution data for this species, using remote sensing and GIS to delineate potential habitat and surveys to determine actual distribution
- Conduct population and metapopulation stud-

ies to determine growth rates, stability, dispersal, habitat use (and landscape distribution of critical habitats)

- Determine threats to local populations and develop population and habitat management plans if feasible

ELEMENT 3: SPECIES AND HABITAT THREAT ASSESSMENT

3.1.1 Development (Fragmentation, Habitat Loss and Conversion)

(A) Exposure Pathway

The loss of leopard frog habitat will result in a population reduction. Habitat loss and fragmentation restrict gene flow, impede recolonization, and compound environmental stochasticity, often leading to local extirpation (Alberta Sustainable Resource Development 2003, Blaustein et al. 1994, Corn 1994). In New Hampshire, the most significant threat comes from development in riparian floodplains and farmland.

(B) Evidence

Habitat loss is believed to be one of the causes of northern leopard frog declines in Washington, Oregon, Idaho and Montana (Alberta Sustainable Resource Development 2003). The extent to which wetland loss and alteration have affected northern leopard frog populations in New Hampshire is unknown; however, significant loss of early successional grassland habitat and farmland has been well documented (see Grasslands habitat profile). Degradation or loss of critical habitat may be deleterious to leopard frog populations (Pope et al. 2000), and because metapopulations depend on the regional flow of genes and individuals, local extirpations can lead to widespread population collapse (Seburn and Seburn 2000, Alberta Sustainable Resource Development 2003, Blaustein et al. 1994, Marsh and Trenham 2001).

3.1.2 Transportation Infrastructure

(A) Exposure Pathway

Road traffic can kill leopard frogs and may be particularly problematic for small populations. Roads fragment habitat and act as partial barriers to migration,

leading to the aforementioned restrictions on gene flow and re-colonization. When (meta) population dynamics are thus disrupted, the species may not remain viable.

(B) Evidence

Amphibians are especially vulnerable to traffic mortality because they migrate between wetland and upland habitats, and because individuals are inconspicuous and sometimes move slowly (Trombulak and Fritts 2000). Ehmann and Cogger (1985) estimated that more than 5 million amphibians and reptiles are killed each year on roads in Australia. Research conducted in the Ottawa area indicates that anuran populations decrease in size with increasing traffic volume (Fahrig et al. 1995). Additionally, Carr and Fahrig (2001) found that traffic can influence leopard frog abundance at least 1.5 km from the population and that more vagile species, such as northern leopard frogs, are more strongly affected by road traffic.

3.1.3 Non-Point Source Pollution (Chemical Contaminants)

(A) Exposure Pathway

Pesticide wetting agents can interfere with cutaneous respiration in metamorphosed and adult frogs and with gill respiration in tadpoles, leading to indirect or direct mortality. Chemicals can suppress the immune system, cause endocrine disruption and developmental malformations, and alter behavior which may lead to decreased vigor, ability to fight off disease, reproduce, or escape predation, thereby increasing the chance of mortality.

(B) Evidence

The northern leopard frog is a frequent subject of toxicity experiments (e.g., see Hoffman et al. 2003). Leopard frogs are commonly found near agricultural areas where they are exposed to pesticides, herbicides, and nutrient (fertilizer) runoff. Low levels of nitrates can cause reduced activity, feeding, reproductive ability, and increases in deformities in tadpoles (Hecnar 1995). Allran and Karasov (2000) report that nitrate slowed the growth of leopard frog larvae. Such a decrease in growth as a larva can have a significant detrimental impact later in the life of a frog by decreasing survival, size as an adult, rate of sexual maturation, mate selection, and locomotion ability for preda-

tor evasion (Allran and Karasov 2000). Ouellet et al. (1997) found higher rates of limb deformities in northern leopard frogs in Ontario, Canada at sites in agricultural area and suggested that contaminants were the likely cause. In addition, *Rana pipiens* tadpoles are also sensitive (e.g., have lower survival, experience paralysis, delayed growth, or abnormal behavior) to low concentrations of insecticides and herbicides commonly used in forest management (Berrill et al. 1994, Berrill et al. 1995). It has also been demonstrated that, for leopard frogs, pesticides can act as immunosuppressive agents at sub-lethal doses that are present in wild frogs. The immunosuppressive effects of pesticides may be contributing to amphibian declines by rendering exposed populations susceptible to common pathogens (Gilbertson et al. 2003). Hayes et al. (2002) reported that very small doses (0.1 ppb) of the commonly used herbicide Atrazine can cause hermaphroditism in northern leopard frogs.

Because of the low buffering capacity of most water bodies in New Hampshire, northern leopard frogs may be at risk from decreased environmental pH resulting from sulfur dioxide and nitrogen oxides emitted by burning of fossil fuels. Simon et al. (2002), found that frogs experimentally exposed to pH 5.5 had spleens colonized with both Gram-positive and Gram-negative bacteria whereas spleens of frogs exposed to pH 7.0 either were sterile or exhibited little bacterial colonization. Resulting systemic infections combined with decreased natural defenses may in part cause increased mortality in leopard frogs (Simon et al. 2002). Leopard frogs collected early in the spring, immediately following hibernation, but prior to the breeding season, exhibited 100% mortality within the first 4 days of exposure to pH 5.5 (Vatnick et al. 1999). Frogs collected later in the season, post-breeding and prior to hibernation, exhibited 58% mortality over the 10 days of exposure. Prolonged exposure to pH less than 4.0 is lethal for leopard frogs, and bacterial infection, inhibition of yolk plug retraction, thoracic swelling, and caudal curling occur at a pH less than 6.3 (Watkins-Colwell and Watkins-Colwell 1998).

3.1.4 Non-Point Source Pollution (Runoff)

(A) Exposure Pathway

Eutrophication from fertilizer and farm runoff can

cause an increase in snail populations that serve as the host for the trematode *Ribeiroia ondatrae* whose larvae (cercariae) infect larval leopard frogs, forming metacercarial cysts that cause malformations. Individuals with malformations are at increased risk of predation and have lower survival rates. Other diseases, both emerging and existing, can cause morbidity and mortality. Immune systems suppressed by, for example, exposure to contaminant (see 3.1.3), can render frogs susceptible to diseases with which they can normally cope. Populations that experience high disease rates may become locally extirpated.

(B) Evidence

Widespread reports of malformed amphibians in North America have prompted investigations into the causes of the deformities. Some amphibian deformities may be the result of a trematode known as *Ribeiroia ondatrae* (Sessions and Ruth 1990, Johnson et al. 2002). Larvae (cercariae) of this parasite infect amphibians around the base of the hind limbs where they form subcutaneous cysts (metacercariae), often causing improper formation of the developing limb bud. If the malformations are severe enough to impair movement, the individual may die due to a reduced ability to acquire food, avoid predators, and reproduce. In addition to eutrophication, loss or replacement or natural wetlands with artificial impoundments (e.g., dams, farm ponds), and introduction of non-indigenous species have all been associated with increases in trematode populations (Johnson et al. 2002). However, not all malformations are caused by the trematode (see previous section), and research on northern leopard frogs in adjacent states suggests multiple causes for malformations (Meteyer et al. 2000).

Amphibians are known to be susceptible to a variety of diseases, including many diseases of fish (Crawshaw 1992). Mortality in northern leopard frogs has often been associated with the condition called red leg, which is not a disease but a condition of kidney failure (Gibbs et al. 1971, Hine et al. 1981). It is often associated with infection by *Aeromonas hydrophila*, a naturally occurring and widespread bacterium. Ordinarily, this pathogen only affects individuals whose immune systems have been weakened by stress and does not affect entire populations.

The fungal disease chytridiomycosis has been found repeatedly at the sites of mass deaths of amphibians

in Australia and North and Central America and was implicated in northern leopard frog declines in Colorado in the 1970s. Chytridiomycosis has now been reported from 38 species of amphibians, representing 12 different families (Daszak et al. 1999).

3.2 Sources of Information

Information about threats was compiled from a literature review.

3.3 Extent and Quality of Data

The northern leopard frog is one of the most studied amphibian species; therefore the quality of the data for the species is reasonably good. There is a significant amount of experimental toxicity research on this species; however, relating laboratory experiments to on-the-ground threats is difficult. We lack data for populations of northern leopard frogs in New Hampshire, so the threats to this species are drawn largely from the general literature and knowledge rather than from specific evidence for this species in New Hampshire. Clearly, the loss of farmland and grassland has resulted in loss of habitat for this species, and this threat remains today.

3.4 Threat Assessment Research

Additional research is needed to establish and thoroughly detail the threat that pesticides and contaminants pose to northern leopard frogs in New Hampshire. However, the most needed research is a systematic survey and mapping of the distribution of this species in the state. Determination of the location and sizes of extant populations is necessary to inform potential land management or protection aimed at this species. Documentation of the effects of development on northern leopard frog population dynamics and dispersal behavior is also vitally needed, as habitat loss and fragmentation and roads are the highest-ranking threats affecting this species.

ELEMENT 4: CONSERVATION ACTIONS

A lack of knowledge about northern leopard frogs in New Hampshire precludes specific conservation. Thus, 4.1.3 of the grassland habitat profile (Permanently Protect Grasslands), broadened to include

grassy riparian floodplains and associated aquatic breeding sites, constitutes the most important conservation action.

4.2 Conservation Action Research

Mapping potential northern leopard frog habitat and conducting a systematic survey for the species is the most critical research needed to inform conservation activities.

