APPENDIX A

Species Profiles

Part Four: Mammals

SPECIES PROFILE

American Marten

Martes americana

State Listing: Threatened
Global Rank: G5
State Rank: S2
Author: Jillian R. Kelly, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

In the Northeast, American marten are found in forests dominated by mid successional, coniferous, and deciduous stands, as well as in partially harvested stands (Chapin et al. 1997, Fuller 1999, Payer 1999). Complex horizontal and vertical structure is especially important to marten, and coarse woody debris is associated with prey access and abundance, denning and nesting sites, refuge from predators, and thermoregulation (Buskirk et al. 1988).

Because canopy cover in deciduous forests decreases dramatically in winter, conifers may be important to martens. During the winter, marten require more horizontal structure (e.g. coarse woody debris) for access to subnivean resting sites, thermal protection (Taylor and Buskirk 1994), and access to prey (Sherburne and Bissonette 1994). To compensate for scarce prey and higher metabolism during winter, marten have been known to shift to larger prey, such as snowshoe hare (Lachowski 1997), which provide more energy per volume than mice and voles (Zielinski 1986). At elevation, deep snow, unique soil composition, inclement weather, and infrequent logging all contribute to the conifer cover and coarse woody debris that marten seek. Thus, ridgelines and areas of high elevation may be particularly important for marten in New Hampshire. Marten compete with species such as the fisher.

1.2 Justification

In New Hampshire, marten were once common and economically important. By 1935, habitat loss and trapping had resulted in a drastic population decline. Marten remained scarce despite 2 reintroduction attempts and were one of the first species legally classified as threatened in New Hampshire.

Since the early 1980s, evidence of marten has been observed in towns throughout northern New Hampshire. Based on tracks, sightings and an examination of marten distribution, it appears that northern New Hampshire has an expanding population of marten. However, marten demographics are still poorly understood. In addition to being threatened in New Hampshire, marten are of particular concern because of their status as an "umbrella species"; their large range and sensitivity to disturbance make them broad indicators of ecosystem health.

1.3 Protection and Regulatory Status

American marten are listed as threatened in New Hampshire (RSA 212-A). Currently, New Hampshire has a Memorandum of Understanding with the majority of the large landowners, which requires consultation with New Hampshire Fish and Game (NHFG) when proposing to harvest timber above 2,700 ft. There is also an informal agreement with fisher trappers pertaining to the reporting and confiscation of marten carcasses if incidentally captured.

1.4 Populations and Habitat Distribution

Marten were once found throughout the state (except along the coast), but currently appear to be found only from the southern end of the White Mountains north to the town of Pittsburg, where populations are highest (Kelly 2005). Populations found further south may be isolated by habitat fragmentation resulting from development and habitat differences (e.g., less snow, less coniferous and mixed coniferous/ deciduous cover). High elevation habitat appears to be extremely important along the southern edge of their current distribution in New Hampshire.

1.5 Town Distribution Map

Figure 1

1.6 Habitat Map

Figure 2

1.7 Sources of Information

Information on marten habitat, population distribution, and status was collected from Kelly (2005), trappers, technical field reports, agency data (United States Forest Service (USFS), United States Fish and Wildlife Service (USFWS)) and scientific journals.

1.8 Extent and Quality of Data

Marten have been a priority research species for the past 3 years, during which time they were systematically sampled. Data on population demography and high-elevation populations are still lacking. Stand-level data, such as coarse woody debris and snag densities, are needed for better marten management.

1.9 Distribution Research

Distribution research has drawn on intense collection and observation data, as well as upon incidental captures data.

Element 2: Species Condition

2.1 Scale

Conservation planning units for American marten are based on watershed, landownership, and ecological subsection characteristics.

2.2 Relative Health of Populations

Historically, marten were likely most common around the Connecticut Lakes. Currently, it appears that marten are well established in the headwaters of the Connecticut River and Magalloway River drainages, and are scarce in the Indian Stream drainage. Marten continue to be common in the Mahoosuc and White Mountains, particularly at higher elevation where snowfall is deeper and coniferous cover is greater.

2.3 Population Management Status

Marten populations are not specifically managed, but see sections 2.4, 2.5, and 2.6 for details on habitat protection and management.

2.4 Relative Quality of Habitat Patches

The Connecticut Lakes subsection provides key ecological attributes for marten. The Connecticut Lakes Headwater Property makes up a large percentage of the subsection and has specific wildlife and timber management objectives that will benefit marten. Specific Special Management Areas (SMA) were set aside as marten habitat and require NHFG consultation before logging. Further restrictions on SMAs are also conducive to linking marten habitat.

The Mahoosuc-Rangeley also has excellent potential to provide key ecological attributes for marten. Large land ownerships make up a large percentage of this subsection and provide excellent opportunity to maintain or increase the amount of marten habitat. Larger ownerships in the subsection have recently experienced a high turnover in ownership, which has resulted in widespread, heavy cutting that has likely reduced the amount of habitat available to marten.

The White Mountain subsection, with its interconnected high elevation habitat patches, is well suited for martens. The White Mountain subsection is virtually all White Mountain National Forest (WMNF) and provides excellent opportunity to manage and monitor marten habitat.

2.5 Habitat Patch Protection Status

The Connecticut Lakes subsection is made up of landowners with conservation easements, as well as land that is owned in fee by the state of New Hampshire. The Connecticut Lakes Timber Company currently owns 146,400 acres of working forest with a comprehensive easement held by New Hampshire Department of Economic Resources and Development. NHFG owns in fee 25,000 acres within the subsection. Habitat that remains unprotected includes Crystal Mountain and Blue Ridge, as well as the Sanguinary and Rice Mountain Ridge with associated lower elevation areas. Unincorporated towns in this subsection have some level of protection through zone districts.

The Mahoosuc-Rangeley subsection is virtually unprotected by ownership and/or easement. High elevation areas have the most protection under unincorporated town zoning and state ownership (e.g., Nash Stream), whereas lower elevation habitats have experienced extensive cutting over the past 10 years with little protection or zoning. Wildlife management objectives are incorporated whenever possible through NHFG's technical assistance program for large landowners. Under this program, compliance with biologists' recommendations is not mandatory. The White Mountain subsection is virtually entirely protected through ownership by the USFS.

2.6 Habitat Management Status

Under the Connecticut Lakes Headwaters Area (CLNA) Draft Stewardship Plan, a primary goal for the property is to establish and maintain wildlife habitats that provide for game and non-game wildlife species native to the Connecticut Lakes Ecoregion. Specific consideration will be given to the landscape context and habitat availability existing outside the boundaries of the CLNA, with emphasis on those species considered to be rare or of conservation concern (e.g., marten). Boreal forest species are also a specific target for this goal. Unincorporated places within the subsection have specific zoning for critical wildlife habitat (PD3 zones), wetlands (PD7 zones), and unusual areas (PD8).

Conserved land within the Mahoosuc-Rangeley subsection includes the Vicki Bunnell Preserve, Nash Stream State Forest, Kilkenny National Forest (part of WMNF), and the Randolph Town Forest, all of which have specific goals for promoting boreal forest and wildlife species within their boundaries. The majority of low-lying habitat remains in large ownerships with few easements and little protection, and is thus at risk of logging. Virtually all of the White Mountains subsection is made up of the WMNF. The age class objectives include having 59 to 63% of the softwood habitat as mature habitat, and 30% as old habitat.

2.7 Sources of Information

Information on habitat protection and management was obtained from literature review, expert review and consultation (W. Staats, NHFG, personal communication), pertinent research, the Connecticut Lakes Headwaters Forest Draft Stewardship Plan, the Draft Plan for Connecticut Lakes Natural Area, Zoning Ordinances for Coos County Unincorporated Places and the WMNF Proposed Land and Resource Management Plan.

2.8 Extent and Quality of Data

Habitat data on stand-level forest condition and landscape connectivity are lacking.

2.9 Condition Assessment Research

An extensive GIS database of habitat age, fragmentation, and management status is needed. Information could be derived from aerial photos and analyzed every 2 to 5 years, or from databases of specific properties held by large landowners.

Element 3: Species and Habitat Threat Assessment

3.1.1. Unsustainable Harvest (Forestry Operations and Management)

(A) Exposure Pathway
As a forest interior species, marten require that a certain percentage of their home range be mature forest.

(B) Evidence
Landscape use, composition, and connectivity are especially important to marten (Hargis et al. 1999, Chapin et al. 1998). In Maine, marten are nearly absent from landscapes where more than 0 to 40% of the landscape is in early successional forest (Hargis et al. 1999). Partially harvested forest stands are still utilized by marten as long as they maintain a basal area greater than 18 m^2/ha in live trees and snags, especially when the stands retain at least 25 to 30% of the stand in coniferous cover.

3.1.2. Development

(A) Exposure Pathway
Development results in direct loss of forested habitat for marten.

(B) Evidence
Marten are less likely to be captured in areas close to open habitat and in areas with increasing amount of high contrast edge (Hargis et al. 1999). Marten are a forest dependent species and are unable to use prey in agricultural lands associated with higher road and people densities. Indeed, marten populations have been shown to be lower near dense road networks (Robitaille and Aubry 2001).

3.1.3. Scarcity (Competition)

(A) Exposure Pathway
Interspecific competition between marten and fisher is likely related to the competition for prey (e.g., red squirrels and snowshoe hare) and denning locations (e.g., cavity trees). Habitat partitioning is likely more prevalent during the winter, when deeper snow limits fisher populations, though during non-limiting conditions marten and fisher habitat overlap extensively. When marten and fisher populations overlap, it is also likely that fisher eat marten.

(B) Evidence
Krohn et al. (1995) noted that age and recruitment ratios of marten differed significantly across areas where fisher and marten overlapped. Furthermore, in core marten habitat there was little to no fisher recruitment. In core fisher habitat, where marten were present, there was a higher percentage of juvenile marten, suggesting that fisher compete with marten where limitations to fisher populations are low (Krohn et al. 1995). Kelly (2005) compared catch per unit effort (CPUE) values between fisher and marten and found that areas with low CPUE for fisher were more likely to have higher CPUE values for marten.

3.1.4. Climate Change

(A) Exposure Pathway
Climate change, which has resulted in decreased snow depths in winter, may be pushing marten further north and into higher elevation habitats with more snow.

(B) Evidence
Marten are smaller, more agile, and more likely to hunt beneath the snow than fisher (Steventon 1979, Raine 1983). Subnivean air pockets can act as thermal insulators, further increasing the marten's advantage in deep snow (Taylor and Buskirk 1996).

3.1.5 Unregulated Take (Illegal or Unregulated Take)

(A) Exposure Pathway
Fisher trappers incidentally capture marten in fisher sets, sometimes killing them.

(B) Evidence
Fisher trappers are required to turn incidental marten kills over to the local conservation officer. Trappers are also required to keep a trapping journal, where incidental captures should be documented.

3.2 Sources of Information

Information on threats was taken from Kelly (2005), Krohn et al. (1995), Ray (2000), expert review, and consultation (W. Staats, NHFG).

3.3 Extent and Quality of Data

There is well-documented information on the effects of climate change, timber harvesting, and development on martens. The impacts of unregulated take and interspecific competition with fisher are more difficult to assess.

3.4 Threat Assessment Research

Potential threat assessment research would include an in-depth examination of the relationships between marten and fisher. The impacts of timber harvesting and development should also be closely monitored by monitoring marten populations across the landscape as cover distribution changes.

Element 4: Conservation Actions

4.1.1 Work with landowners to promote forest management that maintains marten habitat across the landscape, Restoration and Management

(A) Threats
Timber harvesting without regard for non-timber resources and development

(B) Justification
- Working with large landowners to promote mature forest characteristics will directly increase the amount of habitat available for marten.
- The ecological response for this objective is having at least 60% of the landscape in mature forest status (more than 18 m^2/ha of live trees and snags, with a mean height of more than 9 m and more than 7.6 m diameter at breast height (dbh) (Fuller, 1999)).
- The conservation action can be adapted to new information by shifting emphasis to innovative or altered management techniques.

(C) Conservation Performance Objective
The desired outcome is to maintain large forested blocks of habitat, to maintain connectivity, and to maximize sustainable forestry practices on those lands. Integration of landscape level wildlife management objectives should also be included in guidelines for Forest Certification programs. The desired period is the next 30 years.

(D) Performance Monitoring
Specific objectives will be to assess land cover dynamics using GIS and to examine how the changes in cover relate to potential marten habitat.

(E) Ecological Response Objective
The desired ecological response is the increase and maintenance of the amount of suitable marten habitat in New Hampshire by balancing marten habitat needs with sustainable forestry.

(F) Response Monitoring
Studies of marten densities and distribution can be used to assess the impacts of this action.

(G) Implementation
Implementation of each performance objective can be initiated by NHFG. Guidelines for forest certification should be examined and implemented by the forestry industry. Further marten distribution and density information can be collected where appropriate in coordination with cooperating agencies and academic institutions.

(H) Feasibility: 1.56

4.1.2 Encourage the maintenance of large forest ownerships, Policy and Regulation

(A) Threats
Timber harvesting without regard for non-timber resources, development

(B) Justification
Working to maintain large ownerships through tax incentives and conservation easements will minimize the threat of development. The conservation action can be adapted to new information by shifting priorities and methods based on circumstance and timing with landowner interest or turnover.

(C) Conservation Performance Objective
The desired outcomes of maintaining large forest ownerships are to maximize the effectiveness of landscape forest management, minimize development pressures and opportunity, and support local economies dependent on the forest products industry. The appropriate scale for this action is statewide, with a focus on the historic large ownerships found north of the White Mountains that are part of the greater Northern Forest. Maintaining large ownerships through tax incentives and conservation deals (e.g., the Connecticut Lakes Headwaters Area) will provide important management opportunities for specific species such as marten.

(D) Performance Monitoring
Property size and turnover rates can be tracked over time. Existing properties should be identified and prioritized according to immediate threats of development and parceling.

(E) Ecological Response Objective
Maintaining large ownerships will benefit marten populations and other wildlife with similar habitat requirements. This will be accomplished when the majority of large ownerships have long-term incentives to minimize parceling and development.

(F) Response Monitoring
Areas to monitor include properties without ease-

ments, including lands owned by T.R. Dillion, Bayroot, Plum Creek, and GMO. Baseline threats should be identified for each property, and properties should be prioritized based on current threats.

(G) Implementation
Maintaining large forest ownerships is a multi-agency, region-wide endeavor that will involve a large number of stakeholders. NHFG and other conservation organizations such as The Nature Conservancy, Society for the Protection of New Hampshire Forests, New Hampshire Timberland Owners Association, and Trust for Public Land should be integral to this process.

(H) Feasibility: 1.38

4.1.. Continue to monitor and manage fisher populations, Restoration and Management

(A) Threats: Interspecific competition

(B) Justification
Monitoring fisher populations, understanding habitat relationships between fisher and marten, and managing (e.g., trapping) fishers may benefit martens. The action can be adapted to new information, and new data can be collected as needed.

(C) Conservation Performance Objective
The desired outcome of monitoring and managing New Hampshire's fisher population is to minimize interspecific competition between marten and fisher, and to increase knowledge about fisher and marten demographics. The appropriate scale for this action is statewide. Trapper data can be supplemented by compiling track transect data from agencies and landowners who collect it (e.g., USFS and Dartmouth College Grant). This should be a long-term effort.

(D) Performance Monitoring
Trapper survey data should be logged and analyzed in the NHFG furbearer database, and these data should be analyzed to identify the best methods for tracking fisher and marten populations statewide.

(E) Ecological Response Objective
The desired ecological response of monitoring and managing fisher in New Hampshire is the increase in the number of resident, breeding marten in New Hampshire and the existence of a stable marten population. If appropriate, fisher seasons in core marten habitat may need to be liberalized to minimize interspecific competition between the 2 species.

(F) Response Monitoring
Potential areas for response monitoring include the CLNA and the WMNF. Baseline information should be collected on the WMNF to supplement limited fisher trapping data from the remote high elevation locations where marten are likely abundant.

(G) Implementation
Long-term monitoring and management, which for the most part are already taking place under direction of the furbearer biologist for NHFG, should be continued. Further analysis of marten and fisher interactions may be needed and could be coordinated by region 1 biologists.

(H) Feasibility: 3.06

4.1.4 Investigate, adopt and tailor (to minimize marten captures) Best Management Practices (BMPs) for fisher in New Hampshire, Regulation and Policy

(A) Threats: Unregulated take

(B) Justification
Investigating, adopting, and tailoring BMPs for fisher to minimize marten captures will likely decrease the number of marten incidentally killed in fisher traps.

(C) Conservation Performance Objective:
The desired outcome of using BMPs for fisher trapping in New Hampshire is to minimize the number of marten that are incidentally captured in fisher traps, while still maximizing the recreational, economic and management benefits that fisher trapping provides. The appropriate scale for this action is statewide. Marten distribution and abundance may be highly related to fisher distribution and abundance, and trapping data provide important insight into that relationship. The desired period is over the next 2 to 5 years.

(D) Performance Monitoring:
Current BMPs for fisher trapping will be examined, and modifications will be made when necessary. Specific factors to examine are the use of non-lethal traps in areas where marten densities are greatest, or adjusting trigger placement to minimize marten captures in traps. Both methods should be examined for effectiveness, feasibility, and trapper support.

(E) Ecological Response Objective
The desired ecological response of examining fisher BMPs is to minimize impacts on marten populations due to incidental captures. Successful implementation of fisher trapping BMPs will result in fewer than 5 marten incidentally captured per year and the maintenance of fisher trapping as a tool to minimize interspecific competition between marten and fisher.

(F) Response Monitoring
Areas for response monitoring include the CLNA, Dixville Notch, and the WMNF where there has been incidental captures of marten by fisher trappers.

(G) Implementation
Implementation can be accomplished through the furbearer working group, NHFG's furbearer biologist, and regional biologists assisting in the effort.

(H) Feasibility: 2.63

Element 5: References

5.1 Literature

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SPECIES PROFILE

Bobcat

Lynx rufus

Federal Listing: Appendix II of CITES
State Listing: Protected
Global Rank: G5
State Rank: S4
Authors: John A. Litvaitis and Jeffery P. Tash, University of New Hampshire

Element 1: Distribution and Habitat

1.1 Habitat Description

Bobcats (*Lynx rufus*) occupy wooded habitats that provide cover and allow for stalking or ambush (Anderson and Lovallo 2003). In the northeastern United States, lagomorphs are an important prey and thus affect the distribution and abundance of bobcats (Litvaitis et al. 1986*a*, Litvaitis 1993). In New Hampshire, bobcats are associated with uplands or wetlands with dense understory vegetation, and with rugged terrain that may include rocky outcrops.

1.2 Justification

Bobcats are 1 of 5 felids endemic to the northeastern United States. The other felids have been extirpated [cougars (*Felis concolor*)] or are considered threatened [lynx (*Lynx canadensis*)]. In recent decades, bobcat populations in New Hampshire have declined precipitously. Much of this decline is due to the maturation of early-successional forests that dominated New Hampshire during the first half of the twentieth century (Litvaitis et al. 2005).

1.3 Protection and Regulatory Status

Bobcats are a protected species, and trapping and hunting seasons in New Hampshire have been closed since 1989. They are also included in Appendix II of CITES (Convention on International Trade of Endangered Species of Wild Fauna and Flora). This list includes species that are not necessarily threatened with extinction but that may become so unless trade is closely controlled. As a result, state wildlife agencies that allow harvests of bobcats must provide population trends, harvest data, harvest areas, and habitat evaluation to the USFWS.

1.4 Population and Habitat Distribution

Historic accounts of bobcats in New Hampshire are limited. Seton (1925) suggested that bobcats initially benefited from land clearing by early European settlers. His map of the pre-Columbian distribution of bobcats only included southwestern New Hampshire, and he suggested that the range of bobcats expanded north and east as forests were cleared for subsistence agriculture. Based on the distribution of bounty harvests between 1931 and 1965, core bobcat habitat appears to have been predominately in the southwestern New Hampshire (figure 1). This area continues to support a disproportionate number of bobcats (figure 2).

1.5 Town Distribution Map

Recent observations and incidental captures (n = 90) between 1990 and 2004 indicate that a large portion of the state is still occupied by bobcats.

1.6 Habitat Map

Methods

Historic harvest records and recent observations were used to investigate environmental factors that may affect the distribution of present-day bobcat habitats. Habitat associations and suitability were modeled with GIS using two approaches, empirical and mechanistic or process oriented.

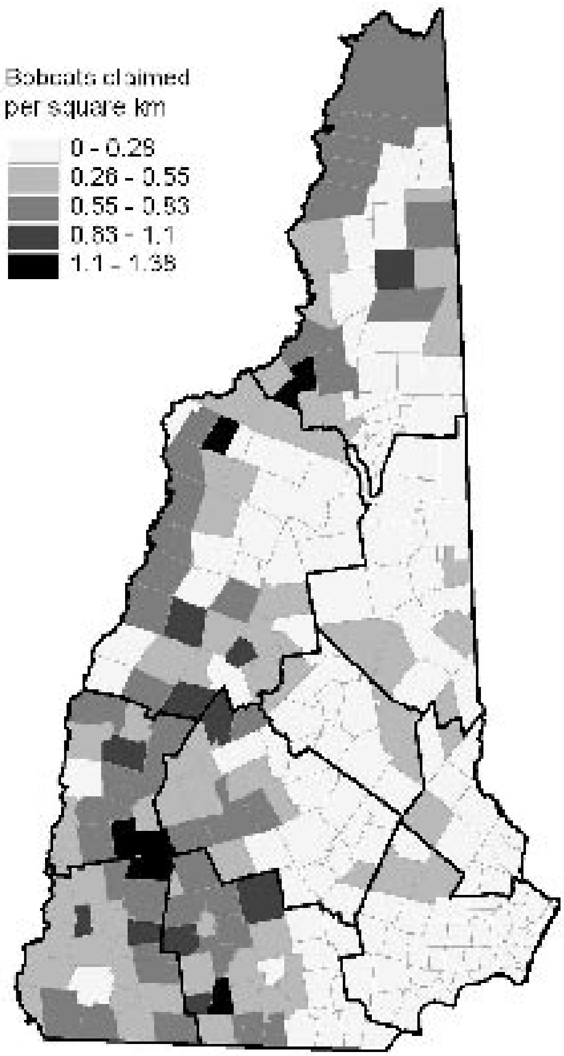

FIGURE 1. Distribution of bobcat harvests by township in New Hampshire from 1931 to 1965.

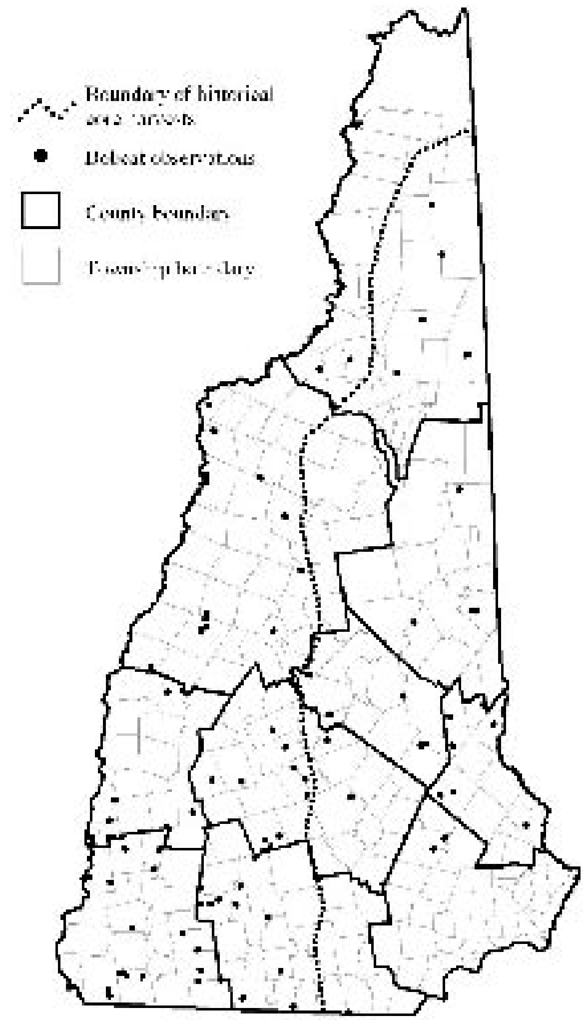

FIGURE 2. Locations of incidental captures, direct observations, and vehicle-killed bobcats (total = 90) during 1990 – 2004. The region to the west of the dashed line represents 49% of the state and it contained 74% of the >9,000 bobcats between 1931 and 1965. Seventy-two percent of the recent observations occurred in this area.

The empirical approach relied on a comparison of habitat features (55 variables) associated with recent (1990 – 2004) observations of bobcats to features associated with a comparable set of random locations within the state. Each known location was buffered with a 34-km^2 area (3.3 km radius). This area is equivalent to the average home range of female bobcats in neighboring Massachusetts (Berendzen 1985) and Maine (Litvaitis et al. 1986*a*). We chose an area equivalent to the range size of female bobcats because females are more closely associated with habitat features that influence survival (especially prey abundance) than are male bobcats (Litvaitis et al. 1986*a*). This approach is similar to the methods used to model felid habitats in other regions (Palma et al. 1999, Woolf et al. 2002, Hoving et al. 2005).

The process-oriented model was similar to the mechanistic approach used in creating habitat suitability models (e.g., Donovan et al. 1987). To identify environmental features that likely affected the distribution and abundance of bobcats, the townships where the majority of bobcats were taken during 1931 – 1965 were examined. This period was selected because harvest regulations were consistent

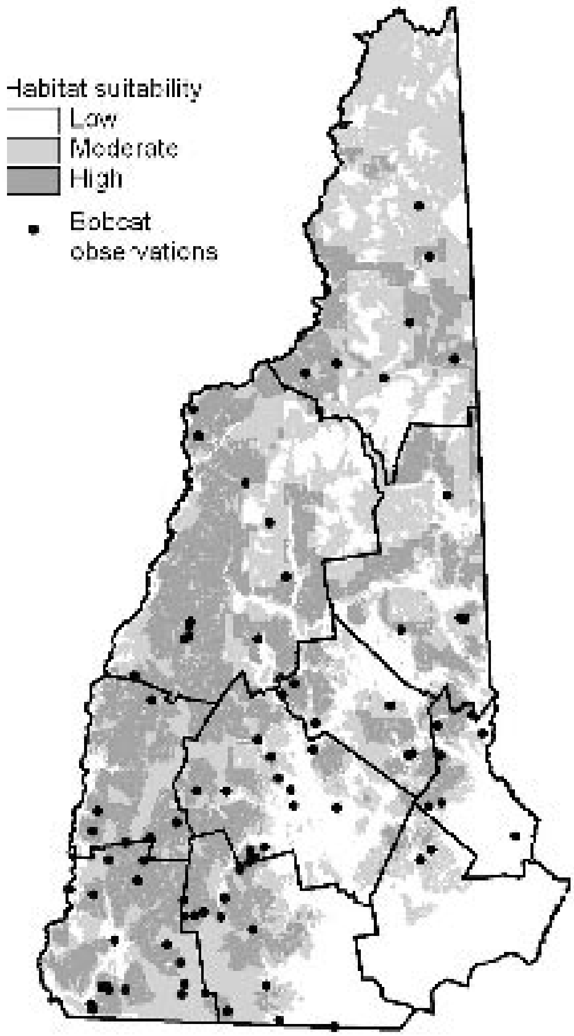

FIGURE 3. Modeled bobcat habitats where suitabilities were based on threshold values of elevation, minimum area of forest or wetland not fragmented by class I or class II roads, and annual snowfall.

in comparison to subsequent years. Based on previous research, these models focused on forest cover, elevation, and annual snowfall. These characteristics seemed to differentiate townships in the "core area" from townships where few bobcats were harvested. Minimum and maximum threshold values were then determined for each variable by visually comparing the spatial distribution of values to the historic core area. Each variable was then coded as suitable or not suitable based on selected thresholds. Habitat suitability of each cell was ranked using the sum of all variables inventoried (Berry 2004). The resulting model would have values between 0 (not suitable, no habitat components) and 3 (high suitability).

Results

Data screening of the empirical model yielded 9 variables that differed between known bobcat locations and random sites. Topographic slope, annual snowfall, area in beech/oak forest, and total forest area were most significant. Accuracy of the resulting model was poor, with only 52% of known locations and 75% of random sites correctly identified.

For the process-oriented model, threshold values for annual snowfall (<2500 mm), elevation (200 - 750 m above sea level), and minimum area of forest or wetland not fragmented by class 1 or 2 roads (34-km^2) seemed to differentiate the core area from areas where few harvests occurred, and were used to construct a habitat suitability model. Map cells were classified as low, moderate, and high suitability. A comparison of the resulting map with recent observations revealed that 79 of 90 (87.8%) of these areas contained some habitats that were classified at high suitability (figure 4). If we consider only the dominant habitat within the 34-km^2 buffer, 52% were classified at high suitability and 32% were classified at moderate suitability.

1.7 Sources of Information

Specific habitat, landscape, and climate features that influence bobcat distributions was based on previous research that examined bobcat-habitat associations in Maine (Litvaitis et al. 1986*a*, Major and Sherburne 1987), New Hampshire (MacLachlin 1981), Massachusetts (McCord 1974, Berendzen 1985), Pennsylvania (Lovallo 1999), Wisconsin (Lovallo and Anderson 1996*a*,*b*), Minnesota (Fuller et al. 1985), Montana (Smith 1984, Knowles 1985), Idaho (Knick 1990), Washington (Koehler and Hornocker 1991), Oregon (Witmer and deCalesta 1986), and British Columbia (Apps 1996). Information was used from the northern portion of the range because bobcats likely respond to a different set of environmental conditions than southern populations. Of particular note for populations in New Hampshire was the effect of snow (Petraborg and Gunvalson 1962, Litvaitis et al. 1986*a*, Matlack and Evans 1992) and low temperatures in winter (Gustafson 1894, Mautz and Pekins 1989).

Data on historic harvests (by township) were obtained from the files of C. L. Stevens, deceased professor at UNH, who conducted a long-term investigation on bobcats during the 1950s through the early 1960s (some of his work was subsequently published by Litvaitis et al. 1984). Stevens compiled a detailed review of bounty records from 1809 to 1965, and when combined with recent information, provides good information on the abundance of bobcats in New Hampshire during the past 200 years.

Data used to develop the habitat models included the New Hampshire Land Cover Assessment 2001 database from the Complex Systems Research Center of the University of New Hampshire (Justice et al. 2002). Measures of topography, including elevation, slope, and aspect were derived from statewide USGS digital elevation models obtained from Complex Systems Research Center at UNH. The NHDOT statewide database was used to inventory roads. Mean annual snowfall from 1971 to 2,000 was obtained from Spatial Climate Analysis Service at Oregon State University.

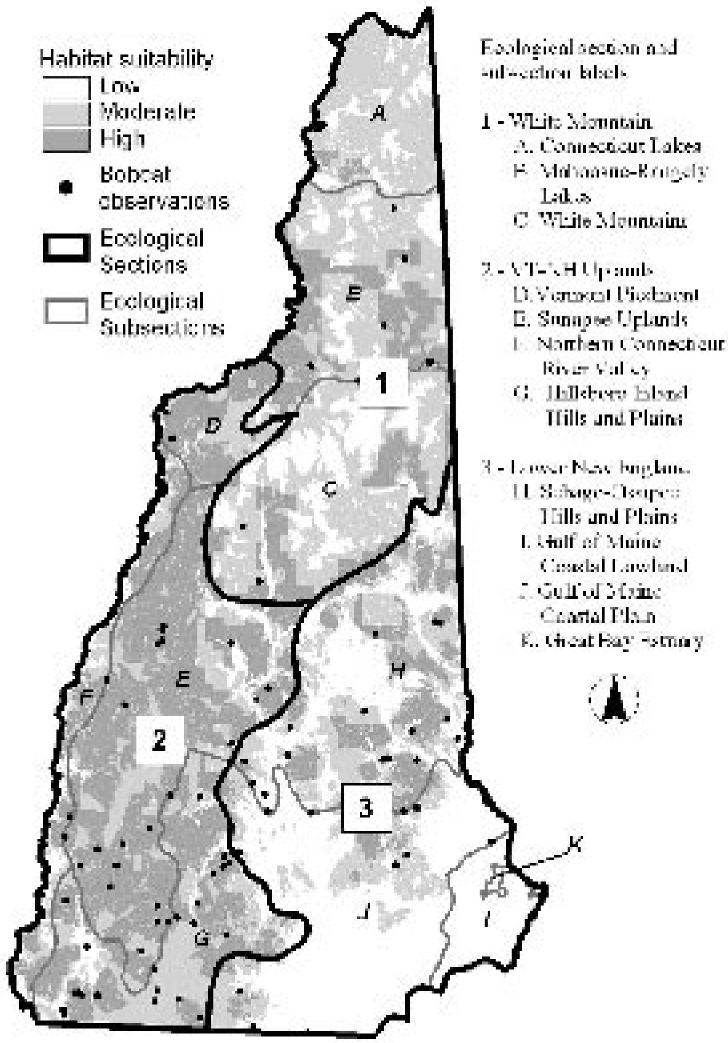

FIGURE 4. Distribution of recent (1990 – 2004) incidental captures and observations in Ecological Sections of New Hampshire.

1.8 Extent and Quality of Data

The variables included in the process-oriented model may not reveal cause-and-effect relationships, but may be functioning as surrogates. For example, threshold values for elevation probably described landscapes with varied topographic relief. Rugged terrains may be important because they incorporate a number of habitat features of bobcats, including loafing sites (Rollings 1945, Anderson 1990), dens (Bailey 1974), stalking cover (Koehler and Hornocker 1989) or refugia from potential competitors or predators (Koehler and Hornocker 1991) and may help to limit the number of human encounters (Nielsen and Woolf 2001).

Annual snowfall is functioning as a surrogate variable in the model for snow depth, a feature that directly influences bobcat mobility and prey acquisition (the deeper the snow the more bobcat movements become restricted) (Marston 1942). Juvenile and female bobcats seem most hampered by snow because the small prey they exploit may be more difficult to capture after snow accumulates (Litvaitis et al. 1986*b*). Higher elevations, although rugged, were probably avoided because annual snowfall increased with elevation. Apps (1996) reported a similar associated with mid-level elevations among bobcats in British Columbia.

Additionally, the process-oriented model only looks at landscape scale variables that may limit bobcat abundance and distribution. However, habitat selection by carnivores occurs at several spatial scales (Brown and Litvaitis 1995). Selection at a local scale is likely influenced by other features, including prey distribution and stalking cover (e.g., Litvaitis et al. 1986*a*). Information on bobcat selection at a finer resolution (i.e., patch or forest stand) is limited for bobcats in New Hampshire. MacLachlin (1981) investigated habitat selection at the stand scale by snow-tracking bobcats along 76 km of tracks in Sullivan County. Unfortunately, this limited data set could not be analyzed statistically. Ranking habitat use, however, suggested a preference for softwood stands (MacLachlin 1981:20). Some effort should be made to obtain information on factors affecting stand-scale selection by bobcats if we are to understand what may limit the current distribution and abundance of this species.

1.9 Distribution Research

- Nothing is known about bobcat habitat selection at the stand scale. Lacking this information limits the ability to understand how forest management and other land uses may affect suitability of bobcat habitats.
- Understanding stand-scale selection patterns will require information on understory vegetation because the feature directly affects prey abundance. Developing methods of obtaining this information using remote-sensing technologies is a priority.
- The influence of class I and II roads is supported by previous research but is not completely clear. Additional information on the influence of traffic volume versus road density is needed to clearly understand how these landscape elements affect regional distribution and local demography.
- Inventory and monitoring protocols should be developed. These protocols would be most likely to be applied if they address multiple species (e.g., forest carnivores).

Element 2: Species Habitat Condition

2.1 Scale

Based on the large home range of individual bobcats, it may be most appropriate to group suitable habitats using the ecological sections defined by Sperduto and Nichols (2004). These 3 sections (Vermont-New Hampshire Upland, Lower New England, and White Mountain) and their respective subsections provide a logical framework to discuss status, distribution, and limiting factors of bobcats in the state (figure 4).

2.2 Relative Health of Populations

Available information suggests that the species may span a larger portion of the state today than at the time of European settlement. However, bobcats are confronting increasingly modified landscapes and new threats (e.g., vehicle collisions). Maintaining viable populations of bobcats will require an understanding of how such factors influence local populations.

2.3 Population Management Status

Bobcats have apparently consistently occupied the southwestern portion of the state for more than 400 years, and portions of that region remain the most productive habitat for bobcats after centuries of human activity. Increasing human development will likely degrade existing bobcat habitats. Maintaining large blocks of continuous forest, a recognized conservation goal in New Hampshire (Thorne and Sunquist 2001), would be beneficial to maintaining current populations of bobcats.

2.4 Relative Quality of Habitat Patches

Approximately 56% of the Vermont-New Hampshire Uplands are highly suitable; within this area, the Sunapee Uplands and Vermont Piedmont were dominated by high quality habitat (68 and 57%, respectively). The Hillsboro Inland Hills and Plains in addition to the Sebago-Ossipee Hills and Plains subsection also contain tracts of high suitability habitat (43 and 26%, respectively).

2.5 Habitat Patch Protection Status

The White Mountains ecosection has the greatest proportion of conservation lands (39%), but this region does not contain much high suitability habitat for bobcats. Twelve percent of the Vermont-New Hampshire Uplands section is in conservation land, some of which is in large parcels (103 that are more than 200 ha; appendix 4). The Hillsboro Inland Hills and Plains and the Sebago-Ossipee Hills and Plains subsections contain lesser amounts of conservation lands.

2.6 Habitat Management Status
Beyond efforts to maintain large blocks of habitat in public lands or in conservation easement, there is no active management of bobcat habitats.

2.7 Sources of Information

Land use and land cover data were obtained from the New Hampshire Land Cover Assessment 2001 database at the Complex Systems Research Center of UNH.

2.8 Extent and Quality of Data:

There is essentially no information on stand or patch-specific features that affect habitat use and fitness of bobcats.

2.9 Condition Assessment Research

An inventory and monitoring protocol could provide an appraisal of bobcat demographics and patch-specific habitat features (Carroll et al. 1999). The USFS *National Forest Inventory* could be used to link habitat and land-use changes to changes in bobcat abundance and distribution (Zielinski et al. 2000). Such an inventory/monitoring program could be designed using a variety of platforms (e.g., snow tracks, sooted panels, or remotely-triggered cameras) and could gather information on a number of mesocarnivores (e.g., bobcats, fishers, and pine marten), making it cost attractive (Zielinski and Kucera 1995).

Element 3: Species Threat Assessment

3.1 Transportation Infrastructure (Mortality, Fragmentation, Dispersal Barriers)

(A) Exposure Pathway
Because bobcats are wide-ranging carnivores, they are likely to encounter and cross roads, where collisions are more likely. Such collisions will reduce local populations and deter immigrants from reaching unoccupied or low-density habitats.

(B) Evidence
The influence of class I and II roads is supported by previous research (Lovallo and Anderson 1996*a*), yet it is not completely clear how roads are affecting bobcats. Crooks (2002) indicated that bobcats were intermediate in their sensitivity to habitat fragmentation, but recommended that connectivity of habitats be considered as essential for bobcats in landscapes undergoing development. Increased mortality from vehicle collisions may reduce local populations or limit immigration from surrounding landscapes. In Maine, Litvaitis et al. (1987) reported that vehicles collisions were the second most frequent cause of mortality (after legal trapping and hunting) among radio-tagged bobcats. However, Nielsen and Woolf (2002) found that vehicle collisions did not limit an unharvested population of bobcats in southern Illinois. Therefore, additional information on the additive versus compensatory nature of vehicle-related mortalities and the influences of traffic volume and road density on immigration rates is needed if we are to understand and mitigate the effects of roads on bobcats in developing landscapes.