ELEMENT 5: REFERENCES

5.1 Literature

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SPECIES PROFILE

Ribbon Snake

Thamnophis sauritus

Federal Listing: Not listed

State Listing: Not listed

Global Rank: G5

State Rank: S5

Author: Kim A. Tuttle and M.N. Marchand, NHFG

ELEMENT 1: DISTRIBUTION AND HABITAT

1.1 Habitat Description

The common ribbon snake is a slender, semi-aquatic snake often observed near the edges of emergent marshes, wet meadows, scrub-shrub wetlands, beaver impoundments, bogs, river and stream floodplains, and vegetated shorelines of ponds and lakes (Ernst and Ernst 2003, M. Marchand personal observation). Ribbon snakes generally avoid deep water but will swim readily along the surface. Juveniles and gravid females may use uplands (Smith 2002), but the extent of use is not well established. Most ribbon snakes documented in New England have been found below 305 m (1,000 ft) elevation (Oliver and Bailey 1939, Klemens 1993).

Possible hibernacula include muskrat (*Ondatra zibethica*) bank burrows and lodges (Ernst and Ernst 2003), ant mounds, mammal tunnels, and rock crevices (Carpenter 1953, Hansknecht et al. 1999). Though ribbon snakes eat primarily amphibians (Carpenter 1952), they will also consume lesser amounts of mice, spiders, small fish, and insects.

1.2 Justification

The common ribbon snake was listed as a species of conservation concern in the northeastern United States due to a lack of data and a suspected decline (Therres 1999). The species is near the northern limit of its range in New England and is listed as a species

of special concern in Maine, Vermont, Connecticut and Rhode Island because of uncommon and localized populations that appear to have declined (Klemens 1993). Ribbon snakes could be used as indicator species (e.g., for contaminants) because of their dependence on amphibians as prey and use of both aquatic and upland habitats (Smith 2002). Also, ribbon snake occupation may indicate high quality wetland habitat that could support other species of conservation concern such as spotted turtle (*Clemmys guttata*), leopard frog (*Rana pipiens*), and blue-spotted (*Ambystoma laterale*) and four-toed salamanders (*Hemidactylium scutatum*) (Klemens 1993).

1.3 Protection and Regulatory Status

No special protection in New Hampshire.

1.4 Population and Habitat Distribution

Ribbon snakes occur east of the Mississippi River from southern Ontario and southern Maine to southeastern Louisiana and the Florida Keys, with isolated records from Nova Scotia (Ernst and Ernst 2003). Two subspecies, the eastern ribbon snake (*T. sauritus sauritus*) and the northern ribbon snake (*T. sauritus septentrionalis*) may occur in New England (Conant and Collins 1998). The range of the northern ribbon snake includes Nova Scotia and extends from southern Maine westward through New Hampshire, Vermont, and New York. The northern limit of the eastern ribbon snake includes the southern parts of Vermont, New Hampshire, and Maine (Conant and Collins 1998). Most Maine records are from York County, and no distinction was made between the two ribbon snake subspecies (Hunter et al. 1999).

In New Hampshire, the majority of records are from the south. County records of ribbon snakes include Carroll, Cheshire, Hillsborough, Merrimack,

and Sullivan (Oliver and Bailey 1939). A 1920 record from Sanbornton (Museum of Comparative Zoology Herpetology Collection at Harvard) is the only documented record for Belknap County.

Recent unverified reports from Sanbornton and New Hampton (Belknap County) suggest the need for further documentation. Recent verified observations of ribbon snakes include Groton (Grafton County), Rindge (Cheshire County), Amherst, Weare, and Lyndeborough (Hillsborough County), Pittsfield, Bradford, Hooksett, Allenstown (Merrimack County), New Durham, Lee, Rochester, Strafford, and Durham (Strafford County), and Portsmouth, Auburn, Raymond, and Nottingham (Rockingham County). There are no confirmed records of the ribbon snake in Coos County.

1.5 Town Distribution Map

1.6 Habitat Map

See Marsh and Shrub Wetlands map.

1.7 Sources of Information

Status and ranking information was taken from NatureServe (2005). New Hampshire RAARP records and Taylor (1993) were the primary source of locality records. Online museum collection databases (Museum of Comparative Zoology, Harvard and Yale Peabody Museum) were searched for historical records. Habitat and life history information was taken from published literature.

1.8 Extent and Quality of Data

The distribution, habitat use, and condition of ribbon snake populations in New Hampshire are not well understood. This assessment was limited to those records that were included in museum collections, were found in scientific reports, were reported to RAARP by a trained expert, or that included a specimen or clear photograph. Trained observers will likely result in many new town records.

1.9 Distribution Research

Encourage RAARP volunteers to identify and report ribbon snake locations, especially in those areas where

records are scarce (e.g. Belknap, Carroll, Grafton, and Sullivan counties). Systematic surveys and research are needed to provide more information regarding the condition and habitat requirements of populations. Ribbon snakes, and other rare reptiles and amphibians, should be incorporated into habitat inventories and management and restoration efforts.

ELEMENT 3: THREAT ASSESSMENT

Wetland loss and degradation and shoreline modification are the greatest threats to ribbon snakes. See Threats in Marsh and Shrub Wetlands habitat profile.

ELEMENT 4: CONSERVATION STRATEGIES

See Marsh and Shrub Wetlands habitat type for relevant conservation strategies.

ELEMENT 5: REFERENCES

5.1 Literature

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5.2 Data Sources

New Hampshire Reptile and Amphibian Reporting Program (RAARP) database. Maintained by the New Hampshire Fish and Game, Nongame and Endangered Species Program, Concord New Hampshire. Accessed 2005 February 14.

SPECIES PROFILE

Smooth Green Snake

Opheodrys vernalis

Federal Listing: None

State Listing: None

Global Rank: G5

State Rank: S3

Authors: Kim A. Tuttle and M. N. Marchand, New Hampshire Fish and Game

ELEMENT 1: DISTRIBUTION AND HABITAT

1.1 Habitat Description

Smooth green snakes may be found in a variety of open or lightly forested habitats such as pastures, old fields, wet meadows, marsh borders, coastal grasslands, pine barrens, blueberry barrens, and grassy hilltops (Klemens 1993, New Hampshire Reptile and Amphibians Reporting Program 2005). Smooth green snakes feed primarily on invertebrates including arthropods, caterpillars, grasshoppers, slugs and earthworms. Females may lay two or more clutches of well developed eggs a season, usually in July- August, in piles of rotting vegetation or sawdust, rotting logs and stumps or mammal burrows (Ernst and Ernst 2003). Ant mounds, rock crevices and mammal burrows may be used during hibernation (Carpenter 1953, Ernst and Ernst 2003).

1.2 Justification

Anecdotal accounts appear to indicate a decline in smooth green snake abundance since the mid-1900s in southern New England (Klemens 1993) and in other areas (Brodman et al. 2002). Since that time, many early successional habitats that smooth green snakes prefer have become reforested or have been converted to residential and commercial developments (Klemens 1993, SPNHF 2005). The maintenance of lawns and hayfields by mowing can lead to

direct mortality of individual smooth green snakes. Frequent mowing may reduce habitat suitability by altering the diversity of vegetation and soil moisture, potentially limiting the abundance of prey such as gastropods (Kjoss and Litvaitis 2001a). Insecticides reduce prey bases and direct mortality to smooth green snakes (George and Stickel 1949).

1.3 Protection and Regulatory Status

No special protection in New Hampshire.

1.4 Population and Habitat Distribution

The smooth green snake likely occurs throughout most of New Hampshire including documented records on Star Island, Isles of Shoals (Taylor 1993, D. Hayward, personal communication). A 2003 record from Berlin in Coos County represents the most northerly location in the state for this species. Other records for Coos County (i.e., Gorham, Shelbourne) are historic (Oliver and Bailey 1939). In a historic unpublished report, Donald Carle, a professor of science at Keene Teachers College, wrote "They have been reported at the tree line on Mount Monadnock in Jaffrey, on top of Mount Stinson in the White Mountains and at the tree line next to the cog railroad going up Mt. Washington."

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

The University of New Hampshire (J. Taylor, Zoology Department, and S. Hale, Complex Systems Research Center) was contracted to map predicted smooth green snake habitat. The New Hampshire Landcover data layer was the primary source of data.

Hayfields, pastures, and orchards were considered favorable habitats. Proximity to known smooth green snake locations was also incorporated. Maps will need field verification.

1.7 Sources of Information

Status and ranking information was taken from NatureServe (2005). New Hampshire Reptile and Amphibian Reporting Program (RAARP) records and Taylor (1993) were the primary source of locality records. Online museum collection databases (Museum of Comparative Zoology, Harvard and Yale Peabody Museum) were searched for historical records. The University of New Hampshire completed predicted habitat maps.

1.8 Extent and Quality of Data

The distribution, habitat use, and condition of smooth green snake populations in New Hampshire are not well understood. This assessment was limited to high quality records that were included in museum collections, were found in scientific reports, or were reported to the New Hampshire Reptile and Amphibian Reporting Program by a trained expert or reports that included a specimen or clear photograph. We suspect that smooth green snakes in towns with historic observations probably have not been extirpated but rather these areas have not received recent survey effort targeting this species.

1.9 Distribution Research

Systematic surveys (either taxonomically or habitat-based) are needed to assess the distribution, relative abundance and condition of populations in different habitats and how populations respond to habitat management (e.g., mowing, prescribed burns). Systematic surveys must first assess the most efficient sampling protocols (Kjoss and Litvaitis 2001b).

ELEMENT 2: SPECIES/HABITAT CONDITION

No information is available to evaluate the condition of smooth green snake populations in New Hampshire although they are thought to be in decline (See element 1.9).