3.2 Sources of Information

A building body of literature indicates that high traffic volume roads can affect the viability of local bobcat populations (e.g., Crooks 2002).

3.3 Extent and Quality of Data

There are no field data on New Hampshire populations.

3.4 Threat Assessment Research

Consider telemetry-based study in occupied habitats that contain a range of traffic volume conditions.

Element 4: Conservation Actions

4.1.1 Maintain large tracts of forests without class I and II roads.

See section 3.1.1

Element 5: References

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Element 6: List of Figures

FIGURE 1. Distribution of bobcat harvests by township in New Hampshire from 1931 to 1965.

FIGURE 2. Locations of incidental captures, direct observations, and vehicle-killed bobcats (total = 90) during 1990 – 2004. The region to the west of the dashed line represents 49% of the state and it contained 74% of the >9,000 bobcats between 1931 and 1965. Seventy-two percent of the recent observations occurred in this area.

FIGURE 3. Modeled bobcat habitats where suitabilities were based on threshold values of elevation, minimum area of forest or wetland not fragmented by class I or class II roads, and annual snowfall.

FIGURE 4. Distribution of recent (1990 – 2004) incidental captures and observations in Ecological Sections of New Hampshire.

SPECIES PROFILE

Eastern Pipistrelle

Pipistrellus subflavus

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S1N,SUB
Authors: Jacques P Veilleux, Franklin Pierce College; Scott Reynolds, St. Paul's School

Element 1: Distribution and Habitat

1.1 Habitat Description

Eastern pipistrelles hibernate in caves or mines, although they occasionally use other structures. For successful hibernation, eastern pipistrelles require habitat with low levels of human disturbance and a proper microclimate (e.g., temperature stability). Although eastern pipistrelles hibernate singly or in groups of two or three, individual hibernacula can have large populations of eastern pipistrelles, including over 750 individuals from a single mine in New York (Hicks 2003). Therefore, the protection of hibernacula is an important conservation concern.

No available data describe the summer habitat requirements of eastern pipistrelles in New Hampshire. The few available data on summer habitat use and life history come from the Midwest (Veilleux et al. 2003, Veilleux et al. 2004, Veilleux and Veilleux 2004). After leaving hibernacula, female eastern pipistrelles form maternity colonies in live or dead foliage of deciduous trees (Veilleux et al. 2003), although individuals in New Brunswick have roosted in Old Man's Beard (*Climatis vitalba*; H. Broders, personal communication) and individuals from the southeastern United States have roosted in Spanish moss (*Tillandsia useoides*; Davis and Mumford 1962). The birth and weaning of young occur within these foliage roosts. Some data indicate that females prefer to roost in oak (*Quercus alba* and *Q. rubra*) and maple (*Acer saccharum*) trees (Veilleux et al. 2003). Although eastern pipistrelles are a foliage-roosting species, individuals occasionally roost in man-made structures (Whitaker 1998).

1.2 Justification

Populations of eastern pipistrelles, like many other bat species, are believed to be decreasing. The likely reasons for the possible declines are the destruction or degradation of winter habitat (hibernacula) and summer habitat (roosting and foraging areas). Like other bat species, the eastern pipistrelle's life history is different from the typical life history of small mammals. Individuals are relatively long-lived and have a low reproductive rate. Eastern pipistrelles give birth to two young per year (Fujita and Kunz 1984), although only one may survive to reproductive age. The slow reproductive rate would, in turn, lead to a slow population recovery time. Since eastern pipistrelles are found in cave/mine habitats that are relatively rare and at risk, this species is at risk of population decline if such habitats are lost or degraded. Eastern pipistrelles are of conservation concern in New Hampshire for the above reasons and because of the lack of knowledge about the species' population status in New Hampshire (see section 1.4).

3.3 Protection and Regulatory Status

No specific ESA or RSA 212 regulations govern the take, transport, or use of this species. Scientific collecting or research involving the capture of individuals requires a permit through NHFG. Possession of live bats requires a permit under NHFG FIS 800. (?)

1.4 Population and Habitat Distribution

Data on the current and historic range of eastern pipistrelles in New Hampshire are too few to allow a regional population comparison. The winter distribution data of eastern pipistrelles are limited to three mine localities with as many as five individuals in Mascot Lead Mine, three individuals in Mt. Kearsarge Lead Mine (Merrimack County), and one individual in Red Mine (Grafton County). One individual was also collected at Ruggle's Mine in Grafton (Grafton County), which is a potential but unsurveyed hibernaculum. Five definite summer records are known from New Hampshire. One individual is known from Canaan (Grafton County) and Chenger (2005) reported single individuals captured in the towns of Bartlett (Carroll County), Bean's Purchase (Coos County), Wentworth (Grafton County) and Warren (Grafton County). Possible echolocation call sequences have been recorded from Albany (Carroll County), Bartlett (Carroll County), New Boston (Hillsborough County), and possibly Nottingham (Rockingham County). These data indicate a potentially broad summer distribution of eastern pipistrelles in New Hampshire.

1.5 Town Distribution Map

1.6 Habitat Map

1.7 Sources of Information

Town data on the eastern pipistrelle's winter distribution were compiled from New Hampshire Natural Heritage Inventory – Bat Hibernaculum Record data sheets museum specimens, and college/university teaching collections. Summer distribution was determined from the published and gray literature of bat research in New Hampshire, as well as from specimen collections.

1.8 Extent and Quality of Data

Data on the distribution of eastern pipistrelles in New Hampshire are extremely limited (see section 1.4) but of high quality because qualified bat biologists identified the animals. The major knowledge gap is the paucity of occurrence records and research into distribution patterns.

1.9 Distribution Research

Priority research on the winter distribution of eastern pipistrelles should include surveys of potential hibernacula. Research on the summer distribution should include long-term mistnetting surveys accompanied by echolocation surveys (using Anabat acoustic survey methods). Mistnetting surveys should incorporate banding into the capture protocol and record all banding records in the Northeast Banding Database developed by the Northeast Working Group on Bats (NEWGB). An intensive banding program using state-issued wing bands would yield data on the summer distribution of all bat species in New Hampshire and may provide insight into overwintering areas.

Element 2: Species/Habitat Condition

2.1 Scale

Due to the small number of mines in New Hampshire that provide or potentially provide habitat for this species, each mine has been treated as a conservation planning unit under the habitat profile.

2.2 Relative Health of Populations

See section 1.4. The sparse data on winter or summer occurrences of eastern pipistrelles in New Hampshire prevent an analysis of the trends and viability of winter or summer populations. Priority conservation actions include winter surveys at New Hampshire mines that have not been surveyed

2.3 Population Management Status

No population management efforts are directed at the conservation of eastern pipistrelles.

2.4 Relative Quality of Habitat Patches

NHNHB has ranked both Mt. Kearsarge and Mascot Lead Mine as "B/C", indicating "fair to good quality and prospects for long-term conservation". Red Mine was ranked "B", indicating "good quality and prospects for long-term conservation". Ruggle's Mine has not been ranked by NHNHB. Although each mine with known wintering bats has been assessed for long-term conservation prospects, no research has determined the microclimate quality.

2.5 Habitat Patch Protection Status

Red Mine and Ruggle's Mine are located on private land, while the DRED manages the Mascot Lead Mine and the Mt. Kearsarge Mine hibernacula.

2.6 Habitat Management Status

The only ongoing habitat management action occurring in New Hampshire is the bat gate at the Mascot Lead Mine (see Caves and Mines habitat profile). A census prior to gate installation (in 1992) found no eastern pipistrelles, and two were documented in the winter following installation. The 2004 winter survey documented five eastern pipistrelles.

2.7 Sources of Information

The winter distribution of eastern pipistrelles at known hibernacula was determined from New Hampshire Natural Heritage Survey – Hibernacula Survey Data Sheets. Scott Reynolds and Heather Durham conducted 1999 and 2000 winter surveys (Durham 2000). To determine habitat patch protection status, each potential and known hibernaculum was mapped on the Conservation Lands GIS data layer (GRANIT – 2003 data).

2.8 Extent and Quality of Data

The quality and extent of data varied between mines. For example, there have been four winter surveys at the Mascot Lead Mine since 1987; two were conducted since the installation of the bat gate in 1992. Since 1986, the Red Mine has been surveyed four times and the Mt. Kearsarge Lead Mine has been surveyed five times. With the exception of data collected in 1999 and 2000 at Red Mine and Mt. Kearsarge Lead Mine (Durham 2000), no microclimate data have been collected at any of these sites. Ruggle's Mine has not been surveyed.

2.9 Condition Assessment Research

The research priority for overwintering eastern pipistrelles is to obtain microclimate data (primarily temperature) at each hibernaculum. These data can then be used to assess microclimates at potential hibernacula. The research priorities for eastern pipistrelles during the summer include a statewide mistnetting survey, telemetry studies to determine roosting and foraging habitats, life history studies, and diet analysis.

Element 3: Species and Habitat Threat Assessment

3.1.1 Recreation

See Caves and Mines habitat profile

3.1.2 Development (Habitat Loss and Conversion), Unsustainable Harvest (Forestry Operations and Management)

(A) Exposure Pathway

As land in New Hampshire is deforested, eastern pipistrelles may experience summer habitat loss and degradation. Bats (particularly non-volant young) may also be killed if deforestation occurs during the parturition/lactation period (late May through mid-July). The additive results of habitat loss, degradation, and possible direct mortality could lead to a reduction in population size.

(B) Evidence

Recent data on colonial bat species indicate that bats occupy individual roost trees within a forest on a year-to-year basis (Barclay and Brigham 2001) and that individual bats return to the same roosting area each summer (Veilleux and Veilleux 2004). Bat biologists hypothesize that strong fidelity to roost areas (and possibly roost trees) allows individuals to relocate colony mates after emerging from hibernation. The removal of roost trees and forest habitat may disrupt the process of colony formation, with a corresponding reduction in individual fitness and population recruitment.

3.2 Sources of Information

Sources of information on threats to eastern pipistrelles include peer-reviewed scientific articles, gray literature, and expert review by John O. Whitaker, Jr. of Indiana State University.

3.3 Extent and Quality of Data

Fidelity of bats to specific roost areas (elements 3.1.3 and 3.1.4) is fairly well documented, but data on the effects of removing roost areas on colony dynamics are not available. Additional data on roost areas and roost trees are needed.

3.4 Threat Assessment Research

The final assessment effort for elements 3.1.3 and 3.1.4 would be to document roost areas in New Hampshire with relatively high numbers of eastern pipistrelles during the summer. Radiotelemetry studies would allow managers to determine the location of a roost area for a small population of eastern pipistrelles. Several years of capture and telemetry data at the roost areas would determine whether individual bats return to the same roost area. Such data would allow managers to assess the impact of removing forested habitat where eastern pipistrelles are known to occur.

Element 4: Conservation Actions

4.1.1 Gating, Habitat Protection

S*ee cave/mine habitat profile.*

4.1.2 Delineate habitat for conservation planning, Habitat Protection

(A) Removal of summer roosting habitat due to development, removal of summer roosting habitat due to logging.

(B) Justification

1) Sparse data on summer distribution patterns and population demographics of eastern pipistrelles limit the ability to determine whether documenting roosting habits (i.e. inter-annual fidelity to roost areas) will result in a measurable ecological response of population in the state. Since eastern pipistrelles breed in New Hampshire during the summer, it is important to understand their breeding habitat requirements and use this information to assess the potential impacts of habitat modification.
3) Veilleux and Veilleux (2004) reported that females return to very small summer roost areas each year. Minimum roost areas containing roost trees used by the same bats during two consecutive years ranged in size from 0.6 to 2.3 ha. Since development and logging can disrupt forested habitat at these small scales, it may be appropriate to limit or mitigate small-scale development or logging to protect eastern pipistrelles.

(C) Conservation Performance Objective
Integrate critical roosting habitats into a wildlife database. By protecting an entire habitat area, the smaller scale habitat needed by eastern pipistrelles (e.g., the preferred species of roost tree) will likely be protected as well.

(D) Performance Monitoring
To determine whether limiting or mitigating development and/or logging can maintain summer populations of eastern pipistrelles at specific habitat sites, managers can monitor whether eastern pipistrelles continue to use the habitat area over a long period (10 years).

(E) Ecological Response Objective
The habitat protection response objective is to maintain the current number of eastern pipistrelles roosting during summer within New Hampshire's forested habitats. Since data are too few to allow a valid estimate of the current eastern pipistrelle population status at summer roost areas, the minimal ecological response should be to maintain the initial populations located by biologists.

(F) Response Monitoring
To determine whether eastern pipistrelle summer populations are being maintained, known habitat areas should be monitored every three years. Such monitoring efforts will provide detailed data on whether eastern pipistrelles remain faithful to specific roost areas during the summer. These data will in turn allow managers to make informed decisions about eastern pipistrelle populations in areas threatened by high levels of development or logging.

(G) Implementation
Data on summer bat locations must be gathered. After summer habitat areas are identified, the state should initiate an intensive radio-telemetry study (1 to 2 years) to determine specific patterns of habitat use by individuals bats, and establish a long term

(10-year) monitoring program to determine if eastern pipistrelles remain faithful to small summer roost areas.

(H) Feasibility
The technical abilities are available in the region to determine both summer habitat areas (through mistnetting) and roosting habits (through radiotelemetry). The overall feasibility of conducting this research is limited by the availability of funding.

4.2 Conservation Action Research

Element 5: References

5.1 Literature

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SPECIES PROFILE

Eastern Red Bat

Lasiurus borealis

Federal Listing: Not listed
State Listing: Not listed
Global Rank: Not ranked
State Rank: Not ranked
Authors: Jacques P Veilleux, Franklin Pierce College; Scott Reynolds, St. Paul's School

Element 1: Distribution and Habitat

1.1 Habitat Description

Eastern red bats inhabit New Hampshire during the summer. Individuals migrate to southern states in the fall and return to New Hampshire and other northern states in the spring (Cryan and Veilleux *in press*). No available data describe the summer habitat requirements of eastern red bats in New Hampshire. During the summer, eastern red bats roost in tree foliage (Shump and Shump 1982, Whitaker and Hamilton 1998). Adult males and non-reproductive females roost singly; reproductive females are colonial and roost with their young (Mumford 1973, Shump and Shump 1982, Hutchinson and Lacki 2000). Females give birth and wean their young within foliage roosts.

Studies have found that red bats roost in a variety of deciduous tree species, in the largest trees, often high off the ground near the outer canopy edge. Hutchinson and Lacki (2001) suggest that eastern red bats roosting at such locations are sheltered from high temperatures caused by direct solar insolation and benefit from the cooling effects of wind caused by evaporative/convective heat loss. Eastern red bats roosting in fragmented habitats, such as urban areas and farmland, may roost nearer the ground. This behavior may reflect the lower height of tree canopies in such areas, as well as benefits from the cooling effects of wind.

Roost trees are typically located close to permanent water sources (Hutchinson and Lacki 2000). Menzel et al. (1998) reported the mean roost area (the area containing all roost trees) at 2.6 ha, while Mager and Nelson (2001) reported a mean roost area of 90 ha. Veilleux and Veilleux (2004) reported individual female eastern pipistrelles, another foliage roost species, return to very small summer roost areas across years.

1.2 Justification

Like other bat species, the eastern red bat's life history is different from the typical life history of small mammals. Individuals are relatively long-lived and have a low reproductive rate with a mean litter size of three young per year (Shump and Shump 1982). Habitat loss and degradation may lead to population declines, which, when coupled with their slow reproductive rate, could lead to a slow population recovery time.

Eastern red bats are of conservation concern in New Hampshire for the above reasons and because of the lack of knowledge about the species' population status in New Hampshire. Only 11 individuals have been captured in New Hampshire. Sasse and Pekins (1996) reported 2 individuals captured in Livermore (Grafton County) and Bartlett (Carroll County). Chenger (2005) captured seven in the White Mountain National Forest, including two from Gorham (Coos County), three from Bean's Purchase (Coos County) and one from both Bartlett (Carroll County) and Piermont (Grafton County). LaGory et al. (2002) captured two at the New Boston Air Force Base in New Boston (Hillsborough County).

Based on echolocation calls, Krusic et al. (1996) reported the presence of eastern red bats in Bartlett (Carroll County). Reynolds (1999) reported echolocation calls recorded at three sites: Giles State Park in Springfield (Sullivan County), MacDowell Lake-

Woodcock in Peterborough (Hillsborough County), and Pawtuckaway State Park in Nottingham (Rockingham County). Chenger (2005) reported echolocation calls from Albany (Carroll County). The above data indicate that eastern red bats may have a wide summer distribution in New Hampshire. The current lack of detailed data on the distribution, habitat use, and life history of eastern red bats in New Hampshire is largely due to a lack of research.

1.3 Protection and Regulatory Status

No specific ESA or RSA 212 regulations govern the take, transport, or use of this species. Scientific collecting or research involving the capture of individuals requires a permit through NHFG. Possession of live bats requires a permit under NHFG FIS 800.

1.4 Population and Habitat Distribution

Data on the current and historical ranges of eastern red bats in New Hampshire are too few to allow a regional population comparison. Available data indicate that eastern red bats may have a wide summer distribution in New Hampshire.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

1.7 Sources of Information

Town data on the eastern red bat's summer distribution were compiled from museum specimens, college and university teaching collections, and the published and gray literature of bat research in New Hampshire.

1.8 Extent and Quality of Data

Data on the distribution of eastern red bats in New Hampshire are extremely limited, but the quality of existing data is believed to be good because eastern red bats are morphologically unique and easy to identify. The major knowledge gap is the paucity of occurrence records and research into distribution patterns.

1.9 Distribution Research

Priority research to determine the summer distribution of eastern red bats should include a long-term mistnetting survey of New Hampshire accompanied by echolocation surveys (using Anabat acoustic survey methods). A statewide mistnetting survey would also yield data on the summer distribution of New Hampshire's other six bat species of conservation concern.

Element 2: Species/Habitat Condition

2.1 Scale

Scale for an appropriate conservation planning unit has not been resolved by the upland forest habitat mapper (Steve Fuller, NHFG).

2.2 Relative Health of Populations

The paucity of data on summer occurrences in New Hampshire prevents an analysis of the population trends and viability of eastern red bats.

2.3 Population Management Status

Eastern red bats are not currently managed in New Hampshire. Lack of data on the distribution of eastern red bats in New Hampshire prohibits the identification of conservation opportunities.

2.4 Relative Quality of Habitat Patches

See section 2.1

2.5 Habitat Patch Protection Status

See section 2.1

2.6 Habitat Management Status

See section 2.1

2.7 Sources of Information

See section 2.1

2.8 Extent and Quality of Data

See section 2.1

2.9 Condition Assessment Research

The research priorities for eastern red bats include a statewide mist-netting to better understand distribution, telemetry studies to determine habitat use, life history studies, and diet analyses.

Element 3: Species and Habitat Threat Assessment

3.1.1 Development (Habitat Loss and Conversion)

(A) Exposure Pathway
As land in New Hampshire is deforested, eastern red bats will experience summer habitat loss and degradation. Bats (particularly non-volant young) may also be killed if deforestation occurs during the parturition/lactation period (late May through mid-July). The cumulative effects of habitat loss, degradation, and possible direct mortality could reduce population size.

(B) Evidence
Recent data indicate that bats occupy individual roost trees within a forest on a year-to-year basis (Barclay and Brigham 2001) and that individual bats return to the same, small roosting area each summer (Veilleux and Veilleux 2004). These data are for colonial bat species, but may also apply to solitary species (C. Willis, personal communication). Bat biologists hypothesize that strong fidelity to roost areas indicates that these sites are high quality breeding sites. The removal of roost trees and loss of forested habitat may reduce the quality of the habitat patch and a corresponding reduction in individual fitness and population recruitment.

3.1.2 Energy and Communication Infrastructure

See Cave and Mine Habitat Profile

Element 4: Conservation Actions

4.1.1 Documenting roosting habits, Habita Protection

(A) Removal of summer roosting habitat due to development, removal of summer roosting habitat due to logging.

(B) Justification
1) Identifying summer roost areas for eastern red bats and determining whether individual bats return to specific roost areas will allow managers to better assess the impact of development and logging.
2) Limited data exist on the spatial scale of the summer roosting habitat used by eastern red bats. Since development and logging can disrupt forested habitat, it may be appropriate to limit or mitigate small-scale development or logging in critical habitat.

(C) Conservation Performance Objective
Critical roosting habitats should be entered into a wildlife database. The summer habitat requirements for populations of eastern red bats will enable managers to assess how development or logging might impact eastern red bat populations. By protecting an entire habitat area, the smaller scale habitat needed by eastern red bats (e.g. the preferred species of roost tree) will likely be protected as well.

(D) Performance Monitoring
To determine whether limiting or mitigating development or logging can maintain summer populations of eastern red bats at specific habitat sites, managers can monitor whether eastern red bats continue to use the habitat area over a long period (e.g., 10 years).

(E) Ecological Response Objective
The habitat protection response objective is to maintain the current number of eastern red bats roosting within New Hampshire's forested habitats. Since the data are too few to allow a valid estimate of the current eastern red bat population, the minimal ecological response should be to maintain the initial populations located by biologists.

(F) Response Monitoring
To determine whether eastern red bat populations are being maintained, known habitat areas should be monitored every three years. These data will in turn allow managers to make better decisions about eastern red bat populations in areas threatened by high levels of development or logging.

(G) Implementation
To document the summer roosting habits of eastern

red bats, preliminary data on summer locations must be gathered. After summer habitat areas are identified, the state should coordinate an intensive short-term (1-2 year) radiotelemetry study to determine the specific patterns of habitat use by individuals, and a long-term (10 year) monitoring program with periodic 3-year monitoring to determine if eastern red bats remain faithful to small summer roost areas.

(H) Feasibility
The technical abilities are available to determine both summer habitat areas (through mistnetting) and roosting habits (through radiotelemetry). The overall feasibility of conducting this research is limited by the availability of funding.

4.1.2 Site-Selection and Pre-Construction Regulations, Regulation and Policy

See Cave/Mine Habitat profile

4.2 Conservation Action Research

Element 5: References

5.1 Literature

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SPECIES PROFILE

Eastern Timber Wolf

Canis lupus lycaon

Federal Listing: TN
State Listing: N/A
Affected Species: N/A
Global Rank: G4TNR
State Rank: SX
Author: Matthew Carpenter, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Historically, wolves lived in a wide variety of habitats throughout the northern hemisphere, from mountain forests to open prairie (Mech 1970). The main requirement for a wolf population is a source of large prey, such as deer, moose, or bison. Modern populations of wolves are limited by habitat fragmentation and direct or indirect human caused mortality (Musiani and Paquet 2004). Road density has been used in the Midwest as an indicator for suitable wolf habitat (Mladenoff et al. 1995). As populations expand in Minnesota, Wisconsin, and Michigan, wolves are adapting to semi-wild areas that were previously considered unsuitable (Mech 1995). The amount of residential or commercial development that wolves can learn to tolerate on a landscape is unclear.

1.2 Justification

Few species are loved and hated as passionately as the wolf. To some the wolf is an abstract symbol of a disappearing wilderness. To others the wolf is a vile murderer of livestock and deer. The wolf, from an ecological perspective, is part of a natural system. It has coevolved with the organisms of the northern forest over thousands of years. By preying on and shifting the distribution of herbivores such as deer, moose, and beaver, wolves indirectly influence plant species composition which in turn influences the very nature of the forest (Laundre et al. 2001). Since the extirpation of the wolf in the early 1800's New Hampshire has been missing the balancing influence of this top predator.

1.3 Protection and Regulatory Status

Gray wolves are currently listed under the federal endangered species act. In 2003, the USFWS divided gray wolf populations into three regions: western, southwestern, and eastern. New Hampshire was part of the Eastern Distinct Population Segment, which included the upper Midwest and the Northeast. In 2004, the USFWS proposed delisting the wolf in the Eastern Distinct Population Segment because populations had met recovery goals in the states of Minnesota, Wisconsin, and Michigan. A ruling in January of 2005 by the U.S. District Court in Oregon invalidated the USFWS population segments and returned the wolf to its status prior to 2003 (USFWS 2005). Therefore the wolf is currently classified as endangered in all eastern states except Minnesota, where it was reclassified as threatened in 1978.

The New Hampshire legislature passed a law (HB 240) in 1999 that bans the reintroduction of wolves into the state. The law does not restrict a natural recolonization by wolves.

1.4 Population and Habitat Distribution

Populations of gray wolves exist throughout northern North America, Europe, Russia, and Asia. A history of wolf persecution in Europe and the continental U.S. has extirpated the wolf from much of its former range (Mech 1970). Wolves were extirpated from New Hampshire in the early 1800's. The nearest population of wolves exists in Quebec, north of the St. Lawrence River. Wolves from this population have been referred to as eastern timber wolves, considered a subspecies of gray wolves (USFWS 1992). Recent mitochondrial DNA evidence suggests that the eastern timber wolves, found in southeastern Canada, may be more closely related to red wolves (*Canis rufus*) and coyotes (*Canis latrans*) than to gray wolves (Wilson et al. 2000). The authors suggest that these wolves should be treated as a separate species, *Canis lycaon*. The issue remains unresolved.

In January of 2002, a wolf was snared near the town of Sainte-Marguerite-de-Lingwick, Quebec, approximately 32 km from the New Hampshire border (Villemure and Jolicoeur 2003). The trapper claimed to have seen other wolves in the area. This report is evidence that wolves are capable of crossing the St. Lawrence River, which is considered a major barrier to wolf dispersal (Wydeven et al. 1998, Harrison and Chapin 1998). It is the first confirmed wolf captured south of the St. Lawrence River, in Quebec, in over 100 years (Villemure and Jolicoeur 2003). Two wolves have been killed in Maine since 1993, although one of the individuals was behaving suspiciously like a released captive animal (Maine Department of Natural Resources [MDNR] 2004). Despite these reports, most studies suggest that a natural wolf recolonization of northern New England from populations in eastern Canada is unlikely (Wydeven et al. 1998, Carrol 2003). However, wolves tend to disperse over long distances, often crossing obstacles such as 4 lane highways (Merril 2000). The recent expansion of wolf populations in Europe and the midwestern states suggests that the potential for a natural recolonization of wolves in New Hampshire should be taken seriously.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

Refer to Mladenoff and Sickley (1998) for a map of potential wolf habitat in the northeast.

1.7 Sources of Information

Literature reviews and communications with New Hampshire Fish and Game biologists.

1.8 Extent and Quality of Data

New Hampshire Fish and Game biologists investigate credible wolf sightings, but have yet to confirm the presence of wolves in the state (Will Statts and Eric Orff, personal communications, NHFGD).

1.9 Distribution Research

Peggy Struhsacker of the National Wildlife Federation, through their northeast office in Montpelier, Vermont, has conducted winter track searches for wolves in New Hampshire and Maine since 2003. None have been detected to date (Eric Orff, personal communication, NHFG). Confirming the presence of wolves in the northeast is made difficult by the eastern coyote, which resembles the wolf in appearance. DNA evidence suggests that wolves in southeastern Canada occasionally hybridize with coyotes, which further complicates the issue (Lehman et al. 1991).

Recent advances in fecal DNA analysis offer an alternative method for confirming the presence of wolves. Fecal DNA sampling was used in France and Switzerland to monitor the recolonization of wolves in the western Alps over ten years (Valiere et al. 2003). NHFGD should adopt a standard procedure for collecting, storing, and shipping out possible wolf scat samples for DNA analysis.

Element 2: Species/Habitat Condition

2.1 Scale

N/A

2.2 Relative Health of Populations

Wolf populations are currently considered stable in Quebec (Lariviere et al. 2000). An increase in protection or a decrease in hunting/trapping pressure on wolves in Quebec would likely lead to an increase in wolf numbers, and ultimately to an increase in dispersal rates (Wydeven et al. 1998). Any increase in wolf dispersal would increase the likelihood of a natural wolf recolonization of the northeastern U.S. A wolf population that establishes in Maine would be likely to expand into northern New Hampshire.

2.3 Population Management Status

New Hampshire would constitute only a small portion of potential wolf range in the northeast, which would be expected to include areas of Maine, New Hampshire, Vermont, and New York. New Hampshire currently has no management plan that addresses the potential return of wolves to the state. Minnesota, Wisconsin, and Michigan are examples of states that have recently dealt with the issue of a naturally recovering wolf population. New Hampshire should look to these states for guidance in the preparation of a strategy for dealing with the potential return of wolves. A key component of this strategy would be to support public education that dispels myths about wolves and focuses on the actual benefits and problems of living with a wolf population. The strategy should also differentiate between short term and long-term management goals. In general, recovering wolf populations require protection in the short term, but expanding populations will need a more flexible management policy to address the inevitable increase in wolf/human conflicts, such as the killing of livestock or pets (Mech 1995). Minnesota has been successful with a strategy that allows for increased harvest in agricultural and suburban areas while maintaining protection in areas of core wolf habitat (Mech 1995).

2.4 Relative Quality of Habitat Patches

Mladenoff and Sickley (1998) identify most of northern New Hampshire as suitable wolf habitat based on its relatively low human population and road density and its abundant moose and deer populations.

2.5 Habitat Patch Protection Status

A portion of northern New Hampshire was recently protected from development with a 171,000-acre (692 km^2) conservation easement in the headwaters of the Connecticut Lakes. However, most of the large, unfragmented blocks of forest in the region are not protected.

2.6 Habitat Management Status

The majority of land in northern New Hampshire is managed for forestry products. Forestry operations actually benefit wolves by creating more browse for deer and moose. Future development could fragment the landscape, which would restrict the movements of a potential wolf population (Carrol 2003).

2.7 Sources of Information

Literature Review

2.8 Extent and Quality of Data

The status of wolves in Quebec is based on hunter survey reports (Lariviere et al. 2000). The potential for natural recolonization of the northeast has been addressed by a number of authors (Harrison and Chapin 1998, Wydeven et al. 1998, Carrol 2003).

2.9 Condition Assessment Research

Future research on the potential for recolonization should include studies of wolf/coyote interactions, a more detailed assessment of the St. Lawrence River as a barrier, and surveys to assess public attitudes toward wolves. Wolf recovery ultimately depends on support from the public. If public opinion toward wolves is unfavorable then any attempts to restore wolves will likely be unsustainable (Mech 1995). The Coalition to Restore the Eastern Wolf (CREW) is a group of organizations working to increase public awareness and influence policy decisions that will facilitate the return of wolves to the northeastern U.S. CREW is a valuable resource for monitoring public opinion toward wolves.

The potential for natural wolf recolonization may currently be limited by the year round open season on coyotes in New Hampshire. Closer monitoring of coyotes harvested in the state would increase the likelihood of intercepting wolves that cross the border. For example, the Maine Department of Natural Resources encourages trappers to report any canid longer than 4.5 ft from nose to tail (MDNR 2004).

Element 5: References

5.1 Literature Cited

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SPECIES PROFILE

Hoary Bat

Lasiurus cinereus

Federal Listing: Not listed
State Listing: Not listed
Global Rank: Not ranked
State Rank: Not ranked
Authors: Jacques P Veilleux, Franklin Pierce College; Scott Reynolds, St. Paul's School

Element 1: Distribution and Habitat

1.1 Habitat Description

Hoary bats leave New Hampshire in the autumn to spend winter months in the South. During spring, they return north to their summer habitat (Cryan and Veilleux in press). No data describe the summer habitat of hoary bats in New Hampshire, though elsewhere they roost in tree foliage or even in woodpecker holes and squirrel nests (Shump and Shump 1982, Whitaker and Hamilton 1998).

Bats are not colonial, but roost singly during all times of the year (except for reproductive females, who birth and wean their young within the roost) (Shump and Shump 1982). Limited research suggests that hoary bats almost exclusively prefer the foliage of white spruce (*Picea glauca*) for their summer roosting (Willis and Brigham 2005). A study by Willis and Brigham (2005) demonstrated that, on average, hoary bats roosted 2 m from the tree trunk and in branches located 12.7 m from the ground. Roosts were oriented to the southeast (mean angle = 158.6). Roosts are typically sheltered by dense, overhanging foliage that forms an umbrella shape above the bats. The southeast exposure, lower canopy closure, and relative roost height may increase exposure of bats to sunlight, thereby providing warmer roost temperatures (Willis and Brigham 2005). Koehler and Barclay (2000) reported hoary bats from Manitoba, Canada, roosting at heights of 8-18 m in the foliage, and occasionally on the bark of trees. Trees bordered clearings or rose above nearby trees in the forest. Willis and Brigham (2005) observed reduced forest density on the roosting side of roost trees, possibly providing a open 'flyway' for bats returning to and leaving the roost. Hoary bats also roost at lower elevations, possibly due to lower wind levels and the abundance white spruce.

1.2 Justification

Hoary bats are relatively long lived and have a low reproductive rate, typically giving birth to 2 young per year (Koehler and Barclay 2000; Shump and Shump 1982). Habitat loss and degradation may lead to population declines, which are compounded by slow reproductive rates.

Only 6 individuals have been captured in New Hampshire, including 1 female in the WMNF (Krusic et al. 1996) and 1 juvenile female and 1 adult female in Livermore, Grafton Country (D.B. Sasse, Arkansas Game and Fish Commission, personal communication). LaGory et al. (2002) captured an adult female and adult male at the New Boston Air Force Base in New Boston, Hillsborough County, and a single hoary bat was collected in Conway, Carroll County. Based on echolocation calls, Reynolds (1999) reported the presence of hoary bats at Gile State Park, Springfield, Sullivan County and Pawtuckaway State Park, Nottingham, Rockingham County. Chenger (2005) reported echolocation calls from Gorham (Coos County) and Albany (Carroll County).

These data indicate that hoary bats may have a wide summer distribution in New Hampshire. The current lack of detailed data on the distribution, habitat use, and life history of hoary bats in New Hampshire is largely due to a lack of research.

1.3 Protection and Regulatory Status

No specific ESA or RSA 212 regulations govern take, transport, or use of this species. Scientific collection or research requiring capture of individuals requires a permit through NHFG. Possession of live bats requires a permit under NHFG FIS 800.

1.4 Population and Habitat Distribution

Data that describe the range of hoary bats in New Hampshire are too few to allow a regional comparison of hoary bat populations. See section 1.2.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

1.7 Sources of Information

Data on species distribution were compiled by searching for specimens deposited in museums and college/university teaching collections and by examining published and gray literature of research on bat populations in New Hampshire.

1.8 Extent and Quality of Data

There are limited data on the distribution of hoary bats in New Hampshire but data quality is believed to be good. Hoary bats are morphologically unique and identifications should be accurate.

1.9 Distribution Research

Research to determine summer distribution of hoary bats should include a long-term, statewide mist-netting survey, accompanied by echolocation surveys (e.g. use of Anabat acoustic survey methods when mistnetting).

Element 2: Species/Habitat Condition

2.1 Scale

Scale for an appropriate conservation planning unit has not been resolved by the Lowland Spruce-Fir Forest habitat mapper (Carol Foss, NHA).

2.2 Relative Health of Populations

Hoary bats have been captured at 3 localities in New Hampshire: WMNF (n = 3), Conway (n = 1) and New Boston (n = 2). Echolocation calls have been recorded in Albany, Gorham, Nottingham, and Springfield. Population trends and viability cannot be assessed with so little data.

2.3 Population Management Status

Hoary bats are not currently managed in New Hampshire.

2.4 Relative Quality of Habitat Patches

Scale for an appropriate conservation planning unit has not been resolved by the Lowland Spruce-Fir Forest habitat mapper, and therefore the data for determining the relative quality of such patches are unavailable.

2.5 Habitat Patch Protection Status

See 2.4.

2.6 Habitat Management Status

See 2.4.

2.7 Sources of Information

See 2.4.

2.8 Extent and Quality of Data

See 2.4.

2.9 Condition Assessment Research

Research of hoary bats during summer should include a statewide mist-netting survey to determine state distribution, telemetry studies to determine habitat use (roosting and foraging habitat), life history studies, and diet analyses.

Element 3: Species and Habitat Threat Assessment

3.1.1 Development (Habitat Loss and Conversion)

(A) Exposure Pathway

As land in New Hampshire is deforested, hoary bats will experience summer habitat loss and degradation. Bats (particularly non-volant young) may also be killed if deforestation occurs during the parturition/ lactation period (late May through mid-July)

(B) Evidence
Recent data indicate that individual roost trees are occupied by bats on a year-to-year basis (Barclay and Brigham 2001), and that individual bats return to the same, small summer roosting area each year (Veilleux and Veilleux 2004). These data are for colonial bat species, but may also apply to solitary species (C. Willis personal communication). Bat biologist hypothesize that strong fidelity to roost areas indicates that the habitat area offers a particularly high quality area for breeding; thus, deforestation may reduce the quality of the habitat patch. If the quality of the habitat patch is reduced, reduction in individual fitness and population recruitment may occur.

3.1.2 Energy and Communication Infrastructure

3.2 Sources of Information

Sources of information on threats to hoary bats included peer-reviewed scientific articles, gray literature, and expert review by John O. Whitaker, Jr. of Indiana State University.

3.3 Extent and Quality of Data

The threats described under element 3.1, and their potential impact on bat populations, are well documented. Data describing the long-term negative effect of habitat conversion (development and logging) is not well understood. Although fidelity to roost areas is well documented in other bats, it is not documented for hoary bats. Data on how hoary bats use roost areas and roost trees on a long-term basis are needed.

3.4 Threat Assessment Research

Areas in New Hampshire with high numbers of hoary bats during summer months should be documented. Radio-telemetry studies will allow managers to determine the location of a roost areas, and several years of capture and telemetry data would determine whether individual bats return to the same roost areas each year. Such data would also allow managers to assess the effects of deforestation on hoary bats.

Element 4: Conservation Actions

4.1.1 Documenting roosting habits, Habitat Protection

(A) Deforestation

(B) Justification

- Identifying summer roost areas and determining roost fidelity will allow managers to assess the effects of deforestation.
- No data on the spatial scale of summer roosting exist, though Veilleux and Veilleux (2004) reported individual female eastern pipistrelles, another foliage roosting species, returning to very small summer roost areas across years. Minimum roost areas containing roost trees used by the same bats during 2 consecutive years ranged between 0.6 and 2.3 ha. Since development can disrupt forested habitat at such small scales, it is appropriate to plan management accordingly.

(C) Conservation Performance Objective
Integrate critical roosting habitats into a wildlife database. Determining summer habitat requirements for populations of hoary bats is intended to allow managers to make good decisions about logging and development. By protecting a habitat area, the smaller scale attributes of a habitat (e.g. a preferred species of roost tree) will likely be protected as well (i.e., a coarse filter approach).

(D) Performance Monitoring
To determine whether limiting or mitigating deforestation results in the maintenance of summer populations of hoary bats, managers can monitor whether hoary bats continue to use a site over a long time period (periodic monitoring over a 10-year period).

(E) Ecological Response Objective
The habitat protection response objective is to maintain the current number of hoary bats roosting during summer within forested habitats. Since current data

are too few to allow an estimate of hoary bat population at summer roost areas, the minimal ecological response should be the maintenance of those populations initially located by biologists.

(F) Response Monitoring
Summer surveys at a known habitat area every three years will determine whether hoary bat populations are being maintained and whether bats remain faithful to specific roost areas during summer. These data will in turn allow managers to make better informed decision about the maintenance of hoary bat populations in areas threatened by high levels of development or logging.

(G) Implementation
Data on summer bat locations must be gathered. After summer habitat areas are identified, the state should initiate an intensive radio-telemetry study (1 to 2 years) to determine specific patterns of habitat use by individuals bats, and establish a long term (10-year) monitoring program to determine if hoary bats remain faithful to small summer roost areas.

(H) Feasibility
The technical competence to determine general summer habitat areas of hoary bats (mist-netting) and detailed patterns of their roosting habits (radio telemetry) is available. Research is limited by funding.