ELEMENT 3: SPECIES AND HABITAT THREAT ASSESSMENT

The loss and degradation of early successional habitats and grasslands, along with frequent mowing or insecticide spraying, pose the greatest threats to smooth green snakes. See Threats in Grassland Habitat Profile for discussion of threats.

ELEMENT 4: CONSERVATION STRATEGIES

See associated habitat profiles for relevant conservation strategies.

ELEMENT 5: REFERENCES

5.1 Literature

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SPECIES PROFILE

Spotted Turtle

Clemmys guttata

Federal Listing: Not listed
State Listing: Special Concern
Affected Species: N/A
Global Rank: G5
State Rank: S3
Author: Michael, N. Marchand, NHFG

ELEMENT 1: DISTRIBUTION AND HABITAT

1.1 Habitat Description

Spotted turtles (*Clemmys guttata*) require large habitats with a diversity of wetland types and hydroperiods, and they tolerate only limited development of uplands and disturbance by humans (Fowle 2001, Joyal et al. 2001, Hinderliter 2003). Spotted turtle aquatic and wetland habitats include marshes, wet meadows, ponds, forested and shrub swamps, fens, shallow slow-moving streams and rivers, and vernal pools (Ernst et al. 1994, Fowle 2001).

Habitat use may shift seasonally and vary geographically, and overland movements among wetlands may be greater than 500 m (Milam and Melvin 2001). Vernal pools often are used extensively in spring and early summer (Joyal et al. 2001, Milam and Melvin 2001). Female spotted turtles usually lay eggs in open canopied uplands, generally between late May and early July (Ernst et al. 1994). Human-altered sites (e.g., pastures, road edges, yards, and agricultural areas) may be used (Carroll 1991, Joyal 1999, Joyal et al. 2001), as may hummocks in emergent wetlands (Milam and Melvin 2001). When summer temperatures are high, spotted turtles may estivate in permanent wetlands (fens, swamps, marshes, ponds, and rivers) and seasonal pools (Fowle 2001, Milam and Melvin 2001, Hinderliter 2003).

1.2 Justification

Spotted turtles use a large matrix of wetland and upland habitats, and because of life history characteristics (e.g., late age of maturity, low fecundity, and high adult survival) are extremely sensitive to small increases in mortality. And because spotted turtles need large protected areas with relatively limited development, maintaining viable populations of spotted turtles should benefit many other rare and common organisms. For example, habitat use may overlap with that of Blanding's turtle (*Emydoidea blandingii*); both species were found in similar shallow-water habitats in southern New Hampshire (Jenkins and Babbitt 2003).

The spotted turtle is declining throughout its range (Litzgus and Mousseau 2004) and is of conservation concern in the Northeast (Therres 1999). Spotted turtles are listed as endangered in Vermont, threatened in Maine, and a Species of Special concern in Massachusetts and New Hampshire. Because their habitat overlaps with the highest human population densities in New Hampshire, spotted turtles are particularly vulnerable in this area and are threatened especially by encroachment of roads.

1.3 Protection and Regulatory Status

- See Marsh and Shrub Wetland profile for regulations regarding wetland impacts.
- NHFG Rule FIS 803.02. Importation. Spotted turtles shall not be imported to New Hampshire
- NHFG Rule FIS 804.02. Possession. Spotted turtles shall not be possessed in New Hampshire
- NHFG Rule FIS 811.01. Sale of Reptiles. No person shall sell spotted turtles in New Hampshire

1.4 Population and Habitat Distribution

Populations range from southern Maine, south along

the Atlantic coast, to Florida, as well as to southern Ontario, New York, Pennsylvania, Ohio, Indiana, Michigan, and Illinois (Ernst et al. 1994). In New Hampshire, Huse (1901) reported that spotted turtles were found ‘everywhere’; however, Oliver and Bailey (1939) knew of only one documented occurrence. Towns with historic records (before 1985) but no recent verified records include Mount Vernon (Oliver and Bailey 1939), Goffstown (1982) and Pembroke (1983). The majority of known spotted turtle locations are concentrated in southeastern New Hampshire (See section 1.5). However, NHFG has received reports far from the core area in the southeast, including two reports in Ossipee, one report in Richmond, and two in Grafton and on the Enfield/Canaan border. An unverified report was received from Effingham, the town east of Ossipee. Though the record in Richmond is isolated from other reports in New Hampshire, reports in the adjacent Massachusetts town of Warwick (Massachusetts Natural Heritage Program) support the validity of this observation. Reports in the Grafton area need further investigation.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

Known spotted turtle habitats (element occurrences) were buffered conservatively by 500 m (Inferred Extent, NatureServe Element Occurrence specifications, 2002), and overlapping buffers were merged. These areas were considered occupied. For each occupied area, a number of variables was measured, including size (ha), area of potentially suitable wetland habitat (ha), conservation land (ha, percent), road density, and amount of development (ha, percent).

1.7 Sources of Information

Distribution information came largely from RAARP. High quality records were submitted to NHNHB and incorporated in the New Hampshire Rare Species Database (NHRSD). New Hampshire studies included an assessment by D. Carroll along the Lamprey River and a graduate research study by M. Hinderliter in 2003.

1.8 Extent and Quality of Data

Location records incorporated into the NHRSD consisted of high quality observations (photographs, specimens, or expert observer). Because spotted turtles are secretive and difficult to detect, focused efforts will likely result in new town records.

1.9 Distribution Research

- Ask RAARP volunteers to gather more information on towns with limited species distribution information and towns distant from the core New Hampshire population (e.g, Richmond, Ossipee, and Grafton/Enfield/Canaan).
- Conduct visual and trapping surveys at locations where the species has not been reported but is most likely to occur because of available habitat.
- NHFG should coordinate this effort and involve other state and federal agencies, universities, non-government organizations, and expert observers.

ELEMENT 2: SPECIES/HABITAT CONDITION

2.1 Scale

Habitat quality was assessed based on known occupied sites (500 m buffer around locations; see element 1.6).

2.2 Relative Health of Populations

There is little information on the abundance and condition of spotted turtle populations in New Hampshire. There are only 64 records (Element Occurrences) in the Rare Species Database maintained by the NHNHB (as of 8 April 2005), seven of which are considered historic (before 1985). Thirty-eight records consisted of 1 spotted turtle observation, and only 2 records in the database had greater than 10 observations. Eleven records were of individuals found only on roads.

2.3 Population Management Status

There is little management of spotted turtles in New Hampshire. Possession of spotted turtles, including manipulation of individuals for research, requires a permit from NHFG. Several individuals have been

permitted to conduct mark-recapture studies, and D. Carroll, who has extensive knowledge of turtle biology, has conducted long-term monitoring of a local New Hampshire population. A search for rare turtles (e.g., Blanding's, spotted, and wood, *Glyptemys insculpta*) was conducted in the Great Bay and Lamprey River areas, and 13 blocks of relatively extensive and contiguous suitable habitat were identified (Carroll 1999). In addition, 14 spotted turtles were monitored at sites in the coastal watershed as part of M. Hinderliter's graduate research.

2.4 Relative Quality of Habitat Patches

Sixty-five occupied habitat areas were mapped, ranging from 95 to 2,702 ha (mean 227 ha \pm 357 SD), and a 500 m buffer around known spotted turtle records restricted the possible sizes of occupied areas.

Roads are a major threat to spotted turtles. In southern New Hampshire, spotted turtles crossed roads in every month from April to August at all 3 sites where roads were near wetlands (Hinderliter 2003). Average road density in mapped occupied areas was 3 km/km² \pm 3 SD (range 0-16 km/km²). Thirty-one occupied areas lacked any state routes and interstates, and in these areas, the percent of residential development was 11 % \pm 18 SD (range 0-68 %). Only 2 sites had road densities less than 1 km/km², one of which was 0.9 km/km². The mean residential development within occupied areas was 13% \pm 20 SD (range 0-91%).

Large, unfragmented habitats with a diversity of wetland types will be necessary to maintain viable populations of spotted turtles (Milam and Melvin 2001, Hinderliter 2003). In general, an undisturbed buffer of more than 400 m around wetland edges may be necessary to protect nesting, estivation, foraging, and travel sites of local spotted turtles (Milam and Melvin 2001), and 430 ha of wetlands and uplands may be needed for a population of 600 adult spotted turtles (Fowle 2001).

2.5 Habitat Patch Protection Status

The percentage of conservation land in spotted turtle habitat was 15 % \pm 23 SD (range 0-99%); mean fee ownership was 13% \pm 22 SD (range 0-99 %) and mean conservation easement was 2 % \pm 6 SD (range 0-40 %). Fifty occupied areas had less than 20% of

land protected, 60 areas had less than 50% protected, and only 3 occupied areas had more than 70% protection.

Of these 3 areas, all had road densities greater than 1.0 km/km² and 2 were bisected by a major state route. The total area protected in occupied lands ranged from 0 to 730 ha (mean = 39 ha \pm 103). No mapped occupied areas were greater than 50% protected, had road densities less than 2 km/km², and lacked major routes.

2.6 Habitat Management Status

There is little management of spotted turtles in New Hampshire. Artificial nesting areas have been created in some areas as part of mitigation during NHFG review of wetland impacts and on other lands, but use of these nesting areas is unknown. Thirty-one wetland impoundments are managed, primarily for waterfowl, by NHFG, and spotted turtles occur in some of these areas.

2.7 Sources of Information

Available information on the condition of spotted turtle populations largely was a result of reports received from the RAARP and several localized research and inventory efforts (Carroll 1999, Hinderliter 2003). Using available data layers from various sources (e.g., University of New Hampshire Complex Systems), GIS were used to assess quantity and quality of known spotted turtle.

2.8 Extent and Quality of Data

Most records consist of only 1 or a few observations, and many were encounters on roads (see element 2.2). Wetland occupation and habitat use at a fine scale (e.g., wetland polygons) is poorly understood for most of the New Hampshire range of spotted turtles, though a few populations in southeastern New Hampshire have been studied in more detail (e.g., Hinderliter 2003).

2.9 Condition Assessment Research

- Continue to add and update spotted turtle records in the NHRSD in accordance with

Element Occurrence standards accepted by the NHFG and the NHNHBB

- Prioritize and continue existing research with other New England states
- Identify viable populations and assess population sizes and structures
- Assess population viability and habitat use on Conservation Land, especially in State Parks and Wildlife Management Areas. Short visual (e.g., basking and nesting) or trapping surveys should be used to assess the relative condition of populations. Because multiple uses of protected habitat might threaten spotted turtles, longer surveys should be conducted at a sample of conservation lands to assess effects of land use. Studying populations in these areas would lead to better management of areas not in conservation land and could provide benchmarks for comparison with populations in disturbed and fragmented areas

ELEMENT 3: SPECIES THREAT ASSESSMENT

Threats to spotted turtles are similar to those of Blanding's turtles (see Threat Ranking Form) and are not discussed in detail here. The greatest threats include loss and fragmentation of large wetland complexes due to development and road construction and mortality of adults from vehicles and, possibly, agricultural machinery. Commercial collection may be a larger threat to spotted turtles than to Blanding's turtles because of the spotted turtles' smaller size and value in the international pet trade. For a discussion of threats, see Blanding's turtle profile (element 3) and habitat profiles (especially Marsh and Shrub Wetlands, Vernal Pools).

3.2 Sources of Information

Information on threats came from literature reviews, summary reports, expert reviews, and available GIS data layers from various sources.

3.3 Extent and Quality of Data

Habitat fragmentation and loss, as well as road mortality of spotted turtles, are known threats. Potential threats such as disease, invasive plants, genetic isolation, and effects of agriculture and forestry in New

Hampshire are less understood.

3.4 Threat Assessment Research

- Evaluate the effects of land management (e.g., water level manipulation, agriculture, and recreation) on spotted turtles.
- Identify populations that are isolated by an anthropogenic barrier (e.g., high traffic road) and identify options for increasing connectivity for spotted turtles.
- Monitor spotted turtle populations (e.g., with radio telemetry) in areas where underpass systems have been installed or are proposed.

ELEMENT 4: CONSERVATION ACTIONS

- Protect spotted turtle habitat through acquisition, easement, and regulation (see Land Protection Strategies):
 - Protect large blocks of unfragmented habitat with a diversity of wetland complexes.
 - Use spotted turtle habitat to prioritize conservation of land.
 - Work with towns to protect critical habitat through land acquisition, prime wetland designation, and wetland buffer regulation.
 - Develop guidelines for landowners, managers, and towns to enhance and protect resources important to spotted turtles.
 - Maintain beaver flowages.
 - Minimize threats to wetlands such as vernal pools used by spotted turtles.
 - Maintain natural vegetation along wetland edges
- Promote wetland restoration, enhancement, and creation projects in areas that will benefit spotted turtles (e.g., restore shallow, wet meadow in agricultural areas) (see Marsh & Shrub Wetland strategies)
- Evaluate current protection status for spotted turtles and consider protection under New Hampshire Endangered Species Conservation Act (RSA 212-A). Develop guidelines for spotted turtles for use during environmental project reviews.
- Design roads and other transportation networks (e.g., railways, bike trails, sidewalks) to reduce threats to spotted turtles and other rare wildlife

- (see Roads strategies)
- Educate public about rules and regulations pertaining to spotted turtles and other reptiles and amphibians (e.g., sale and possession) through updated NHFG website and other media (see Wildlife Collection strategy)
- Reduce anthropogenic food sources for predators (see Predator control strategy)

ELEMENT 5: REFERENCES

5.1 Literature

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5.2 Data Sources

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- New Hampshire Reptile and Amphibian Reporting Program (RAARP). Coordinated by New Hampshire Fish and Game Department's Non-game and Endangered Species Program.

ELEMENT 6: LIST OF FIGURES

- Figure 1. Town distribution map of known spotted turtle locations in New Hampshire, March 2005. Town records reported included a photograph, specimen, or were reported by an expert observer. Most reports were received through the New Hampshire Reptile and Amphibian Reporting Program (RAARP).

SPECIES PROFILE

Timber Rattlesnake

Crotalus horridus

Federal Listing: Not listed

State Listing: Endangered

Global Rank: G4

State Rank: S1

Authors: James Taylor, University of New Hampshire; Michael Marchand, NHFG

ELEMENT 1: DISTRIBUTION AND HABITAT

1.1 Habitat Description

Timber rattlesnakes in the northeast spend the winter in a communal den, a rocky area with crevices leading to a hibernaculum below frost line (Brown 1993). They emerge from the den in May, and proceed to transient habitat, a relatively exposed rocky area where they can alternately bask and seek shelter from the sun; this may or may not be the den site. Males and non-gravid females often bask until the skin is shed, before making extensive movements into summer range habitat, often mixed deciduous forest. Gravid females are relatively sedentary and remain near exposed slopes and protective rocks until parturition, usually in September (Brown et al. 1982). Males pursue reproductive females by scent pheromone trails in order to mate with them, usually mid- to late summer. The resulting copulations provide sperm that is retained through hibernation for next years' ovulation (M. McCurley, personal communication).

The timber rattlesnake is a sit-and-wait predator, primarily preying on small mammals and birds to a lesser extent (Ernst and Ernst 2003). All individuals of the population return to the den in September. Depending on weather conditions, they may bask at the den, but they often go into the den immediately upon return. Young snakes may follow the scent trails of adults to find communal den sites (Reinert and Zappalorti 1988)

1.2 Justification

The Northeast Endangered Species and Wildlife Diversity Technical Committee determined that the timber rattlesnake is a species of regional concern in the northeastern United States. This species warrants federal endangered or threatened species listing consideration, including prelisting status reviews (Therres 1999). In New England, timber rattlesnakes are listed as extirpated in Maine and Rhode Island, and endangered in Connecticut, Massachusetts, Vermont, and New Hampshire. In New Hampshire, the timber rattlesnake is likely the most endangered of any wildlife species, as there is only one known extant population. Timber rattlesnakes have large home ranges, especially males, and individuals may be killed as they cross roads or as human-snake encounters increase (see element 3). Southern New Hampshire is rapidly developing, and large undeveloped tracts of land needed to sustain timber rattlesnake populations are dwindling rapidly. As a result, opportunities for natural recolonization or restoration have been substantially reduced.

1.3 Protection and Regulatory Status

Listed as state endangered and protected by the Endangered Species Conservation Act (RSA 212-A). A petition to list the timber rattlesnake as federally endangered was submitted in September 1991; this petition was rejected by the USFWS in January 1992.

1.4 Population and Habitat Distribution

Rattlesnakes have been historically reported from scattered locations throughout the southern half of the state, extending into the White Mountains. Clusters of reports came from along the Connecticut River in the southwest corner of the state, along the

Merrimack River, the Lakes Region, and from the edge of the White Mountains. Historic locations for timber rattlesnakes included Rattlesnake Island in Lake Winnepesaukee (reportedly the site of heavy nineteenth century depredations for the manufacture of rattlesnake oil (Oliver and Bailey 1939)), and other locations near the lake; the Mt. Thorn area in Bartlett (Allen 1899); Dan Hole Pond (Carle 1953) in Tuf-tonboro; Bear Brook State Park and Pinckney Hill in Allenstown and Rattlesnake Hill in Hooksett; the Mt Wantastiquet/Rattlesnake Mountain area of Hinsdale, Chesterfield, Swanzey and Winchester; and Fall Mountain in Walpole. Oliver and Bailey (1939) note that a Conservation Officer reported that rattlesnakes were occasionally killed in the Mt. Monadnock area, although these reports may not be confirmed.

In addition, there are many geographic features named for rattlesnakes in New Hampshire (table 1). Some of these were indeed probably named for the animal being present there, although one must bear in mind that almost all reports of rattlesnakes in recent times referred to milk snakes (*Lampropeltis triangulum*), a harmless snake which ‘rattles’ its tail against the ground when disturbed, making a sound that people may mistake for that of a rattlesnake.

There is now only one known extant population. No rattlesnakes were reported from 1981 to 1991, despite efforts to search for them at locations that they had traditionally inhabited, e.g., Pinckney Hill in Allenstown, Mt. Wantastiquet in Chesterfield, Dan Hole Pond in Tuf-tonboro (Carle 1958). In 1991, a forester accurately reported a rattlesnake to the author, and the den site was located in 1992.

1.5 Town Distribution Map

N/A

1.6 Habitat Map

UNH (J. Taylor, Department of Zoology and S. Hale, Complex Systems Research Center) completed a potential habitat map for timber rattlesnakes for New Hampshire. Maps for timber rattlesnake were primarily derived from the New Hampshire Landcover 2001 dataset, soils dataset, and the digital elevation model (UNH Complex Systems Research Center, GRANIT), as well as data on development and unfragmented forests. The landcover, soil, and aspect data layers were then combined to produce a final

layer with all possible combinations of favorable/non-favorable landcover and transient/non-transient soil types, and aspect categories. Various query combinations can be performed to extract polygons matching user-defined criteria. Finally, the maps were overlain with the location of all geographic features containing ‘rattlesnake’ in their name. There were no available soils data for Merrimack and Belknap counties, the White Mountain National Forest, and other parts of the North Country.

1.7 Source of information

The major sources of information included the authors’ professional experiences, scientific literature, historic newspaper articles, and personal communications with current experts and laymen.