4.1.2 Site-Selection and Pre-Construction Regulations, Regulation and Policy

(A) Wind Resource Development

4.2 Conservation Action Research

Element 5: References

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SPECIES PROFILE

Indiana Bat

Myotis sodalis

Federal Listing: Endangered
State Listing: S1
Global Rank: G2
State Rank: SNA
Authors: Jacques P Veilleux, Franklin Pierce College; Scott Reynolds, St. Paul's School

Element 1: Distribution and Habitat

1.1 Habitat Description

During winter, Indiana bats require cave or mine habitat that provides adequate characteristics for successful hibernation. Such characteristics mainly include proper microclimate (i.e. temperature stability) and low levels of human disturbance. Within the hibernaculum, Indiana bats often form tight clusters (Griffin 1940). They prefer roost temperatures between 1°C - 10°C and relative humidity in excess of 75% (Menzel et al. 2001, Tuttle 2003). Indiana bats generally enter the hibernacula during late October and begin leaving in March, with over 50% of the hibernating population usually emerging by mid-April (Richter et al. 1993). Male Indiana bats are often found either using caves or mines during the summer months or are captured in adjacent habitat (Whitaker and Brack 2002).

The summer habitat requirements of Indiana bats in New Hampshire are unknown; in fact, there is only one summer record of an Indiana bat in New Hampshire (Krusic 1996). Elsewhere in the summer, Indiana bats roost in trees with exfoliating bark or, rarely, in cavities. This habitat provides females with a physical space for forming maternity colonies where young are reared. Ideal habitat includes a roost tree and proximity to food and water.

1.2 Justification

Indiana bats are listed as federally endangered due to severe population declines at major hibernacula in the Midwest. Indiana bats have experienced a range-wide decline of approximately 57% in the last 50 years (Clawson 2002). In the 1930s, Indiana bats were the most abundant wintering bat species in Vermont. Of the 24 historic hibernacula known in the Northeast, at least ten have not been used by Indiana bats since 1980 (Hicks and Novak 2002). Massive deforestation in the 1880s was the primary cause of their decline in the Northeast (Trombulak et al. 2001). Currently, most hibernating Indiana bats in the northeast are found in New York (Hicks and Novak 2002).

Bats have a unique life history compared with other small mammals. Individuals are relatively long-lived and have a low reproductive rate, usually giving birth to a single young (Thompson 1982). Their slow reproductive rate contributes to a slow recovery time following population losses. Indiana bats are found in relatively rare, at-risk habitats during winter (caves/mines) and are thus particularly vulnerable to habitat loss or degradation. Indiana bats are of conservation concern in New Hampshire for the above reasons and because so little is known about the species' population status. Indiana bats have not been found hibernating in any of the 7 known hibernacula in New Hampshire, although there may exist unsurveyed mines that serve as hibernacula.

One male Indiana bat was captured in Bartlett (Krusic 1996), indicating that the species occurs in New Hampshire. It is possible that additional Indiana bats reside in New Hampshire during the summer, but few surveys have been completed. Some females that hibernate in New York currently form maternal colonies in Vermont's Green Mountain National Forest, which is approximately 65 km from the New Hampshire border.

3.3 Protection and Regulatory Status

No additional laws, ordinances, or rules, beyond those outlined in the Endangered Species Act (ESA), regulate the take, transport, or use of this species in New Hampshire. Scientific collection or research requiring capture of individuals requires a permit through NHFG (NHFG). Possession of live bats requires a permit under NHFG FIS 800.

1.4 Population and Habitat Distribution

Too little is known about the historic or current distribution of Indiana bats to assess regional distribution in New Hampshire. There are no winter records of Indiana bats hibernating in New Hampshire, and only one adult male was collected in the summer. A single summer record (adult male) is known from Albany, Carroll County.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

1.7 Sources of Information

Distribution information was compiled by examining New Hampshire Natural Heritage Inventory – Bat Hibernaculum Record data sheets, and by examining the collection dates of specimens deposited in museum collections and university teaching collections, and from published and gray literature on bats in New Hampshire.

1.8 Extent and Quality of Data

Data on the distribution of the Indiana bat in New Hampshire are extremely limited and of limited quality. A University of New Hampshire Master's student identified the lone summer record, and since identification of Indiana bats is difficult and requires experience, the record should be considered tentative. More research should be aimed at determining distribution patterns for this species.

1.9 Distribution Research

Surveys of previously un-surveyed mines that may serve as bat hibernacula are needed to determine the winter distribution of Indiana bats in New Hampshire. A long-term, statewide mist-netting survey (with a protocol that meets the *de minimus* standards set out in the Indiana Bat Recovery Plan (USFWS 1999)), accompanied by echolocation surveys (e.g. use of Anabat acoustic survey methods when mist-netting), is needed to determine summer distribution. Initial mist-netting surveys should focus on bottomland forest and riparian corridor habitat in southwest New Hampshire. Mist-netting surveys should incorporate banding into the capture protocol and record all banding records in the Northeast Banding Database developed by the Northeast Working Group on Bats (NEWGB).

Element 2: Species/Habitat Condition

2.1 Scale

Due to the small number of mines in New Hampshire that may provide habitat for this species, each mine has been treated as a conservation planning unit under the habitat profile.

2.2 Relative Health of Populations

There is no known population of Indiana bats in New Hampshire. High priority conservation actions include the winter survey of the previously un-surveyed mines that may provide adequate winter habitat.

2.3 Population Management Status

Indiana bats are not currently managed in New Hampshire. Too little distribution data is available to develop conservation or management strategies.

2.4 Relative Quality of Habitat Patches

Indiana bat hibernacula in the Northeast tend to be large and thermally stable mines and caves with low ambient temperature, proximity to riparian habitat, and freedom from disturbance (Tuttle and Kennedy 2002, Tuttle 2003). Mascot Lead Mine is likely the only known hibernaculum that meets these characteristics. It is within 0.9 km of riparian habitat and located on land managed by the Department of Resources and Economic Development (DRED). Yuhas Mine

#2 in Alstead (Sullivan County) is within 0.8 km of riparian habitat, but total adit length could not be determined (Table 1). Because New Hampshire is in the northeastern periphery of the Indiana bat's range (Evans et al. 1998), it will be important to assess any potential hibernacula in Hillsborough, Merrimack, Cheshire, and Rockingham counties that meet these characteristics.

2.5 Habitat Patch Protection Status

2.6 Habitat Management Status

Bat gates have been installed at hibernacula for the last 35 years to reduce or eliminate disturbance to bats (Tuttle 1976). Bat gates are steel-welded structured installed in the entrance to a mine or cave to restrict human access while causing minimal impact on air flow and flight behavior of bats. Because many caves and mines are found in remote locations, bat gates have been described as "the only means available for protecting these [colonies of Indiana bats]" (Pierson et al. 1991: 31).

In New Hampshire, Mascot Lead Mine is the only known hibernaculum that is likely to have a microclimate conducive to Indiana bats, and it is the only hibernaculum where bat habitat is managed. This mine could potentially support Indiana bats, if the species were to overwinter in New Hampshire.

2.7 Sources of Information

To determine the winter distribution at known hibernacula, New Hampshire Natural Heritage Survey – Hibernacula Survey Data Sheets were examined. To determine habitat patch protection status, each hibernaculum, whether known or potential, was mapped on the Conservation Lands GIS data layer (GRANIT – 2003 data). Information about the summer habitat needs for Indiana bats is available from Menzel et al. 2001 and Clawson 2002.

2.8 Extent and Quality of Data

The data on known and potential hibernacula were collected in the summer of 2004 by Veilleux and Reynolds (2005).

2.9 Condition Assessment Research

Scientists need to determine the distribution and importance of mines that serve as winter roosts in New Hampshire. This requires establishing a monitoring program that will assess the physical attributes of potential hibernacula and document whether Indiana bats use any of these mines.

Research priorities for summering Indiana bats include the initiation of a state-wide mist-netting survey to document state-wide distribution, telemetry studies to determine habitat use (roosting and foraging habitat), life history studies to determine breeding status and reproductive patterns (e.g. timing of birth, weaning of young), and food habit analyses to determine prey preference.

Element 3: Species and Habitat Threat Assessment

3.1.1 Recreation

See Caves and Mines habitat profile.

3.1.2 Development (Habitat Loss and Conversion)

(A) Exposure Pathway

Industrial or residential development and forest cutting may affect Indiana bats and other species that rely on trees for summer roosting habitat. Individual bats may experience direct mortality (especially non-volant young) if the disturbance occurs during the parturition or lactation period (late May through mid-July: Thomson 1982). The cumulative results of habitat loss, degradation, and possibly direct mortality could lead to a corresponding reduction in population size.

(B) Evidence

Recent data indicate that Indiana bats rely on multiple roost trees (up to 18 trees by one colony) within a single season (Kurta and Whitaker 1998). Indiana bats appear to choose tree characteristics (such as tree width and roost height) rather than tree species (Kurta and Rice 2002, Miller et al. 2002, Lacki and Baker 2003). Radiotelemetry studies have shown that roost trees are usually clustered, with most trees within 1.0 km of each other (Kurta et al. 2002). Maternity colonies of Indiana bats show some degree of site fidelity and often occupy the same roost trees for multiple seasons (Kurta et al. 2002). These data suggest that strong fidelity to roost trees and core roosting allows individuals to relocate colony mates after emerging from hibernation in the spring. The removal of roost trees below a critical density (estimated at 42 trees per hectare in bottomland forest and 67 trees per hectare in upland forests: Garner and Gardner 1992), or the loss of roost trees within the core roosting area, may disrupt colony formation. If individuals are unable to form a colony, it is likely that a corresponding reduction in individual fitness, and therefore population recruitment, will occur.

3.2 Sources of Information:

Much of the information on the biology of Indiana bats in caves and mines comes from the published literature and experts such as Alan Hicks of the New York Department of Environmental Conservation. Information on the biology of the summer foraging and roosting habitat of Indiana bats comes from the published literature.

3.3 Extent and Quality of Data

There are no data on the potential impact of wind resource development (Element 3.1.2) on Indiana bats. Habitat preference and fidelity of Indiana bats to specific roost areas (Element 3.1.3 and 3.1.4) is fairly well documented, but data on whether the removal of roost areas will negatively affect bats by disrupting colony dynamics is not available.

3.4 Threat Assessment Research

Element 4: Conservation Actions

4.1.1 Gating, Habitat Protection
See caves/mines habitat profile.

4.1.2 Site-Selection and Pre-Construction Regulations, Regulation and Policy
See caves/mines habitat profile.

4.1.3 Documenting roosting habits, Habitat Protection

(A) Removal of summer roosting habitat due to development, removal of summer roosting habitat due to logging.

(B) Justification
1) Identifying summer roost habitat for Indiana bats and determining whether individual bats return to specific roost areas each year will allow managers to better assess the impact of habitat disturbance.

2) The lack of data on the summer distribution and population demographics of Indiana bats in New Hampshire prevents informed management decisions on the impact of development and forest cutting on this species.

3) Research on Indiana bats in other states suggests that the core roosting habitat of a maternity colony encompasses up to 150 ha (Miller et al. 2002) and that the foraging area is often substantially larger (Evans et al. 1988, Callahan et al 1997). Since development activity, and especially logging, can disrupt forested habitat at similar scales, it is appropriate to plan management actions at this scale. By focusing on smaller scales, key habitat features such as preferred roost trees are more likely to be identified and protected.

4) As new information is gathered that refines our understanding of summer habitat use by Indiana bats, managers can inform development or logging interests about conservation action that may be required.

(C) Conservation Performance Objective
Integrate critical roosting habitats into a wildlife database. Better summer range data of Indiana bats may allow managers to make informed decisions about the limiting or mitigating development and logging activities within critical habitat.

(D) Performance Monitoring
Managers can monitor habitat use by Indiana bats over long periods (perhaps periodic monitoring over a 10-year period) to determine whether modified development and logging activities result in the maintenance of summer populations at specific sites.

(E) Ecological Response Objective: Maintain popu-

lations in delineated areas
The habitat protection response objective is to maintain the current number of Indiana bats roosting during summer within their core roosting habitat. Since there are virtually no data on the current Indiana bat population within the state, the minimal ecological response should be to maintain any populations located by biologists.

(F) Response Monitoring: Identify more specific monitoring parameters
If populations are identified, critical habitats will need to be surveyed (for example, every three years). Monitoring should provide data on whether Indiana bats show roost or habitat fidelity during the summer. These data will allow managers to make better-informed decision about the maintenance of Indiana bat populations in areas threatened by development or logging.

(G) Implementation
Preliminary data on the location of Indiana bats must be gathered. If summer habitat areas are identified, the state could consider more intensive population and habitat studies.

(H) Feasibility
The technical competence to determine general summer habitat areas of Indiana bats (mist-netting), as well as the detailed methods of evaluating their roosting habits (radio-telemetry), are available in the region.

4.2 Conservation Action Research

The conservation action research objective for Indiana bats is to document their existence within the state and protect critical habitats and resources. Documentation of Indiana bats' distribution and abundance will require extensive research at both the landscape level (for example, summer surveys within riparian and bottomland forest habitat) and habitat level (roost tree surveys within these habitats). If Indiana bats are found, research should move toward radio-telemetry in order to document core foraging and roosting habitat. Additional effort should then be concentrated on conserving and managing these critical resources.

Element 5: References

5.1 Literature

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SPECIES PROFILE

Canada Lynx

Lynx canadensis

Federal Listing: Threatened
State Listing: Endangered
Global Rank: G5
State Rank: S1
Authors: John A. Litvaitis and Jeffery P. Tash, University of New Hampshire

Element 1: Distribution and Habitat

1.1 Habitat Description

Lynx occupy various habitats in the boreal forests and their southern extensions (Anderson and Lovallo 2003). In eastern forests, dominant vegetation includes spruce (*Picea* spp.) and balsam fir (*Abies balsamea*). Snowshoe hare (*Lepus americanus*) are important prey for lynx, and young or subalpine stands may be preferred because they contain more hare than do mature stands (Anderson and Lovallo 2003). Though data on competition and predation are equivocal, lynx may avoid bobcat (*Lynx rufus*) and coyote (*Canis latrans*) by seeking deep snow, to which lynx are morphologically adapted (long legs and large feet, Parker et al. 1983).

1.2 Justification

Lynx have been listed as endangered in New Hampshire since 1980. The United States Fish and Wildlife Service (USFWS) listed all lynx populations in the lower 48 states as threatened in 2000.

1.3 Protection and Regulatory Status

Lynx trapping and hunting seasons in New Hampshire have been closed since 1971. Lynx are also protected under federal endangered species legislation (USFWS 2000).

1.4 Population and Habitat Distribution

Although there are no records of lynx reproducing in New Hampshire (McKelvey et al. 2000), lynx were frequently encountered in Coos and northern Carroll and Grafton counties (Siegler 1971, Silver 1974, Hoving et al. 2003). Lynx are more common toward the north, particularly in Quebec and New Brunswick. Large-scale timber harvests for agriculture and suburban developments north of the St. Lawrence Seaway combined with intensive lynx harvests and land clearing south of the Seaway may have resulted in isolation of lynx in northern New England (Litvaitis et al. 1991). Recent evidence indicates that core lynx populations in the Gaspé Peninsula may be the source for satellite populations in northwestern Maine and northern New Hampshire (Carroll 2005). Few lynx have been captured or killed in New Hampshire in recent years. In 1966 and 1992, adult lynx were killed after collisions with vehicles in Lee and west of Concord on Interstate 89, respectively (Litvaitis 1994).

1.5 Town Distribution Map

Recent observations are quite limited (figure 1). No conclusions can be drawn from this limited dataset.

1.6 Habitat Map

We relied extensively on the recent habitat modeling efforts by Hoving et al. (2005). Initial estimates of lynx habitat were obtained from the model developed by Hoving et al. (2005) in conjunction with information on land cover obtained from the New Hampshire Land Cover Assessment 2001 database from Complex Systems Research Center of the University of New Hampshire (Justice et al. 2002). This digital raster dataset was classified from 1990-1999 Landsat

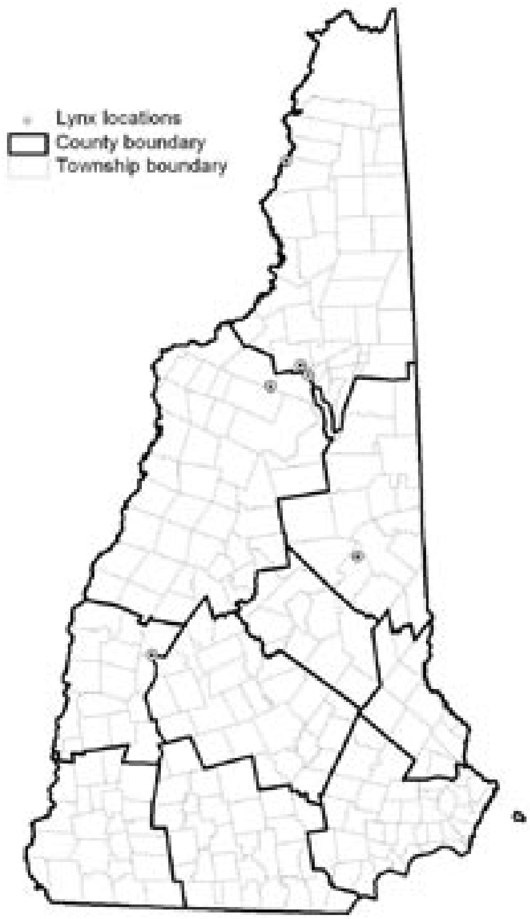

FIGURE 1. Location of incidental observations of lynx during 1990-2004 (from NHDRED).

Thematic Mapper imagery into 23 classes with a cell size of 30 meters. Overall classification accuracy at this level was assessed at 82.2%. Mean annual snowfall from 1971 to 2000 was obtained from Spatial Climate Analysis Service at Oregon State University. This dataset uses the PRISM modeling system to estimate annual snowfall for each 2 x 2 km pixel based on data from over 7,000 weather stations nationwide and digital elevation models. Suitable lynx habitat in New Hampshire was estimated combining all cells that had a probability of occurrence of > 0.5.

Because lynx are dependent on snowshoe hares (Quinn and Parker 1987, Anderson and Lovallo 2003), a layer was added that included habitats known to support abundant hare populations. Specifically added were high elevation spruce (*Picea* spp.), fir (*Abies balsamea*) stands, and recent clearcuts that were in areas where annual snowfall was >250 mm [estimated snowfall threshold that limits bobcats in New Hampshire (Litvaitis et al. 2005)]. Both of these habitats are characterized by dense understory vegetation and contain an abundance of snowshoe hare. Information on high elevation spruce-fir stands was provided by New Hampshire Fish and Game (J. Oehler, personal communication). The clearcut dataset was provided by Complex Systems at UNH. Cuts had a minimum size of 1.2 ha, residual basal area of < 2 m^2/ha, and were harvested within 10-15 years (D. Justice, personal communication). Overall accuracy of the clearcut layer was 92%. Supporting this addition, Fuller and Harrison (2005) found that lynx showed a strong selection for mid-successional spruce-fir stands (~3.3 – 4.3 m tall) that were 11-22 years old in northwestern Maine. Hoving et al. (2004) also reported an association of lynx with regenerating stands.

Model Results

The total area estimated to be suitable for lynx [>50% probability of occurrence according to model developed by Hoving et al. (2005)] was 5,187 km^2 (figure 2). Because land cover and snowfall information were different from the sources used by Hoving et al. (2005), mapped habitats for this study are slightly different. Regional predicted habitat from Hoving et al. (2005) is shown in Figure 3.

According to Hoving (2001), the 2 variables in the habitat model probably do not directly influence lynx distributions. Annual snowfall is likely functioning as a surrogate variable for mean snow depth. This feature may influence foraging success and affect the distribution of possible competitors of lynx. The negative relationship with lynx presence and the abundance of deciduous forests is less obvious. In comparison to conifer stands, deciduous forests may represent habitats that support fewer snowshoe hares (e.g., Litvaitis et al. 1985) and red squirrels (*Tamiasciurus hudsonicus*) (Obbard 1987), an important secondary prey of lynx (O'Donoghue et al. 1998*b*). As a result, lynx may not be able to meet prey needs in areas dominated by deciduous forests.