1.8 Extent and Quality of the Data

Historical occurrence data are good, although the extent to which geographic features with ‘rattlesnake’ in their names actually attest to existence of the animals at that location is uncertain. In addition, not all historic den sites within larger known metapopulations are likely documented.

1.9 Distribution Research

Field-survey sites historically occupied by timber rattlesnakes in New Hampshire and those identified as potential through habitat mapping efforts (see element 1.6). Site assessments should include an assessment of potential habitat based on surrounding land-uses. All potential reports from the public should be forwarded to one contact person at NHFG. NHFG biologists or individuals contracted by the state should follow-up on any credible reports of rattlesnakes in undocumented locations.

ELEMENT 2: SPECIES/HABITAT CONDITION

2.1 Scale

The information discussed in this profile focuses on the one known extant population but discusses historic populations when appropriate.

2.2 Relative Health

The condition and viability of the extant population needs further detailed evaluation. Based on limited information, the population seems relatively stable over the last decade, and reproductive females continue to produce viable offspring. However, because there is only one known den site, the population is extremely vulnerable to human-induced or natural extirpation resulting from demographic or environmental stochasticity. There are also concerns about the genetic health of the population and the possibility of genetic drift and inbreeding depression (see element 3, Threats).

2.3 Population Management Status

No official population management occurs for timber rattlesnakes at this time. The known population is periodically monitored by conservation officers at NHFG, biologists, and expert naturalists.

2.4 Relative Quality of Habitat Patches

At the known extant site, existing habitat quality is relatively high. Most of the summer range is undeveloped continuous mixed deciduous forest, some of which is in protected as conservation land, and road density is low. However, much of the critical habitat is on private land. Because rattlesnakes roam widely (> 5 km) Brown 1993), one occasionally leaves the forested summer range and enters human development, where it may encounter humans (see element 3-Threats).

Several sites bearing the rattlesnake have been destroyed by gravel extraction activities or development (see element 3-Threats). A historic den site at Pinckney hill, in close proximity to Bear Brook State Park was apparently active at least up to 1983 (A. Chaput, personal communication) and was the site of the killing of 10 adult timber rattlesnakes by the landowner in September, 1976 (H. Laramie, personal communication).

2.5 Habitat Protection Status

The area of habitat currently permanently protected is not sufficient to maintain a population or meta-

population of timber rattlesnakes in New Hampshire (see Conservation Actions).

2.6 Habitat Management Status

Habitat protection is a top priority for this species in New Hampshire, either through fee-simple acquisition or acquisition of conservation easements (see Conservation Actions). Some activities such as limited forestry may not be detrimental long-term to timber rattlesnakes, especially if conducted during frozen conditions and the den site is not harmed. Limited managed timber harvesting may provide openings in the forest canopy that provide opportunities for basking individuals. However, this needs further review; a habitat and population management plan needs to be created for this site.

2.7 Sources of Information

The site has been periodically monitored by biologists, expert naturalists, and conservation officers. Other sources of information include a timber rattlesnake assessment for the White Mountain National Forest (Sweeney and Marchand 2002), historical documents (Oliver and Bailey 1939, Carle 1958), and an on-site assessment conducted by Bill Brown (Brown 2002).

2.8 Extent and Quality of the Data

Several individual rattlesnakes from the extant population have been monitored by radio-telemetry in recent years, but movement data are limited for the site, especially for males. Hibernacula and important basking sites are known, but unknown sites may exist. The condition of several historically occupied den sites has been evaluated, but other sites need further field surveys.

2.9 Condition Assessment Research

Annual monitoring should be expanded to include regular monitoring of the den and basking sites, as well as summer activity of males. At a minimum, annual counts of the number of snakes entering and exiting den sites and the number of young born and surviving winter should be conducted. Marking individual snakes (e.g., colored rattle) will help determine biological parameters of the populations, movement

patterns, and identify individuals that are observed at a distance from the den site. Historic or potential den sites should be evaluated for potential expansion of the known site. Genetic studies should be conducted to assess local genetic distinctiveness and possible effects of small population sizes.

ELEMENT 3: SPECIES AND HABITAT THREAT ASSESSMENT

3.1.1 Scarcity (Natural Rarity)

(A) Exposure Pathway

Problems with small population size are well supported in ecological theory (Meffe and Carroll 1998). The population growth rate of the timber rattlesnake in the northern part of its range is survival-limited, with late female sexual maturity (7-11 years, Brown 1991), individual reproduction at 3 to 4 year intervals (Brown 1991), small litter size (6-9 on average, but as low as 3 observed in New Hampshire), and high juvenile mortality (Brown 1993). Because of these traits, recovery of a depleted population is slow. Such a life history requires a long adult lifespan with low adult mortality, and in a small population, the premature death of a single adult may significantly harm a local population. Small populations are also susceptible to genetic drift, inbreeding depression, and demographic and environmental stochasticity (Meffe and Carroll 1998). Brown (1993) estimated that a minimum population size of timber rattlesnakes to be viable might consist of 30-40 individuals, including at least 3-5 reproductive females (Brown 1993). However, if adult mortality were increased by human actions, a population of this size would likely not be viable.

(B) Evidence

Individual timber rattlesnakes from a hibernaculum in Pennsylvania were more closely related to each other than they were to snakes from other hibernacula, suggesting inbreeding (Bushar et al. 1998). Since there is only one known den in New Hampshire, this problem may be exacerbated. Most timber rattlesnake populations have a mixture of black phase and yellow phase individuals. The New Hampshire population is unusual in that most individuals are strongly melanistic. However, Art Chaput (personal communication) once told the author that he had seen yellow phase individuals in New Hampshire, and an old local news-

paper photograph shows a man with what appears to be a yellow phase animal. The loss of the yellow phase and colorations unknown in other timber rattlesnake populations suggest possible future genetic challenges in this population due to genetic drift and/or inbreeding depression. At least one newborn had a scoliotic spine with external adhesion, probably a birth defect (H. B. Bechtel, MD, personal communication). However, the genetic characteristics of the extant population need further analysis.

3.1.2 Development

(A) Exposure Pathway

Residential and commercial developments may directly destroy habitat (den sites, basking sites, transient, summer range) required by local rattlesnake populations. As a result, prey sources may be reduced, preferred vegetation may be altered, and snakes may become more vulnerable to humans and other predators. NHFG may have to dedicate significant time to relocating snakes that are found in human developments. Automobiles can result in direct mortality of individuals (Aldridge and Brown 1995), and road construction near rattlesnake populations will increase access to those areas. Recreational demands (e.g., ATV, bike, and hiking trails) on private and public lands may also impact rattlesnake populations by increasing snake-human encounters.

(B) Evidence

Male rattlesnakes are especially vulnerable during mating season, when they are more likely to encounter humans and cross roads (Aldridge and Brown 1995). Several individuals have been found in residential developments in New Hampshire, at least two snakes being killed by local residents. Much of the known timber rattlesnake habitat is on private land and residential and/or commercial developments will likely be proposed over time if these lands are not protected. Effects of recreational activities on the current population need further evaluation.

3.1.3 Development (Habitat Loss and Conversion)

(A) Exposure Pathway

Timber rattlesnakes congregate in den sites during winter. Extracting of gravel or rock at the den site

will destroy a critical habitat component for local rattlesnake populations. In addition, large vehicles carrying rock and gravel could kill individual snakes if within transient or summer range habitat. In New Hampshire, there is only one known den site, so any disturbance to the den site or surrounding habitats could be catastrophic.

(B) Evidence:

Several sites in New Hampshire having “rattlesnake” names are currently or have been destroyed by commercial mining extractions (e.g., Rattlesnake Mountain, Concord; Rattlesnake Hill, Hooksett).

3.1.4 Unregulated Take

(A) Exposure Pathway

All other populations in New Hampshire have been destroyed by human actions. People tend to fear snakes, especially venomous species, and will kill snakes when they are encountered. In addition, because snakes congregate at den sites, knowledgeable collectors (commercial pet trade, personal use) are capable of depleting or eliminating local populations (Tynning 1992, Klemens 1993). In fact, one individual, Rudy Komarek, has reportedly greatly contributed to population depletions, including populations in New York and Massachusetts (Brown et al. 1994). The current New Hampshire population is vulnerable to illegal killing and collection. As a survivorship-limited species, loss of a single reproductive female from the remaining population may be enough to reduce the net reproductive rate below what is sustainable, leading to local and state extinction.

(B) Evidence

Unregulated take and persecution are undoubtedly the reasons behind extirpation of populations at traditional locations. Legislation once encouraged the killing of rattlesnakes, and zealous collectors and “bounty” hunters have decimated populations in the state.

3.2 Sources of Information

Sources included professional experiences, direct observation of the extant population, and searches of traditional locations, literature reviews, and personal communications.

3.3 Extent and Quality of Data

The major threats to the extant population are known. The frequency of unregulated take and other sources of unnatural mortality are probably not completed known.

3.4 Threat Assessment Research

Constant monitoring of the population is required to document potential and actual threats to the only known extant population.

ELEMENT 4: CONSERVATION ACTIONS

As a first step to protecting timber rattlesnakes in New Hampshire, the NHFG needs to develop a detailed recovery plan for timber rattlesnakes in New Hampshire. This plan will more thoroughly detail monitoring and research needs, education and technical assistance, habitat protection, restoration and management, and recovery goals. To ensure that timber rattlesnakes are not extirpated from New Hampshire, conservation efforts should focus on maintaining and/or restoring multiple metapopulations in New Hampshire, which will require a combination of efforts. The immediate primary goal is to protect the known existing population. Specific recovery goals need to be established. Specific conservation objectives and monitoring responses will be evaluated for this plan based on available information and will be updated as new monitoring or other information becomes available. In the interim, the status of the extant population must be monitored intensely each year.

4.1.1 Habitat Protection

Habitat protection will be critical to the future survival of timber rattlesnakes in New Hampshire. Ideally, all habitat used by female rattlesnakes should be protected, along with known habitat used by male snakes, and dispersal corridors to other historic or potential den locations. It is imperative that the areas around the den be afforded maximum protection and that all activities proposed in the protected area be compatible with timber rattlesnake conservation. Land values in southern New Hampshire are high, and a large land purchase will require a coordinated

effort among state agencies, conservation agencies, municipalities, and private funding.

4.1.2 Technical Assistance and Education

Information about the perilous state of the rattlesnake in New Hampshire should be made available to those close to (e.g., residential neighborhoods) or working in the summer range of occupied timber rattlesnake habitat (e.g., foresters), and the general public (NHFG website, press releases), along with information about rattlesnake biology, contact information in case a rattlesnake is encountered, and penalties for harming, harassing, or killing a rattlesnake. However, secrecy about the exact location is critical in preventing unscrupulous people from destroying individuals or critical habitat components (Brown 1993).

4.1.3 Restoration and Management

Timber rattlesnake populations are known to exist in a metapopulation structure, with several den sites within dispersal distances of each other. In New Hampshire, only one den is known to remain, although habitat in close proximity may remain.

Captive breeding has been successfully initiated for other endangered fauna in New Hampshire (e.g., Karner blue butterfly). Although captive breeding of rattlesnakes is relatively new, there are individuals and organizations within New England that have the experience to at least begin experimental captive breeding. Goals of captive breeding would include maintaining a genetic stock of New Hampshire rattlesnakes, in the event that a catastrophic event occurs in the natural population. Captive-breed individuals could also be used to augment the natural population, both in terms of number of individuals and genetic material. Appropriate methodology for breeding and releasing individual snakes would require detailed discussion prior to taking any actions.

Translocation of rattlesnakes to formerly occupied dens has been suggested as a possible conservation strategy (Brown 1993). However, this technique needs further evaluation and intense monitoring if implemented (see Dodd and Seigel 1991). In studies of nuisance timber rattlesnakes translocated from state parks in North Carolina to less populated areas, Sealy (1995) found that the snakes did not thrive. Reinert and Rupert (1999) conducted a controlled

radiotelemetry study in which behavior of translocated rattlesnakes was compared to that of residents and found immediate and long-term negative effects of translocation. There are too few rattlesnakes in New Hampshire to attempt this at present without the initiation of a captive breeding program. Release of captive-raised neonates to augment existing populations may be a more feasible option (Conner et al. 2003).

Appropriate habitat management in rattlesnake habitat will be addressed when a full recovery plan is developed. Likely, there should be several buffers of varying distances from the den and basking sites that allow different levels of management and recreational activities (Brown 1993). Appropriate habitat management must be clearly communicated to those involved (e.g., foresters).

Although not a primary conservation technique, fencing to prevent rattlesnakes from entering private property or other threatening habitat has been suggested. However, preventing rattlesnakes from accessing habitat could be considered take of an endangered species habitat (Amato and Rosenthal 2001). Fencing should not be used as a justification for the construction of residential or commercial structures in rattlesnake habitat. Fencing may be a viable option if snakes continually enter an existing residential area at the periphery of the snakes' summer range.

4.1.4. Regulation and Policy

Continue to actively pursue and enforce violations that involve humans illegally killing rattlesnakes. Monitoring of the local population will help determine what habitat should be reviewed and protected during NHFG's review of proposed developments.

4.2 Conservation Action Research

The extant population must be monitored to assess viability and success of proposed conservation actions. For example, individual age-specific survivorship and reproductive data should be taken annually so that over time life-table methods can be used to estimate the net reproductive rate. The genetic structure of the existing New Hampshire population should be analyzed and compared to other populations in the region.

ELEMENT 5. REFERENCES

5.1 Literature

[For thorough bibliographies on timber rattlesnakes, see Bill Brown (1991, 1993)]

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SPECIES PROFILE

Wood Turtle

Glyptemys insculpta

Federal Listing: Not listed

State Listing: Special Concern

Global Rank: G4

State Rank: S3

Authors: Heidi Holman and Michael Marchand,
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ELEMENT 1: DISTRIBUTION AND HABITAT

1.1 Habitat Description

Wood turtles (*Glyptemys insculpta*) are associated with rivers and streams with hard sand or gravel substrate (Ernst et al. 1994) but make extensive use of surrounding uplands during the summer (Compton et al. 2002, Tuttle and Carroll 2003). Turtle terrestrial activity often is within 300 m of streams and rivers (Kaufmann 1992, Arvisais et al. 2002). Habitat use and home range may vary among individuals of a local population (Kaufmann 1992, Compton 2002).

A mosaic of river or stream, forest, dense shrub thicket, and bare sandy substrate may attract turtles and provide habitat for a higher density of turtles (Kaufmann 1992). In Maine, wood turtles were near streams and rivers that had moderate forest cover (Compton et al. 2002). Within activity areas, wood turtles in Maine selected areas that were near water, were non-forested, and had low canopy cover (Compton et al. 2002). Compton et al. (2002) attributed this difference in selection at the 2 spatial scales to a preference for forest edges, where basking and feeding opportunities are abundant. Some disturbances (e.g., agriculture, hayfields, gravel pits) may provide habitat heterogeneity that wood turtles prefer.

Wood turtles can be found closer to the river after emerging from hibernation in late April and May (Tuttle 1995). At this time, and throughout the summer, dense riparian and early successional shrub

thickets are extremely important cover (Kaufmann 1992, Compton 2002, Arvisais et al. 2004). Alder (*Alnus spp.*), dogwoods (*Cornus spp.*), and arrowwood (*Viburnum spp.*) are good cover plants along riparian areas and other edges (D. Carroll, personal communication). A mixture of herbs and grasses (e.g., meadow-sweet, *Spiraea latifolia*, goldenrod *Solidago spp.*), shrubs (e.g., dogwoods), and vines (e.g., woodbine *Parthenocissus quinquefolia*, grape *Vitis spp.*) reduce detection by humans and other predators and provide abundant food for the turtles (D. Carroll, personal communication). Food includes green leaves, earthworms, fruit, fungi, insects, and carrion (Ernst et al. 1994, Niederberer and Siedel 1999). Emergent marshes, swamps, and vernal pools may be used during spring and summer (Hunter et al. 1999, Arvisais et al. 2004), and at night wood turtles enter shallow forms under grass, leaves and brush, fallen logs, and flood debris (Harding and Bloomer 1979, Ernst 1986, Farrell and Graham 1991).

Female wood turtles lay eggs during late May and early July in sparsely vegetated, sandy-gravelly, well-drained soils, often near water (Harding and Bloomer 1979, Klemens 1993, Buech et al. 1997). Nests may be excavated in natural (e.g., sandbars, sandy banks) and anthropogenic (e.g., gravel and sit pits, railroad beds) sites (Brooks et al. 1992, Tuttle and Carroll 1997, Buech et al. 1997). Hatchlings emerge from the nest chamber between mid August and early October (Ernst et al. 1994).

Turtles return to the river daily in September and October before settling into hibernation before mid November (Tuttle 1995). Hibernation sites include undercut banks, submerged tree snags, and woody debris in rivers, wildlife burrows, and deep pools (Garber 1989, Ernst and McBreen 1991). Most wood turtles hibernate in the same location annually (Garber 1988) and may hibernate communally (Harding and Bloomer 1979).

1.2 Justification

The wood turtle is a species of concern in the northeast that warrants federal endangered or threatened species listing considerations (Therres 1999). Though many states across the species range have reported declines, population structures with a disproportionate number of adults, or local extirpations (Ross et al. 1991, Garber and Burger 1995, Ernst 2001a). The wood turtle is listed as a species of special concern in Maine (Hunter et al. 1999), Massachusetts (Massachusetts Natural Heritage and Endangered Species Program 2004), Connecticut, and New Hampshire, and is listed as a species at risk in Vermont (Vermont Nongame and Natural Heritage Program 2000). Wood turtles were once one of the most common turtle species in New Hampshire (Oliver and Bailey 1939).

Life history traits including late sexual maturation (Ontario: 17-18 years, Brooks et al. 1992) and limited fecundity (Garber 1989, Farrell and Graham 1991, Ross et al. 1991, Brooks et al. 1992) make wood turtles extremely vulnerable to increased adult mortality. Wood turtles depend on high rates of adult survival to compensate for large mortality in the early stages of life. A model developed by Compton (1999) predicted that the annual removal of only 2 adult wood turtles from a stable population of 100 individuals would result in the extirpation of the population in fewer than 80 years.

As human populations expand in New Hampshire, development and disturbance will likely harm the wood turtle (Tuttle and Carroll 1997; M.N. Marchand, personal observation.)

1.3 Protection and Regulatory Status

- Convention on International Trade of Endangered Species (CITES) Appendix II restricts the import and export of the species from the country.
- A petition to list the wood turtle as threatened under the Endangered Species Act by the Federal government was refused in the mid 1990s, when the United States Fish and Wildlife Service (USFWS) stated the petition did not present “substantial scientific or commercial information indicating that listing the species is warranted” (USFWS 1995).