Although this model performed well on a regional scale [correctly classified 94% of a reserved dataset (Hoving et al. 2005)], it is not certain that that it adequately described habitats on a more restricted basis (e.g., northern New Hampshire). As indicated, neither of the 2 variables directly affects carrying ca-

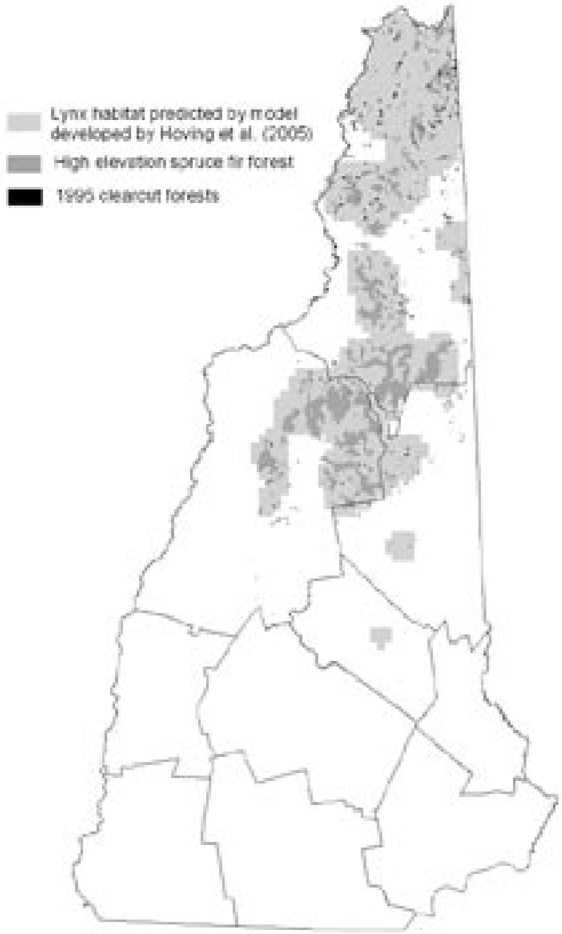

Figure 2. Lynx habitat in New northern New Hampshire predicted by the model developed by Hoving et al. (2005). High elevation spruce-fir stands and recent clearcuts also are included because these habitats support dense populations of snowshoe hares. Clearcuts (> 1.2 ha with < 2 m^2 residual basal area) were only included if they had an average annual snowfall of > 250 mm.

pacity or suitability at a landscape scale. To increase understanding of lynx requirements at landscape and stand scales, a modeling effort by Steury and Murray (2004) was used to examine the prey requirements of translocated lynx. If dispersing lynx that colonize habitats in New Hampshire are assumed to have prey requirements that are comparable to translocated individuals, this study may provide additional insight.

Populations of snowshoe hare in northern New Hampshire are not cyclic (Murray 2000). Under such circumstances, Stuery and Murray (2004) indicated that 1.5 hares/ha are needed for positive population growth among translocated lynx. Litvaitis et al. (1985) found that habitats capable of supporting that

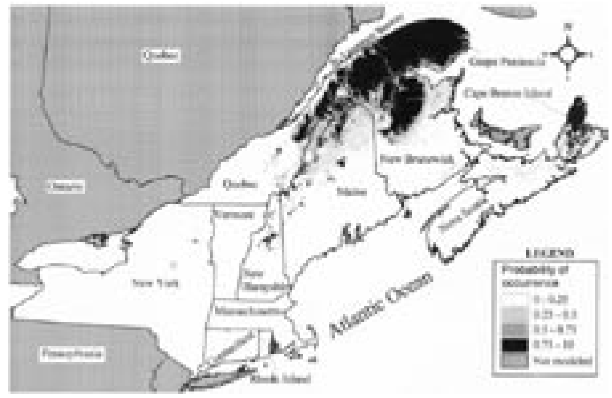

Figure 3. Regional lynx habitat predicted by Hoving et al. (2005).

density of hare are characterized by very dense understory vegetation [>50,000 stem cover units/ ha. Such vegetation is found in regenerating clearcuts, high elevation conifer stands, and some shrub-dominated wetlands. Therefore, the inclusion of recent clearcuts and high elevation spruce-fir stands may provide a more realistic representation of important habitats for lynx, albeit a minimum estimate. Combined, these enriched prey habitats represent only 888 km^2 [17% of the total lynx habitat predicted by the Hoving et al. (2005) model]. Although northern populations of lynx are known to exploit alternative prey (especially red squirrels) when cyclic populations of hare crash (e.g., O'Donoghue et al. 1998*b*), lynx demography is directly dependent on snowshoe hare abundance (Brand and Keith 1979, O'Donoghue et al. 1997). Therefore, the modest abundance of high-density hare habitat supports the notion that New Hampshire does not contain sufficient habitat to support a viable, stand-alone population of lynx. Long-term persistence of lynx in New Hampshire is probably dependent on immigrants (Litvaitis et al. 1991, Carroll 2005), and the State likely represents the southern limit of lynx in eastern North America.

1.7 Sources of Information

Published investigations, summary papers (Quinn and Parker 1987, Anderson and Lovallo 2003), and unpublished reports (e.g., Carroll 2005, Fuller and Harrison 2005) were used.

1.8 Extent and Quality of Data

Although no information exists on the habitat needs of lynx in New Hampshire, substantial interest in this species has resulted in a number of investigations in regions with comparable habitat.

1.9 Distribution Research

1. Developing protocols to provide a comprehensive monitoring of lynx populations should be considered. However, based on the limited habitat for lynx in New Hampshire, such a protocol should be developed to address multiple species (e.g., forest carnivores).
2. Any effort to understand the demography of lynx in New Hampshire should be placed in a regional context that considers lynx populations in Maine, New Brunswick, and Quebec.

Element 2: Species Habitat Condition

2.1 Scale

Based on the large home range of lynx (circa 100 km^2), it may be most appropriate to group suitable habitats using the ecological sections defined by Sperduto and Nichols (2004). Over 95% of the lynx habitat estimated by the model proposed by Hoving et al. (2005) was in the White Mountain Ecosection and 99% of suitable clearcuts and high elevation spruce-fir stands occur in this ecosection.

2.2 Relative Health of Populations

There is no evidence that a population of lynx currently resides in New Hampshire.

2.3 Population Management Status

Other than protected status, there are no efforts under way to manage lynx in New Hampshire. The status of lynx in New Hampshire will largely be determined by the ability of lynx emigrating from northern source populations to reach the State. Specifically, habitat continuity along the suspected dispersal corridor (figure 4) should be maintained.

2.4 Relative Quality of Habitat Patches

It is suspected that the highest quality lynx habitat is associated with high elevation spruce-fir stands (figure 3).

2.5 Habitat Patch Protection Status

Approximately 89% of high elevation spruce-fir stands occur on public lands.

2.6 Habitat Management Status

Management options within the State are restricted to providing quality habitat for snowshoe hare. However, given the reduction in even-aged timber management in recent decades and increased tendency for modifications in silviculture practices [e.g., use of pre-commercial thinning; see Homyack (2003)], it is likely that the abundance of habitats that support high density populations of snowshoe hare will decline.

In 2000, the USFWS and USFS developed a lynx conservation agreement that requires the USFS to promote the conservation of lynx habitat on national forests within the historic range of lynx (USFS Agreement 00-MU-11015600-013). Application of even-aged timber management on the White Mountain National Forest could enhance prey abundance for lynx. However, all management alternatives considered in the revised White Mountain National Forest Plan do not include an increase in the amount of forest that will be under even-aged management. In fact, the most liberal application of even-aged management that is being considered would not replace the hare habitat that is being lost to succession.

2.7 Sources of Information

Historical data on abundance of lynx were obtained from Silver (1974). Recent observations were obtained from the Natural Heritage Bureau Element Occurrence database.

2.8 Extent and Quality of Data

As indicated previously, there is no information on stand or patch-specific features that affect habitat use and fitness of lynx in New Hampshire.

2.9 Condition Assessment Research

An inventory and monitoring protocol would provide information on lynx demographics and habitat (including patch-level) preferences. Potentially, this inventory could be associated with USFS National Forest Inventory and could link habitat and land-use changes to changes in lynx demographics (Zielinski et al. 2000). An inventory and monitoring program could be designed using a variety of platforms (e.g., snow tracks, scooted panels, or remotely-triggered cameras) and gather information on a number of mesocarnivores (e.g., bobcats, fishers, and pine marten), making it cost attractive (Zielinski and Kucera 1995).

Element 3: Species and Habitat Threat Assessment

3.1.1 Unsustainable Forestry Operations

(A) Exposure Pathway
Timber harvest programs are moving away from even-aged management and thus are reducing local populations of snowshoe hare.

(B) Evidence
A recent shift in New England from conifer clear cutting to pre-commercial thinning will enhance growth of young trees but will reduce carrying capacity of a young stand for snowshoe hares (Homyack 2003).

3.1.2 Scarcity (Hybridization)

(A) Exposure Pathway:
Lynx colonizing New Hampshire will likely encounter low-density bobcat populations in northern counties (Litvaitis et al. 2005). Under these conditions, hybridization is possible because neither species may encounter conspecifics.
(B) Evidence:
Hybridization between bobcats and lynx has been detected in northern Minnesota where both species are at relatively low densities (Schwartz et al. 2004).

3.1.4 Unregulated Take

(A) Exposure Pathway
Leghold traps can capture lynx

(B) Evidence
No direct evidence; speculation.

3.2 Sources of Information

Published papers, as well as summary reports by Ruediger et al. (2000) and Carroll (2005) were used.

3.3 Extent and Quality of Data

Recent research efforts have increased our understanding of factors limiting the density of lynx populations.

3.4 Threat Assessment Research

It is difficult to conduct research in New Hampshire because lynx may be extirpated.

Element 4: Conservation Actions

Any effort seems tenuous based on the current abundance of lynx (extirpated)

Element 5: References

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Element 6 : List of Figures

Figure 1. Location of incidental observations of lynx during 1990-2004 (from NHDRED).

Figure 2. Lynx habitat in New northern New Hampshire predicted by the model developed by Hoving et al. (2005). High elevation spruce-fir stands and recent clearcuts also are included because these habitats support dense populations of snowshoe hares. Clearcuts (> 1.2 ha with < 2 m^2 residual basal area) were only included if they had an average annual snowfall of > 250 mm.

Figure 3. Regional lynx habitat predicted by Hoving et al. (2005).

SPECIES PROFILE

New England Cottontail

Sylvilagus transitionalis

Federal Listing: Under review for threatened/ endangered status
State Listing: Management concern
Global Rank: G4
State Rank: S3
Authors: John A. Litvaitis and Jeffery P. Tash, University of New Hampshire

Element 1: Distribution and Habitat

1.1 Habitat Description

New England cottontails (hereafter referred to as 'NEC') occupy a variety of habitats including native shrublands and regenerating forests associated with small-scale disturbances that result from beavers (*Castor canadensis*), local windstorms, and human land uses. Less frequent but larger-scale disturbances (including hurricanes and wild fires) also provide early-successional habitats, especially near the Atlantic coast (Lorimer and White 2003). Habitats of NEC are described by vegetation structure (especially height and density) rather than specific plant communities (Eabry 1968).

The most consistent characteristic of NEC habitat is dense understory cover (Fay and Chandler 1955, Eabry 1968, Linkkila 1971). Coniferous stems provide NEC with approximately 3 times the visual obstruction of deciduous stems in winter (Litvaitis et al. 1985). NEC prefer sites with more than 50,000 stem-cover units/ha and are reluctant to venture more than 5 m from cover (Barbour and Litvaitis 1993). In regenerating stands or idle agricultural fields, NEC colonize after secondary succession has progressed and a woody understory is well developed (approximately 5 to 7 years). As the stand matures and young trees develop a closed canopy (approximately 20 to 25 years after disturbance), understory vegetation becomes sparse and the site is no longer suitable for NEC.

1.2 Justification

Since 1960, the distribution and abundance of NEC has declined substantially throughout New England (Johnston 1972, Jackson 1973, Litvaitis 1993). See section 1.4.

1.3 Protection and Regulatory Status

The species is currently being considered for threatened or endangered status by the USFWS (Federal Register: June 30, 2004; Volume 69, Number 125, Pages 39395-39400). The hunting season of NEC in New Hampshire was closed in September 2004.

1.4 Population and Habitat Distribution

Present-day populations of NEC span < 25% of their historic range (figure 1). A recent range-wide survey of the historic range of NEC (protocol described by Litvaitis et al. 2002) indicated that the distribution of NEC in New Hampshire has declined substantially. Only eastern cottontails and snowshoe hares were

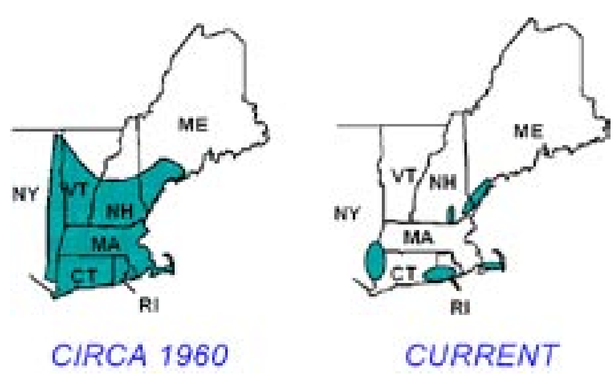

Figure 1. Historical and current distributions of New England cottontails. Historical distribution is a compilation of Hall and Kelson (1959), Johnston (1972), and Jackson (1973). Current distribution is based on a range-wide survey of suitable habitats (J. Tash et al., unpublished data).

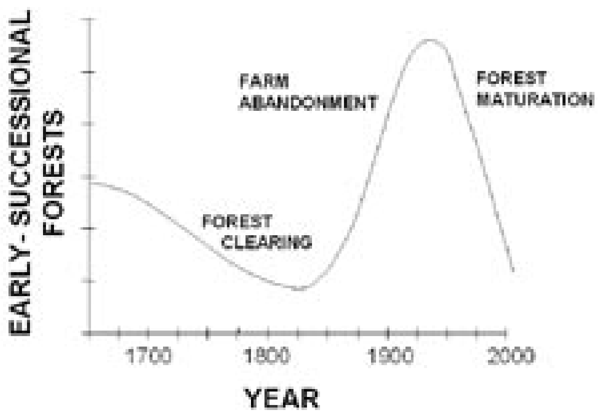

Figure 2. Successional wave that is passing through forests in the northeastern United States following land clearing for agriculture and subsequent abandonment of these lands. Modified from Litvaitis (1993).

found in the western portion of the state.

Probably the most important disturbance that influenced the abundance of NEC was the clearing of forests for agriculture by European settlers and subsequent abandonment of these lands (Ahn et al. 2002, Hall et al. 2002). Cleared lands were abruptly abandoned in the mid-1800s for more productive farms in the midwestern United States. Many of these tracts reverted to second-growth forests (Irland 1982), and NEC and other early-successional forest species reached unprecedented levels of abundance throughout the northeastern United States in the early 1900s (DeGraaf and Miller 1996, Foster et al. 2002, Litvaitis et al. 2005*b*). Litvaitis (1993) used information on the rate of farmland abandonment and developed a simple model of forest succession to estimate the approximate recruitment of early-successional habitats. Most of the abandoned lands matured into closed-canopy forests by 1960 and species dependent on these habitats quickly declined, including NEC (figure 2). Litvaitis (1993) summarized the approximate range retraction by NEC in New Hampshire (figure 3).

If populations of NEC stabilized at reduced densities reached in the 1960s, conservation actions probably would not be needed. However, early-successional habitats in the northeastern United States continue to decline (Brooks 2003) and remaining populations of NEC in New Hampshire and elsewhere are vulnerable to extinction (Litvaitis and Villafuerte 1996).

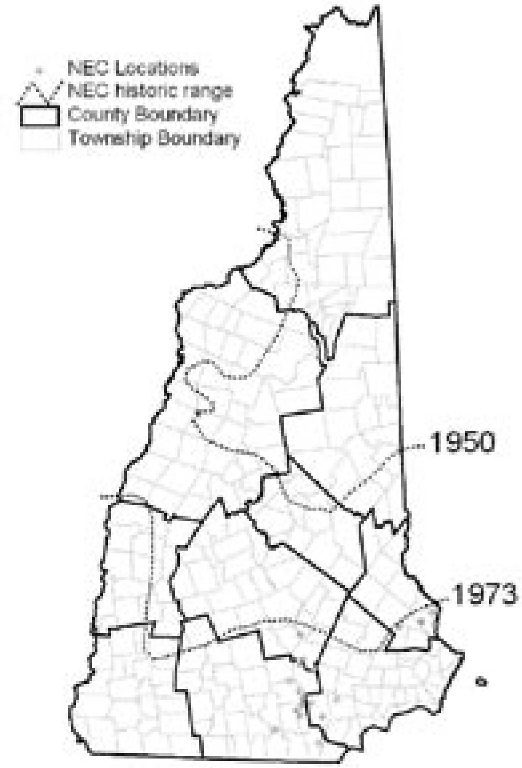

Figure 3. Range change of New England cottontail in New Hampshire from 1950 to present day. The 1950 delineation is based on a survey of conservation officers conducted by C.L. Stevens (unpublished map). Retraction by 1973 is based on livetrapping survey conducted by Jackson (1973). Locations of known populations of New England cottontails are indicated and were based on field surveys during 2002 and 2003.

1.5 Town Distribution Map

Remnant populations are restricted to southeastern and south-central New Hampshire.

1.6 Habitat Map

We used the results of the range-wide inventory that included NEC-occupied sites in Maine and New Hampshire to investigate landscape-scale environmental factors that affect their distribution. Seventeen habitat features, including class I and II road density, local road density, forest-open edge, and percent forest, were inventoried within 1-km around each NEC location and an equivalent number of patches known to be vacant within occupied quads. A 1-km radius (3.14 km^2) represents a reasonable approximation of dispersal distance of NEC (Litvaitis and Villafuerte

1996). We then used GIS to compare the inventoried information between the occupied and unoccupied sites to determine if any differences occurred.

Our data screening yielded 13 variables that differed between known NEC locations and vacant sites (appendix 2). Data analysis indicated that class I and II road density, local road density, forest-open edge, and percent forest were the most significant. Seventy-seven percent of known locations and ninety-one percent of vacant sites were correctly identified using these variables

1.7 Sources of Information

Information on current distribution of NEC came from a recent range-wide survey of the historic range of NEC (Litvaitis et al. 2002, Tash and Litvaitis, unpublished data). We also relied on other published investigations. Sources of information for the habitat map included USGS National Land Cover Characterization Project derived from early to mid-1990s Landsat Thematic Mapper satellite data (Vogelman et al. 2001), class I and II roads, rights-of-way (e.g., powerlines and pipelines) and railroad corridors from United States Census Bureau 2000 TIGER data, and snow coverage data from the Spatial Climate Analysis Service at Oregon State University.

1.8 Extent and Quality of Data

The habitat model does not identify habitats that will support NEC but describes areas that are similar to habitats that are currently occupied by NEC in New Hampshire and Maine. Most of the variables used in model development were obtained at a landscape scale (e.g., abundance of forest edges and class I + II roads), and do not provide a complete description of patch suitability. The most influential feature at the patch scale—understory density—could not be obtained from satellite imagery. Additionally, this model was based on habitats currently occupied by NEC and it does not represent the habitats that the species could potentially occupy but were not encountered during our survey. Based on the distribution of remaining NEC populations in New Hampshire (largely human-dominated landscapes), the features identified as important are probably only important in similar landscapes.

The remaining variables may have more obvious influences on habitat suitability. Local roads (class III and higher) had a negative influence probably because these roads lack the brushy corridor and fragment existing habitats. Forests also had a negative effect because NEC rely on dense understory vegetation that is usually sparse in closed-canopy forests. Finally, the abundance of forest-open area edges (positive influence) may index the abundance of brushy edges that are often found at the edge of forest stands.

The distribution of present-day populations of NEC is substantially affected by heterospecific interactions that were not included in our model. These include competition with expanding populations of eastern cottontails (*S. floridanus*) (Fay and Chandler 1955, Reynolds 1975) and interactions with snowshoe hares (*Lepus americanus*). The latter has not been studied in any detail.

1.9 Distribution Research

Develop a monitoring program to track changes in the abundance and distribution of NEC. This will

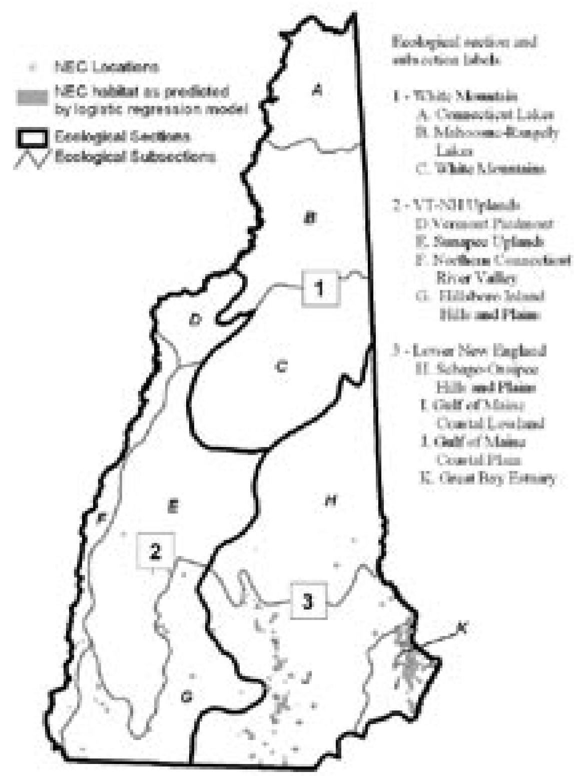

Figure 5. Modeled habitats of New England cottontails based on Class I and II road density, local road density, forest-open edge, and percent forest cover within 1 km. Habitats depicted had a >50% of being occupied.

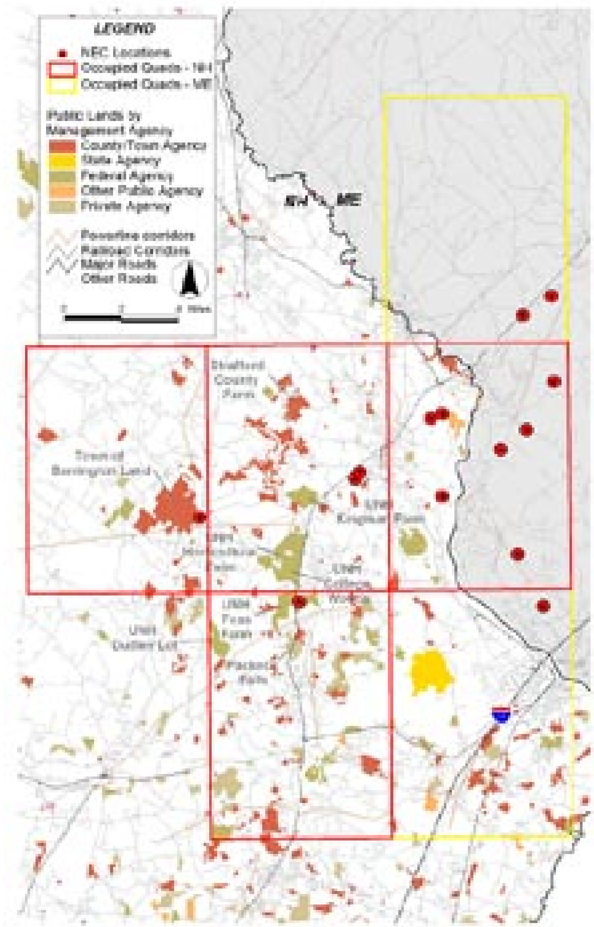

Figure 5. Distribution of public land in relation to habitats occupied by New England cottontails in southeastern New Hampshire.

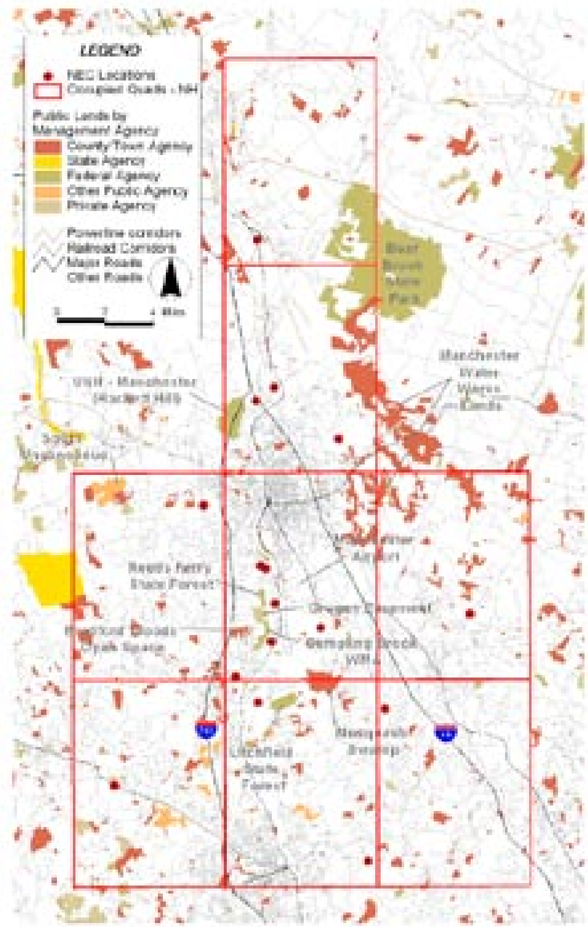

Figure 6. Distribution of public land in relation to habitats occupied by New England cottontails in southcentral New Hampshire.

become increasingly important as management efforts are directed toward expanding remaining populations. A monitoring program that relied on fecal analysis would be cost effective (Kovach et al. 2003).

Element 2: Species Habitat Condition

2.1 Scale

Based on the ephemeral nature of habitats, and the restricted distribution of NEC, we believe ecological subsections (Sperduto and Nichols 2004) is an appropriate scale to develop habitat management plans (figure 4).

2.2 Relative Health of Populations

Remaining populations of NEC in New Hampshire span a modest portion of the region that was occupied historically, including the Seacoast (figure 5) and Merrimack River Valley (figure 6).

2.3 Population Management Status

There have not been any habitat-based management efforts directed toward NEC. The recent closing of hunting seasons on this species will have little influence on long-term patterns of abundance.

2.4 Relative Quality of Habitat Patches

Modeled habitats with a greater than 50% probability of NEC occurrence (according to the generated model) averaged 223 ha, and 65% of sites were greater than 5 ha. Again, a distinction must be made between model habitats and actually occupied habitats. Litvaitis and Villafuerte (1996) reported that patches occupied in southeastern New Hampshire ranged from 0.2 to ~15 ha, and that populations of NEC in the region are functioning as induced metapopulations (Litvaitis and Villafuerte 1996). In such an arrangement, small patches (less than 3 to 5 ha) may represent the majority. Such patches are dependent on the colonization of surplus rabbits from larger patches of habitat (Litvaitis and Villafuerte 1996). Although large patches have been identified, the majority of these sites probably do not contain adequate patch-specific features (especially dense understory vegetation) to support NEC.

2.5 Habitat Patch Protection Status

Habitats with a greater than 0.5 probability of NEC occurrence (according to model predictions) totaled 34,061 ha. Approximately 21% (7,222 ha) occur on existing conservation lands or easements. Modeled habitats were most abundant in the Lower New England Ecosection (28,593 ha), especially in Gulf of Maine Coast Plain (13,454 ha) and Gulf of Maine Coast Lowland (14,523 ha) subsections.

2.6 Habitat Management Status

There is no NEC-specific habitat management.

2.7 Sources of Information

Land use and land cover data were obtained from the New Hampshire Land Cover Assessment 2001 database at the Complex Systems Research Center of UNH.

2.8 Extent and Quality of Data

There has been sufficient research on patch-specific habitat features. This information would be complemented by additional efforts to understand landscape elements that influence metapopulation survival (Litvaitis and Villafuerte 1996).

2.9 Condition Assessment Research

Substantial research has been conducted on the status and distribution of NEC and their habitat in New Hampshire.

Element 3: Species and Habitat Threat Assessment

3.1.1 Altered Natural Disturbance (Natural Succession)

(A) Exposure Pathway
NEC are obligate residents of habitats with dense understory vegetation. Forest succession and contemporary land uses have limited the generation of such habitats (Brooks 2003), and natural disturbance regimes in relatively young forests are not sufficient to provide adequate habitats (Litvaitis et al. 1999, Litvaitis 2003). Additionally, the current range occupied by NEC in New Hampshire (Figures 5 and 6) are embedded in rapidly developing landscapes (Sundquist and Stevens 1999).

(B) Evidence
Based on existing literature and recent survey of NEC habitats in New Hampshire.

3.1.2 Predation and Herbivory

(A) Exposure Pathway
Predation is the most common proximate mortality factor of NEC. Cottontails occupying small patches of habitat (les than 3 ha) are most vulnerable (Barbour and Litvaitis 1993, Brown and Litvaitis 1995, Villafuerte et al. 1997).

(B) Evidence
Extensive investigations of NEC in New Hampshire.

3.1.3 Scarcity (Competition)

(A) Exposure Pathway
NEC are sympatric with eastern cottontails and snowshoe hares in New Hampshire. Eastern cottontails are currently found along the Connecticut River Valley where NEC have apparently been extirpated. Allopatric populations of eastern cottontails also occur in the southern portion of the Merrimack River Valley and along the Atlantic coast to Great Bay in the southeastern portion of the State (Tash and Litvaitis, unpublished data). Stochastic events (e.g., winter with deep snow) also may benefit snowshoe hares.

(B) Evidence
Speculation based on literature review.

3.2 Sources of Information

Extensive research conducted in New Hampshire (reviewed by Litvaitis et al. 2005*a*).

3.3 Extent and Quality of Data

Substantial information on NEC status and conservation is available on New Hampshire populations.

3.4 Threat Assessment Research

The interactions between NEC and either eastern cottontails or snowshoe hares in contemporary landscapes, where human land uses are a dominant force creating early-successional habitats, warrant additional investigation.

Element 4: Conservation Actions

4.1. Development of early-successional habitat networks in landscapes currently occupied by NEC.

Based on the status of NEC populations in New Hampshire, habitat restoration and translocations are essential. If such efforts were undertaken, initial efforts would be most effective by expanding existing populations. The majority of NEC-occupied habitats occur on private lands, but several are near public land (figures 5 and 6). Indeed, cottontails for translocations may come from private lands that undergo development. Remaining populations also are associated with rapidly expanding human populations and associated developments (Sundquist and Stevens 1999). Additionally, remaining populations are associated with disturbance-generated habitats. As such, they have a finite period of suitability (figure 1). Unless active management programs develop, the long-term viability of these populations is unlikely. Habitats with a greater than 0.5 probability of NEC occurrence (according to model predictions) totaled 34,061 ha (figure 5). Approximately 21% (7,222 ha) occur on existing conservation lands or easements. Some of these lands may become suitable habitat with only modest intervention. Although modeled habitats do not reveal any information about the suitability of specific patches of habitat, the model does provide a landscape context within which suitable patches could be managed. Additionally, the habitat model provides insight into important landscape features that likely facilitate demographic exchanges among populations of NEC in human-dominated landscapes. For example, classes I and II roads were associated with NEC sites because the roads often have a brushy corridor associated with them. In southern Maine (included in model development), Litvaitis et al. (2003) encountered extensive stretches of Interstate 95 that had shrub-dominated margins more than 10 m wide. Additionally, rest areas and exit ramps had sufficient disturbance-generated habitats to support 1 to 2 cottontails (J. Litvaitis, personal observation). Although Interstate 95 poses a formidable barrier (up to 7 or 8 lanes of vehicle traffic) to east–west movement, the substantial habitat associated with this corridor may facilitate north–south movement.

In southern New Hampshire, one of the most expansive populations was associated with railroad corridors. Here, the strip of brushy vegetation also may be functioning as an important dispersal corridor. Management of habitats exclusively along the corridor of multi-lane highways, however, may create some unexpected problems. Specifically, enhancing habitats in these areas may benefit local NEC populations but create a potential "ecological trap" for wide-ranging predators of NEC by exposing them to elevated risks of vehicle collisions. A more prudent approach may be to rely on brushy edges of roads or utility rights-of-way as movement corridors but enhance habitats some distance (circa 0.5 km) from these corridors.

Predation is clearly the most common mortality factor among NEC in New Hampshire, especially by coyotes (*Canis latrans*) and foxes (*Vulpes vulpes*) (Barbour and Litvaitis 1993, Brown and Litvaitis 1995, Villafuerte et al. 1997). Populations of these carnivores have increased in southern New Hampshire as forest-dominated landscapes are converted into agricultural fields or suburban developments (Oehler and Litvaitis 1996). NEC occupied patches in southeastern New Hampshire ranged from 0.2 to greater than 15 ha, but very small patches (less than or equal to 2 ha) were inherently vulnerable because of intense predation (Barbour and Litvaitis 1993, Villafuerte et al. 1997). As a result, any effort to manage habitats of NEC in human-dominated landscapes should be directed toward larger patches of habitat (Litvaitis 2001).

As populations of NEC respond to restoration, additional management should occur. In less developed landscapes, management activities may shift toward developing a network of patches that compliment native shrublands and land uses that provide early-successional forests or old-field habitats. In regions where the historic abundance of shrublands and barrens was limited, timber harvests will provide a practical approach to diversify stand age distributions. Here, a "sliding scale" approach would be appropriate in mid-successional forests where natural disturbances are rare (Litvaitis 2003). Initially, the size of timber harvests would be larger than natural disturbances to offset the shortfall in early-successional habitat that currently exists. Once established, some of these openings could be maintained by active management (e.g., cutting, mowing, or control fires). As forests mature, management efforts (especially timber harvests) could be patterned after canopy gaps (Runkle 1991) or modified to specific silviculture practices of a region (Seymour et al. 2002) if other forms of NEC-suitable habitats (e.g. native shrublands and beaver impoundments) are adequately represented. Such an approach may be most appropriate on public lands or industrial forests where road networks and elevated populations of generalist predators may not be a concern (Litvaitis et al. 2005).

Element 5: References

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Element 6: List of Figures

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Figure 6. Distribution of public land in relation to habitats occupied by New England cottontails in southcentral New Hampshire.

SPECIES PROFILE

Northern Bog Lemming

Synaptomys borealis sphagnicola

Federal Listing: Not listed
State Listing: Not listed
Species Global Rank: G4T3Q
State Rank: SH
Author: Mariko Yamasaki and Angela Karedes, United States Department of Agriculture Forest Service

Element 1: Distribution and Habitat

1.1 Habitat Description

The northern bog lemming (hereafter called bog lemming) is found in northern New England, New York, and eastern Canada in higher elevation mossy spruce woods (1,300 to 4,500 feet), low elevation spruce-fir, hemlock and beech forests, sphagnum bogs, damp weedy meadows, and alpine sedge meadows (Clough and Albright 1987, DeGraaf and Yamasaki 2001, Banfield 1974, Saunders 1988). Special habitat requirements include moist loose soils or leaf mold (Banfield 1974, DeGraaf and Yamasaki 2001). Bog lemmings feed on grasses and sedges and are active year-round. Bog lemmings use tunnels several inches below ground and shallow runways on the ground surface (Banfield 1974). In the summer, bog lemmings construct spherical nests of dried grasses in burrows, and in winter, it nests on the ground (Banfield 1974).

1.2 Justification

Bog lemmings are probably the rarest mammal in New England and eastern Canada, making them vulnerable to local extirpation (Banfield 1974). Recent surveys in the White Mountains found one individual at one out of 108 sites (Yamasaki, unpublished data). Only two other sites in the region have yielded specimens over the last 100 years. Comprehensive surveys for bog lemmings have been not been conducted outside of the White Mountains; difficulty in properly identifying this species may contribute to its lack of detection. Considerable work is required to understand the habitat requirements of this rare mammal in northern New Hampshire, as it has been found in low numbers across a variety of northern forest, alpine, and sphagnum vegetative communities. Further surveys for bog lemmings in sphagnum-dominated vegetative communities might be productive as in Montana surveys (Reichel and Beckman 1993, Reichel and Beckman 1994, Reichel 1995, Reichel and Corn 1997).

1.3 Protection and Regulatory Status

The bog lemming is currently listed as having historical occurrences in the NHNHB database (2005).

1.4 Population and Habitat Distribution

Three specimens of bog lemmings have been recorded in New Hampshire in the past 100 years in the White Mountains region (Preble 1899, Clough and Albright 1987, Yamasaki, unpublished data). Northern New Hampshire represents the southernmost edge of the range of bog lemmings in northern New England and eastern Canada (DeGraaf and Yamasaki 2001, NatureServe 2004). There are insufficient data to determine any further spatial distribution patterns.

1.5 Town Distribution Map

Specimens of *S. borealis* have been reported from the towns of Carroll, Coos County, in 1898 (Preble 1899), Benton, Grafton County, in 1958 (Clough and Albright 1987), and Bean's Purchase, Coos County, in 1996 (M. Yamasaki, USDA Forest Service, unpublished data).

1.6 Habitat Map

It is difficult to delineate a habitat map for this species from three locations spanning 100 years with limited sampling effort. With the cooperation of the WMNF, Yamasaki conducted a 3-year systematic survey of small mammals between 1995 and 1997. This survey took place in potential habitats across three levels of vegetation management in the White Mountains region. Directed searches used snap trap grids and 10-bucket, Y-shaped, drift fence pitfall sets to target rock voles *(Microtus chrotorrhinus)*, long-tailed shrews *(Sorex dispar),* and northern bog lemmings. Out of the 108 study sites surveyed across managed, unmanaged, and remote locations in the forest, one managed site in a lowland spruce-fir stand yielded a bog lemming specimen (Yamasaki 1997). The positive identification was confirmed by the American Museum of Natural History where the specimen now resides.

While 10 years of small mammal sampling at the Bartlett Experimental Forest in Bartlett produced many specimens of small mammal species from the White Mountains region, including occasional specimens of southern bog lemmings, it produced no specimens of northern bog lemmings.

1.7 Sources of Information

Information on habitat, population distribution, and status was collected from unpublished data, scientific literature, and limited agency data.

1.8 Extent and Quality of Data

The bog lemming is probably the least understood mammal species in New Hampshire due to its rarity. Systematic searches in the White Mountains region from 1995 to 1997 located one individual at 1 of 108 sample sites (M. Yamasaki, USDA Forest Service, unpublished data).

1.9 Distribution Research

Directed, systematic, and long-term small mammal surveys and vegetation sampling in appropriate habitat types (e.g., sphagnum bogs, sub-alpine meadows, and upland forests with moist soils), especially north of the notches of the White Mountains, are needed to better describe the distribution and ecology of this species.

Element 2: Species/Habitat Condition

2.1 Scale

Lands north of the notches in the White Mountain section M212A appear to be the southerly extent of the range of the bog lemming. These lands include subsections M212Ad, M212Ae, and M212Af in Avers et al. (1994) and would likely be a component of a greater North Country conservation planning unit.

2.2 Relative Health of Populations

There are insufficient data to draw conclusions about the population health or distribution of bog lemmings.

2.3 Population Management Status

There are no management efforts for bog lemmings in New Hampshire.

2.4 Relative Quality of Habitat Patches

There are no data to with which to assess the relative quality of habitat patches for *S. borealis*.

2.5 Habitat Patch Protection Status

All documented specimens in New Hampshire are within the proclamation boundary of the White Mountain National Forest. The bog lemming is recognized as a "Region 9 Regional Forester Sensitive Species" whose special concerns are addressed in the planning or analysis phases of management programs.

2.6 Habitat Management Status

There are no habitat management efforts for bog lemmings.