- New Hampshire Fish and Game (NHFG) Rule Fis 803.02. Wood turtles shall not be imported to New Hampshire.
- NHFG Rule Fis 804.02. Wood turtles shall not be possessed in New Hampshire.
- NHFG Rule Fis 811.01. No person shall sell wood turtles in New Hampshire.
- Fill and Dredge in Wetlands; New Hampshire Department of Environmental Services (NHDES, RSA 482-A, Wt 302). Projects that propose to impact jurisdictional wetlands or the banks or channel of rivers or stream are reviewed by NHDES and NHFG.
- Comprehensive Shoreland Protection Act; NHDES (RSA 483-B). Applies to waterbodies larger than 4.05 ha (10 acres). Restricts work conducted within 76.2 m (250ft) from fourth order or greater streams (e.g., tree, shrub and groundcover removal) and requires primary structure setback of 15.24 m (50 ft). Individual towns have the authority to extend these regulations to lower order streams and smaller bodies of water.
- Rivers Management and Protection Program; NHDES (RSA 438) designates rivers in New Hampshire for protection of cultural or natural resources. Established to protect public uses and includes habitat protection. No channel alteration activities shall be allowed in rivers designated as “natural”. No dams will be built on rivers designated as natural, rural, or rural community rivers. A protected instream flow level shall be established for each designated river. No motorized watercraft are allowed on designated natural rivers. Within 15.24 m (50ft) of a stream, 50% of basal area of trees cannot be cut. For fourth order streams and higher this extends to within 45.72 m (150 ft).

1.4 Population and Habitat Distribution

Wood turtle range extends from Maine to Minnesota, south to Virginia and Iowa in the United States, as well as from Nova Scotia to Ontario (Ernst et al. 1994). The northeast United States comprises a significant portion of the wood turtle’s global range (Therres 1999). Wood turtles appear to be distributed throughout New England but are less common in coastal zones (Klemens 1993).

In New Hampshire, wood turtles likely occur throughout much of the state, excluding higher altitudes such as the White Mountains Region (Taylor 1993, New Hampshire Natural Heritage Bureau (NHNHB) 2005). High elevation records for southern New England include 442 m (1,450 ft) at Norfolk, Connecticut, 497 m (1,630 ft) Becket, Massachusetts, and 518 m (1,700 ft) Plainfield, Massachusetts (Klemens 1993). Scarcity of deep, low gradient streams, as opposed to altitude, may be the limiting factor at high elevation (Klemens 1993). Historical town locations identified by Oliver and Bailey (1939) included 12 towns with no recent records (before 1985).

1.5 Town Distribution Map

1.6 Habitat Map

Wood turtle habitat was mapped at 2 scales: known occupied sites and watersheds. Known wood turtle records (Element Occurrences, New Hampshire Natural Heritage Bureau Rare Species Database) were assigned to the closest point in a river or stream. These stream locations were then expanded to include areas 0.5 km up and downstream (Inferred Extent, Nature-Serve Element Occurrence specifications) as well as 300 m of adjacent uplands. These areas were considered occupied habitat patches.

A second scale was created using the 12-digit watersheds (HUC-12) to map potential habitat. Non-tidal rivers and streams below 550 m elevations were buffered by 300 m, marsh and shrub wetlands partially within this buffer were included in entirety. Because use of deep, open water habitat by wood turtles has not been observed, lakes were removed from the potential habitat model. The potential habitat map was meant to be inclusive rather than exclusive. Therefore, over prediction of potential habitat is likely, and this map will be refined based on field inventory and updated Geographic Information System (GIS) data layers.

1.7 Sources of Information

Habitat information came from peer-reviewed literature and a wood turtle species viability report conducted by the White Mountain National Forest (unpublished document, originally prepared by K.

Marchowsky 2001; revised by M. Marchand 2002). The Reptile and Amphibian Reporting Program (RAARP) and NHNHB databases were used to assess distribution. Neighboring state websites were consulted for recent distribution information. Habitat maps were produced by NHFG using available GIS data layers from various sources (metadata available upon request).

1.8 Extent and Quality of Data

Observations from RAARP were reviewed for quality before inclusion. However, distribution information is not complete, and new town records are likely. Information has been collected on a few populations by researchers conducting mark-recapture studies, and Tuttle and Carroll (1997, 2003) conducted an intensive population study for NHFG in the early 1990s.

1.9 Distribution Research

Potential wood turtle habitat within watersheds will be evaluated by GIS analysis to identify and prioritize future survey efforts. Multiple RAARP observations in a particular section of a watershed may indicate high priority areas for surveying efforts. Surveys would verify if a watershed provides likely habitat.

ELEMENT 2: SPECIES/HABITAT CONDITION

2.1 Scale

Habitat condition was assessed based on occupied and potential habitat patches with HUC-12 watersheds.

2.2 Relative Health of Populations

Conditions of most populations are not known. Wood turtles were reported in 78 towns at 108 various locations. Sixteen records reported more than 1 individual. Nine dead individuals were reported (2 males, 3 females, 3 juveniles and 1 unidentified). Sixteen reports were near roadsides; 6 of 9 deaths were among these (2 males, 1 female, 3 juveniles). Nesting has been observed in 9 reports; this included actual nesting or behavior indicative of nesting.

2.3 Population Management

There is no management of wood turtles by the NHFG. Independent researchers (e.g., David Carroll) and universities (St. Anselm's, Plymouth State) in the state are conducting local monitoring, mark-recapture, and radio telemetry studies.

2.4 Relative Quality of Habitat Patches

There are 327 12-digit watersheds in New Hampshire. Ninety-three watersheds had known wood turtle habitat, and potential habitat occurred in the 93 occupied watersheds as well as 226 additional watersheds (table 1). Only 8 watersheds were not mapped as potential wood turtle habitat; these watersheds were all in northern New Hampshire and continued into Maine. Most attributes measured were similar among occupied and potential watershed units. However, only 1 occupied watershed lacked any state routes and interstates in potential or known wood turtle habitat, compared to 23 potential watersheds.

2.5 Habitat Patch Protection Status

The total area of known and potential wood turtle habitat protected in occupied watersheds ranged from 0 to 2,193 ha (mean = 518 ha). Only 29% (27 of 93) of occupied watersheds had more than 20% protection of wood turtle habitat (table 2), though a number of watersheds where wood turtles have not been documented have a greater degree of protection. The actual habitat quality of these protected areas is not known and should be ascertained. Also, areas listed as conservation land may not be protecting wood turtles because of permitted land or recreational uses. Therefore, protection status for wood turtles may be much lower than what is represented in the conservation lands data layer used for these analyses.

2.6 Habitat Management Status

There is no habitat management being conducted for the wood turtle by NHFG, although recommendations pertaining to wood turtles have been made to private landowners by NHFG.

2.7 Sources of Information

Condition information was obtained from the NHNHBB Element Occurrence database. Additional GIS data layers were used to analyze habitat quality.

2.8 Extent and Quality of Data

Wood turtle may occupy many of the available watersheds in the state, but only portions of watersheds have been documented (93 known of 319 potential), and only a few populations have been studied in detail through mark-recapture and radio telemetry.

2.9 Condition Assessment Research

Surveys should be conducted in areas that most likely support large remnant populations (vis-à-vis historical and current observation, lack of threats, adequate nesting and hibernation sites, undeveloped upland habitat). A multivariate analysis could be conducted to determine watershed characteristics associated with wood turtle occupancy. Long-term studies should be conducted on a few populations to assess and monitor viability. These studies should be coordinated with universities and other researchers and be consistent with other regional efforts.

ELEMENT 3: SPECIES THREAT ASSESSMENT

Additional threats specific to habitats used by wood turtles can be found in relevant Habitat Profiles (e.g., Watersheds, Marsh and Shrub Wetlands, and Floodplain Forests). See form 2: Threat Ranking for details on all threats considered.

3.1.1 Development (Fragmentation, Habitat Loss and Conversion)

A) Exposure Pathway

Residential and commercial development results in loss of upland habitat for wood turtles. Conversion of disturbed sites (e.g., gravel pits) to impervious surfaces or manicured lawns reduces the quality of nesting habitat. Increased recreation (e.g., hiking and water sports) along streams and rivers can result in removal of dense riparian vegetation and trampling of sandbars and other potential nesting areas.

B) Evidence

Habitat loss and fragmentation are the main threats to wood turtles throughout their range (Kaufmann 1992, Ernst 2001a). In New Hampshire, large wetland systems are being bisected by development, especially in the southern portion of the state (Tuttle 1995) and the human population and associated development is rapidly expanding (Society for the Protection of New Hampshire Forests 2005).

Wood turtles use upland habitats extensively during the summer (Ernst 1986, Kaufmann 1992, Tuttle and Carroll 2003, Arvisais et al. 2004). Development and other alterations within the summer activity range of wood turtles may result in mortality and injuries to wood turtles (Harding and Bloomer 1979, Saumure and Bider 1998, Marchand and Litvaitis 2004), as well as loss of protective vegetative cover.

3.1.2 Transportation Infrastructure

A) Exposure Pathway

Increasing human population is associated with increasing road densities and traffic volume, as well as with road widening. Turtles are relatively slow when traveling through upland habitat, and individual turtles are extremely vulnerable when crossing moderate to high traffic roads. Small annual losses of only a few adult wood turtles may result in population extirpation.

B) Evidence

Roads located near local turtle populations can lead to mortality of individual and altered population structures, including skewed age or sex ratios (Ernst and McBreen 1991, Klemens 1989, Garber 1989, Marchand and Litvaitis 2004, Steen and Gibbs 2004).

Sixty-seven percent (6 of 9) of dead wood turtles reported in New Hampshire were located on roads (New Hampshire Natural Heritage Bureau 2005). There are 23 watersheds with no major roads in potential wood turtle habitat, but only 1 known occupied watershed without major roads. The mean number of stream road crossings per occupied watershed is 30.

3.1.3 Recreation

A) Exposure Pathway

Converting abandoned railways to active hiking and

biking trails (i.e., Rails to Trails) may reduce nesting habitat available to turtles and increase human-wood turtle encounters, leading to collection of individuals. The construction of parking lots at recreation areas may increase injuries or mortality of individual wood turtles, and injuries or mortality resulting from domestic dogs could be a factor in recreation areas with walking trails. Canoeists may harm nest sites on beaches, and Off-Highway Recreational Vehicle (OHRV) use in riparian corridors could result in collision with individuals and destruction of nests.

B) Evidence

Most recreational threats to wood turtles are anecdotal. However, a long-term study in Connecticut documented the extirpation of 2 wood turtle populations following an increase in human recreation (Garber and Burger 1995).

3.1.4 Unregulated Take

A) Exposure Pathway

Commercial collection is a major threat to wood turtles. Wood turtles often hibernate in groups, making them easy for collectors to find.

B) Evidence

Illegal collection has eliminated entire populations of wood turtles in some areas (NatureServe 2005), though the NHFG has no evidence of commercial collection of wood turtles in New Hampshire. However, reptile dealers have advertised wood turtles in New Hampshire in the past (Levell 2000). In 1992 a wood turtle sold for \$75, and in 1994 a pair sold for \$275 (RESTORE: The North Woods et al. 1994). Adults, which are crucial to population stability, are collected most often because they are easy to find (Ernst 2001b).

3.1.5 Altered Hydrology

A) Exposure Pathway

Dams alter the flow of a stream, and the impoundment of water and regulated release may reduce natural erosion processes that create nest sites, and may flood any nests that are laid when water levels are low. Also, turtles hibernating in the undercut banks of streams may freeze when water discharge is stopped. Dams or ineffective culverts under roadways

may impede the movement of turtles, fragmenting populations and reducing gene flow. Channelization of streams may also alter stream flow by increasing water velocity, causing sections of river to be unusable for the wood turtle. Dredging may cause sediment loading in rivers, degrading water quality. The use of riprap along shorelines reduces availability of food and cover vegetation.

B) Evidence

At a dam site in Maine, female wood turtles delayed nesting and eventually relocated their nest sites due to lack of water flow needed to maintain nesting areas (Compton 1999). Water releases resulted in the flooding of 25% of nests at the site each year. Flooding later in the season could result in a higher mortality rate of developing wood turtle embryos.

3.1.6 Agriculture

A) Exposure Pathway

The maintenance of agricultural crops and hayfields may result in injury to adult turtles using the area during the summer. The loss of individuals, especially adult females, can have a severe impact on the population due to the low recruitment of juveniles into the breeding population.

B) Evidence

Observed effects of agriculture on a wood turtle population include lower numbers of juveniles, decreased growth during the second decade of life, and increased shell injury (Saumure and Bider 1998). Numerous wood turtles in New Hampshire have been found in hay pastures dead from apparent collision (M. Marchand, personal observation). Female wood turtles have been observed nesting in agricultural fields (Kaufmann 1992), which increases the risk of collision and nest loss.

3.2 Sources of Information

Reviewing literature identified threats to wood turtles throughout the species' range. Threats were ranked based on databases, survey reports, literature reviews, and personal experiences by the authors.

3.3 Extent and Quality of Data

There is a lack of information about commercial and casual collection occurring in the state. Without knowing the location of large populations, threats are difficult to monitor. Potential threats such as disease, invasive plants, genetic isolation, and effects of forestry activities in New Hampshire are also less understood.

3.4 Threat Assessment Research

Identify and assess threats (e.g., trails, agricultural areas, and gravel pits) to specific populations, including those in conservation land, and develop local conservation actions.

ELEMENT 4: CONSERVATION ACTIONS

- Use occupied habitats to prioritize conservation of land through acquisition, development restrictions, and mitigation, and work with towns to protect critical habitat through land acquisition, prime wetland designation, and wetland buffer regulations.
- Evaluate protection status and develop guidelines for regulatory review of threats to known potential habitat.
- Design and place roads and other transportation networks to reduce impacts to wood turtles and other rare wildlife.
- Identify dams and alterations to water flows that occur near wood turtle populations.
- Educate public about rules and regulations pertaining to wood turtles and other reptiles and amphibians (e.g., sale and possession) through updated and improved NHFG website and other media. More inquiry into local pet stores and traders in the region needs to be conducted. Critically evaluate all possession permits in the state.
- Reduce anthropogenic food sources for predators.

Wood Turtle Actions

4.1.1 Raise mower level and time mowing appropriately, Restoration and Management

(A) Direct Threats Affected: Agriculture, Development (Habitat Loss and Conversion)

(B) Justification:

- Raising mower height will decrease the risk of turtle injury caused by collision with machinery.
- The ecological response to raising mower height will be a decrease in turtle mortality.
- Wood turtles rely on habitat that includes open meadows and fields. The mowing of any field could have a large impact on a particular population.
- The action can be adapted if it is found that the mower height should be adjusted for decreased mortality or increased economic benefit, without accidental take occurring

(C) Conservation Performance Objective

The objective of raising the mower height is to decrease the number of collisions with adult wood turtles.

(D) Performance Monitoring

The success of raising mower height will be indicated by a decrease in wood turtle carcasses found in fields. Monitoring of fields that are mowed at a variety of heights could indicate the level that is required for protection of individuals and is most cost effective for the landowner.

(E) Ecological Response Objective

The desired ecological response to raising mower height is to maintain population viability by decreasing additive adult mortality.

(F) Response Monitoring

A long-term, mark-recapture study could determine if the action is successful. Conduct surveys during the early spring or nesting period to find individuals that are coming out of hibernation (this is the easiest time to find them). Information on the age of individuals captured over time will reveal if the average population age were increasing, indicating a declining population size.

(G) Implementation

Identify landowners with fields that are maintained along segments of river that support wood turtle populations. Produce a flyer with information regard-

ing the effect that 1 adult wood turtle death has on the health of a population, and indicate the benefits to raising the height of mower blades before this can be done, the blade height at which turtles become safe must be established. Discuss the possibility of performing mowing and other maintenance after mid-September, when wood turtles are more likely to be near or in the river. The Landowner Incentive Program (LIP) or the Wildlife Habitat Incentives Program (WHIP) could be used to compensate farmers who choose to enroll.

Alternatively, an unmowed buffer could be left at the edge of hayfields while turtles are active; research would need to determine an appropriate width. Reducing the economic impact that this action has on the cooperative landowner is imperative to its success.

(H) Feasibility

Long-term monitoring is labor intensive and so can only be initiated at several priority sites. Remaining agricultural land in New Hampshire is important to landowners, so it may be difficult to engage them.

4.1.2 Divert recreational activities to avoid wood turtle areas, Education and Outreach

(A) Direct Threats Affected: Unregulated Take, Transportation Infrastructure, Development (Habitat Loss and Conversion)

(B) Justification

- Reducing human use in an area that supports a wood turtle population would prevent destruction of nests, injury or mortality of individuals due to collision with OHRV, and the removal of individuals from a population.
- Diverting trails and access points away from areas that support wood turtle populations would ensure greater protection for a population. All populations that are identified should be protected.
- The conservation action may be adjusted if wood turtle populations increase

(C) Conservation Performance Objective

The objective of redirecting recreational access away from wood turtle habitat on public lands is to reduce the collection of individuals from the wild and reduce

destruction of nest sites and risk of collision with vehicles.

(D) Performance Monitoring

A long-term population study in a conservation land, such as a state park, would identify primary wood turtle habitat. Long-term mark-recapture and radio telemetry monitoring would indicate where individuals are affected (e.g., by injury, mortality, and collection) by ongoing recreational uses.

(E) Ecological Response Objective

The desired ecological response to isolating areas that support wood turtle populations is to stabilize existing wood turtle populations by preventing the loss or removal of individuals.

(F) Response Monitoring

These data could be obtained by a long-term, mark-recapture study. The stability of populations over time would be measured by population size, age and sex structures, and reproductive success.

(G) Implementation

Identify conservation land where wood turtles are likely to occur. Communicate with land managers regarding wood turtle habitat needs and vulnerability to recreational activities. Monitor several wood turtle populations that are affected by recreational activities.

(H) Feasibility

Managers of state lands may be seeking guidance to ensure development has minimal impact on the resources in their areas. The implementation of this action would be most successful in areas where recreation is currently limited.

4.2 Conservation Action Research

Use GIS models created for the comprehensive management plan to prioritize areas to be targeted for these conservation actions. Monitor long-term effects to determine if they are successful.

ELEMENT 5: REFERENCES

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5.2 Data Sources

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Element 6: List of Figures

Table 1. Habitat quality attributes for New Hampshire HUC-12 watersheds that were known to be occupied by wood turtles ('Watershed Occupied') and watersheds that were mapped as potential habitat but where wood turtles have not been verified ('Watershed Potential'). Metadata is available that describes how variables were calculated.

Table 2. Protection status for New Hampshire HUC-12 watersheds that were known to be occupied by wood turtles ('Watershed Occupied') and watersheds that were mapped as potential habitat but where wood turtles have not been verified ('Watershed Potential'). Protection status was assessed for all mapped

wood turtle habitat (known and potential) within watersheds. The conservation lands data layer from the University of New Hampshire Complex Systems (GRANIT) was used to calculate protection status. Table 1. Habitat quality attributes for New Hampshire HUC-12 watersheds that were known to be occupied by wood turtles ('Watershed Occupied') and watersheds that were mapped as potential habitat but where wood turtles have not been verified ('Watershed Potential'). Metadata is available that describes how variables were calculated.

REPTILE AND AMPHIBIAN MAPS