2.7 Sources of Information

Information on habitat, population distribution, and status was collected from unpublished data, scientific literature, and limited agency data.

2.8 Extent and Quality of Data

The bog lemming is probably the least understood mammal species in New Hampshire due to its rarity. Systematic searches in appropriate habitats in the White Mountain National Forest located one occurrence out of 108 sample sites during a study from 1995 to 1997 (M. Yamasaki, USDA Forest Service, unpublished data).

2.9 Condition Ranking

There is no information with which to make this assessment.

2.10 Condition Assessment Research

Directed, systematic, and long-term small mammal surveys and vegetation sampling in appropriate habitat types (e.g., sphagnum bogs, sub-alpine meadows, and upland forests with moist soils), especially north of the notches of the White Mountains, are needed to better describe the habitat characteristics of bog lemmings (e.g., associated vegetative communities, habitat condition indicators, potential impacts of forest management and recreation).

Element 3: Species and Habitat Threat Assessment

3.1.1 Scarcity (Natural Rarity)

(A) Exposure Pathway
The most significant threat to the bog lemming is its rarity. The natural distribution may be that of isolated metapopulations with few individuals in each location. This pattern might inhibit dispersal and habitats may not repopulate easily if there are local extirpations (Clough and Albright 1987).

(B) Evidence
There are no data for this analysis. The work by Reichel and Corn (1997) in Montana may demonstrate a similar set of habitat conditions and distribution patterns for bog lemmings in the northern Rockies
.

3.2 Sources of Information

Information on the habitat, population distribution, and status was collected from unpublished data, scientific literature, expert review and consultation, and limited agency data.

3.3 Extent and Quality of Data

There are no data with which to conduct metapopulation analyses in New Hampshire.

3.4 Threat Assessment Research

There are no baseline data with which to test threat hypotheses.

Element 4: Conservation Actions

The first conservation action is to develop data on baseline occurrence, habitat use, and distribution.

4.1.1 Developing data on baseline occurrence, habitat and distribution, Restoration and Management

(A) Rarity

(B) Justification
- Surveys north of the notches of the White Mountains may provide more intensive population and habitat data for metapopulation analyses
- Surveys of the probable habitat can test the rarity hypothesis.
- Surveys north of the notches of the White Mountains should be followed by further investigation of sphagnum-dominated vegetative communities in the North Country of New Hampshire.
- Rarity is a low threat ranking, making this conservation action less urgent for NHFG. Unless there are imminent plans to modify sphagnum-dominated vegetative communities, the time frame for this work is not immediate.
- Further investigations that increase NHFG's knowledge of population dynamics and habitat availability for will help to better conserve and manage habitats for this species.

(C) Conservation Performance Objective

The objective of surveying for the presence of the bog lemming in potential habitats is to test the rarity hypothesis and to better understand the status of this poorly known species. Determining the basic ecological attributes of bog lemmings will help assess threats to its survival at the most southerly edge of its range in the northeastern United States and eastern Canada. Successful survey protocols will increase the likelihood of correctly identifying critical habitat.

(D) Performance Monitoring
There is no monitoring program for bog lemmings. Systematic searches of potential habitat would establish the distribution of this species in the North Country of New Hampshire before initiating other conservation actions.

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

(F) Response Monitoring
There are no data with which to formulate response monitoring.

(G) Implementation
There are opportunities to partner with the USDA Forest Service, USFWS, industrial forestry concerns, New Hampshire Division of Forest and Lands, and NHNHB to extend existing small mammal survey protocols used by USDA Forest Service to the greater North Country area.

(H) Feasibility
The USDA Forest Service conducted systematic surveys for bog lemmings during 1995 to 1997. Much cooperation and coordination would be required to accomplish a similar survey in the North Country, but it could be accomplished with adequate funding, personnel, and resources.

4.2 Conservation Action Research

Directed, systematic, and long-term small mammal surveys and vegetation sampling in appropriate habitat types (e.g., sphagnum bogs, sub-alpine meadows, and upland forests with moist soils), especially north of the notches of the White Mountains, are needed to describe habitat characteristics of bog lemmings (e.g., associated vegetative communities, habitat condition indicators, potential impacts of forest management and recreation).

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SPECIES PROFILE

Northern Myotis

Myotis septentrionalis

Federal Listing: Not listed
State Listing: Not listed
Global Rank: S4
State Rank: Not ranked
Authors: Jacques P Veilleux, Franklin Pierce College; Scott Reynolds, St. Paul's School

Element 1: Distribution and Habitat

1.1 Habitat Description

During winter, the northern myotis requires cave or mine habitat that provides adequate characteristics for successful hibernation. Such characteristics include proper microclimate (i.e. temperature stability) and a low level of human disturbance. During hibernation, the northern myotis often retreats into small holes, cracks, and crevices in the walls and ceiling (John Whitaker, Indiana State University, personal communication, Durham 2000), though they will also cling to the wall and ceiling surface. It is unknown whether the northern myotis prefers caves and mines with large numbers of small crevices for hibernation. Northern myotis is often found deep within mine shafts (Durham 2000). Northern myotis bats are known to use caves and mines year-round and often maintain some activity throughout the winter months (Whitaker & Rissler 1992).

In the White Mountain National Forest (WMNF), sixty-six percent of northern myotis roosted in snags (dead trees) and the remainder roosted in live trees (Sasse 1995), They will use a variety of deciduous species, and choice may be influenced by availability. Large, tall trees with intact bark and moderate levels of decay are commonly chosen, especially if they have hollows (Sasse 1995). Most roost trees used by northern myotis in West Virginia were located in 70-90 year-old intact forests that had not been logged in 10 to 15 years (Owen et al. 2003). However, some females have been observed roosting in actively managed industrial forests in West Virginia (Menzel et al. 2002).

1.2 Justification

Like other bats, northern myotis' life history is different from the typical life history of other small mammals. Individuals are relatively long lived and have a low reproductive rate, generally giving birth to a single young each year (Whitaker and Hamilton 1998). Since northern myotis is found in relatively rare, at-risk habitats during winter (caves/mines), they are at risk of population decline if such habitats are lost or degraded. Their slow reproductive rate would, in turn, lead to a slow population recovery time.

Northern myotis are of conservation concern in New Hampshire for the above reasons and because of the lack of knowledge about the species' population status in New Hampshire. Northern myotis represents approximately 12.5% of New Hampshire's overwintering bats and has been documented in each of New Hampshire's known hibernacula (table 1). Individuals have not been banded at these hibernacula, and therefore no data on population turnover are available.

The majority of data describing summer population status is limited to the region of the WMNF (Sasse 1995, Krusic 1996, Chenger 2005), with limited additional data from other regional surveys. No systematic surveys have confirmed its statewide distribution or provided population estimates. Because most bat species are experiencing population declines, it is important to establish such baseline data to monitor population trends.

1.3 Protection and Regulatory Status

No specific Endangered Species Act or RSA 212 regulations govern take, transport, or use of this species. Scientific collecting or research requiring capture of individuals requires a permit through New Hampshire Fish and Game Department (NHFG). Possession of live bats requires a permit under NHFG FIS 800.

1.4 Population and Habitat Distribution

Winter distribution of the northern myotis includes each of New Hampshire's seven hibernacula (figure 1). The concentration of northern myotis among the hibernacula ranges from fewer than 1% (Mascot Lead Mine) to 47% (Bristol Mine) of the total bat population. Northern myotis in New Hampshire tend to be less common (fewer than 1% of hibernating bats) in the large hibernacula such as Mascot Lead Mine, intermediate (less than 20%) at medium-sized mines such as Paddock Copper Mine and Mt. Kearsarge Lead Mine, and relatively abundant in small hibernacula such as Bristol Mine, Beebe River Mine, and the Red Mine (table 1). This pattern is consistent with hibernaculum surveys in Vermont (Trombulak 2001).

Summer records are known from Carroll, Coos, Cheshire, Grafton, and Hillsborough counties. Of 141 summer captures of the northern myotis in New Hampshire, 74.2% are from the White Mountain National Forest (Sasse 1995, Krusic 1996, Chenger 2005), 24.3% are from northern Cheshire County (Chenger 2002, J.P. Veilleux, unpublished data) and 3.5% are from Merrimack and Hillsborough County (LaGory et al. 2002, Reynolds, unpublished data). Any apparent geographical clustering may be an artifact of sampling effort.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

1.7 Sources of Information

Town data on species distribution during winter were compiled by examining New Hampshire Natural Heritage Inventory – Bat Hibernaculum Record data sheets. Summer distribution data were determined by examining published and gray literature of research on bat populations in New Hampshire, as well unpublished bat survey data (J. Veilleux).

1.8 Extent and Quality of Data

Data on the distribution of northern myotis in New Hampshire are mainly limited to the two regions described in element 1.4 (WMNF and northern Cheshire County). The quality of existing data, in relation to accuracy of identification of individuals and echolocation calls, is believed to be good. However, a Master's student with little experience identified bats in the WMNF. Although it may be confused with the little brown bat, the northern myotis is relatively easy to identify.

1.9 Distribution Research

Potential winter hibernacula in New Hampshire need to be surveyed. Likewise, statewide studies (using mist-netting and Anabat acoustic survey equipment) are needed to determine the summer distribution of northern myotis. Mist-netting surveys should incorporate banding into the capture protocol and should list all banding records in the Northeast Banding Database developed by the Northeast Working Group on Bats (NEWGB). An intensive banding program using state-issued wing bands would yield data on the summer distribution of all bat species in New Hampshire and might indicate where summer populations of bats in New Hampshire spends each winter.

Element 2: Species/Habitat Condition

2.1 Scale

Due to the relatively small number of viable mines in New Hampshire, each mine has been treated individually as a conservation planning unit in the habitat profile.

2.2 Relative Health of Populations

Northern myotis is known from each of the seven mine hibernacula in New Hampshire (table 1), and there has been decline in northern myotis within the two largest hibernacula over the last 15 years. Between 1993 and 2004, Mascot Mine had a 91% reduction in the northern myotis population (figure

1). Similarly, Paddock Copper Mine had a 53% reduction in the northern myotis population between 1991 and 1999. The data are too sparse to determine whether this decline represents an increase in mortality or a reduction in population recruitment.

2.3 Population Management Status

Northern myotis are not specifically managed in New Hampshire. The bat gate at Mascot Lead Mine is a conservation tool for hibernating bats collectively, but this mine has also seen the greatest reduction in northern myotis over the last 12 years. Lack of data on the summer distribution of northern myotis hinders effective management.

2.4 Relative Quality of Habitat Patches

The New Hampshire Natural Heritage Survey (NHNHS) has ranked all known northern myotis bat hibernacula according to habitat quality and prospects for long-term conservation. Carter's Mine (Grafton County), Paddock Copper Mine (Grafton County), and Bristol Mine (Grafton County) each received an 'A', indicating excellent quality and prospects for long-term conservation. Dodge Mine (Grafton County) was ranked 'B', indicating good quality and prospect for long-term conservation. Both Mt. Kearsarge Lead Mine and Mascot Lead Mine were ranked as 'B/C', indicating fair to good quality and prospects for long-term conservation. Beebe River Mine was ranked as 'C', indicating fair quality and/or prospects for long-term conservation. However, NHNHS ranking does not appear to reliably assess the value of northern myotis mine habitats, because the two hibernacula in serious decline received a 'B/C' (Mascot Lead Mine) and an 'A' (Paddock Copper Mine).

2.5 Habitat Patch Protection Status

Five of the seven known mines (Carter's Mine, Beebe River Mine, Bristol Mine, Paddock Copper Mine, Red Mine) are located on private land, and two (Mascot Lead Mine and Mt. Kearsarge Lead Mine) are managed by the DRED. Each mine identified as a potential habitat is located on private land. The exact location of one mine (Keyes Mine) could not be determined, and therefore its protection status is unknown.

2.6 Habitat Management Status

The only ongoing habitat management practice in New Hampshire is the bat gate at Mascot Lead Mine. Bat gates (see Caves and Mines habitat profile). Mascot Lead Mine, which was gated in 1992, had lost all but 11 individuals by 2004, despite having 67 northern myotis in 1992 and 127 in 1993. These results testify to the need for further study of northern myotis' management needs in New Hampshire.

2.7 Sources of Information

NHNHS – Hibernacula Survey Data Sheets were examined to determine the winter populations at known hibernacula. To determine habitat patch protection status, each hibernaculum (both known and potential) was mapped on the Conservation Lands GIS data layer (GRANIT – 2003 data). The physical attributes of four of the known bat hibernacula (Mt. Kearsarge Lead Mine, Paddock Copper Mine, Carter's Mine, and Red Mine) were recorded in 1999 and 2000 by Durham (2000). Data were used to generate mine maps and to examine species-specific thermal preferences.

2.8 Extent and Quality of Data

The quality and extent of data collected varies between the mines. For example, there have been four winter surveys at Mascot Lead Mine since 1987, two of which were conducted since installation of the bat gate in 1992. Red Mine has been surveyed four times since 1986, and the Mt. Kearsarge Lead Mine and Paddock Copper Mine have been surveyed five times since 1986. Carter's Mine (three surveys since 1989), Beebe River Mine (three surveys since 1988), and Bristol Mine (one survey in 1989), have generally been surveyed less frequently. With the exception of data collected in 1999 and 2000 at Red Mine, Paddock Copper Mine, Carter's Mine, and Mt. Kearsarge Lead Mine (Durham 2000), no microclimate data have been collected at any of these sites. Furthermore, there are no known bat surveys from Ruggle's Mine.

2.9 Condition Ranking

2.10 Condition Assessment Research

A research priority for overwintering northern myotis is to determine the cause of population decline in Mascot Lead Mine and Paddock Copper Mine. Once microclimate data (primarily temperature) have been obtained at each hibernaculum for an entire winter, the data can be used to assess microclimate at potential hibernacula throughout the state.

Research priorities for summering northern myotis include a statewide mist-netting survey, telemetry studies to determine roosting and foraging behavior, life history studies, and diet analysis.

Element 3: Species and Habitat Threat Assessment

3.1.1 Recreation

See Caves and Mines habitat profile.

(A) Exposure Pathway

Caves and abandoned mines are natural destinations for spelunkers. Though spelunkers may never come into contact with bats, noise and lights may rouse bats from hibernations, depleting bats' scarce energy reserves.

(B) Evidence

Northern myotis occur at hibernacula that may experience high levels of human disturbance (Beebe River Mine, Carter Mine, and Paddock Copper Mine). Carter Mine and Paddock Copper Mine are the two largest hibernacula for northern myotis, comprising over 50% of the known hibernating population of the species, and both of these mines are considered 'at risk'. Paddock Copper Mine and Beebe River Mine have seen the largest decline in hibernating northern myotis since 1986, whereas northern myotis populations within the gated hibernaculum (Mascot Lead Mine) remained stable during this same period.

3.1.2 Development (Habitat Loss and Conversion), Unsustainable Harvest (Forestry Operations and Management)

(A) Exposure Pathway

As New Hampshire land is deforested, northern myotis will experience summer roosting habitat loss and degradation. Individual bats (particularly non-volant young) may experience direct mortality if deforestation or disturbance occur during the parturition or lactation period. The cumulative result of habitat loss, degradation, and possibly direct mortality may lead to a reduction in population size.

(B) Evidence

Northern myotis generally relies on intact interior forests (Carroll et al. 2002, Owen et al. 2003, Patriquin and Barclay 2003) but will use forest edge habitat as well (Hogberg et al. 2002). Northern myotis relies on multiple roost trees per colony (Sasse and Pekins 1996), with a series of secondary roosts that are often clustered around a primary roost tree (Sasse 1995). Northern myotis uses a variety of trees as roosts (Sasse 1995, Owen et al. 2002) and relies more on living hardwoods and closed canopy habitat than do Indiana bats (Foster and Kurta 1998). These data suggest strong fidelity to core roosting areas within intact forest habitats. Although northern myotis is known to use human structures (Caceres and Barclay 2000), deforestation or fragmentation appears to be a substantial threat to this species. Logging, particularly at higher elevations such as the WMNF, also seems to pose a substantial threat.

3.1.3 Energy and Communication Infrastructure

Element 4: Conservation Actions

4.1.1 Gating, Habitat Protection

See Caves and Mines habitat profile.

4.1.2 Site-Selection and Pre-Construction Regulations, Regulation and Policy

4.1.3 Documenting roosting habits, Habitat Protection

(A) Removal of summer roosting habitat due to development, removal of summer roosting habitat due to logging.

(B) Justification

- Identifying summer roost areas of northern myotis and determining whether individual bats return to specific roost areas year-to-year will allow managers to better assess the effects of logging and development.

- The data on summer demographics of northern myotis are limited to the northern part of the state. It is therefore unclear whether documentation of roosting habits (e.g., annual fidelity to roost areas) will be relevant to populations that occur in the southern half of the state, where development is intense.
- Data on the spatial scale of northern myotis' summer roosting is limited. However, the average home range of northern myotis in West Virginia is 65 ha, so it is reasonable to plan logging and development activity at such a scale (Owen et al. 2003).

(C) Conservation Performance Objective
Integrate critical roosting habitats into a wildlife database. Determining summer habitat requirements for northern myotis bats is intended to allow informed decisions about limiting or ameliorating development and logging in bat habitat. In addition, broad protection of habitat areas may also preserve smaller habitat attributes, such as preferred species of roost tree.

(D) Performance Monitoring
Observation of summer habitat use will allow managers to decide whether limiting or mitigating development and logging is successful. Observations should be long-term, perhaps including periodic monitoring over a 10-year period.

(E) Ecological Response Objective
Maintain populations in delineated areas. Since data are too few to allow a valid estimate of current northern myotis population at summer roost areas, the minimal ecological response should be the maintenance of those populations initially located by biologists.

(F) Response Monitoring
Long-term monitoring may include summer surveys in areas used by northern myotis every three years. These data may reveal whether northern myotis remains faithful to specific habitats and roost areas each summer. Managers, in turn, will make better decisions about the maintenance of northern myotis populations in areas threatened by development or logging.

(G) Implementation
After summer habitat is identified, the state should coordinate the following:

- An intensive short-term radio-telemetry study to determine specific patterns of habitat use by individual bats
- The establishment of a long term monitoring program to determine if northern myotis remain faithful to small summer roost areas

(H) Feasibility
The technical competence to determine general summer habitat areas of northern myotis (mist-netting and acoustic monitoring) and roosting habits (radio telemetry) is available. The overall feasibility of conducting this research is limited by funding.

4.2 Conservation Action Research

Element 5: References

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SPECIES PROFILE

Silver-Haired Bat

Lasionycteris noctivagans

Federal Listing: Not listed
State Listing: Not listed
Global Rank: Not ranked
State Rank: Not ranked
Authors: Jacques P Veilleux, Franklin Pierce College; Scott Reynolds, St. Paul's School

Element 1: Distribution and Habitat

1.1 Habitat Description

Silver-haired bats do not remain in New Hampshire during the winter (see Izor 1979 for discussion of silver-haired bats remaining in northern latitudes during winter). Individuals that inhabit New Hampshire during the summer migrate to southern states in autumn. During spring, individuals return to their summer habitat in New Hampshire (or, more generally, to northern states; Cryan and Veilleux *in press*).

The silver-haired bat is a tree roosting species that roosts in tree hollows (e.g. Vonhof 1996, Betts 1998a, Crampton and Barclay 1998). No data describe the summer roosting ecology of silver-haired bats in New Hampshire, but several studies have examined summer roosting in the northwestern United States and southwestern Canada (Campbell et al. 1996, Vonhof and Barclay 1996, Betts 1998a, Crampton and Barclay 1998). Though results of habitat studies varied, in general, silver-haired bats preferred to roost in large tall trees, often in early to moderate stages of decay, in deep cavities relatively high off the ground.

Betts (1998a) found most roosts used by silver-haired bats were in mature rather than young stands. Campbell et al. (1996) found roost sites located > 100 m from riparian areas, on slopes averaging 38%, and the slope aspect for 11 of 15 roosts within 70° of north. The maternity roost described by Parsons et al. (1986) was located within a mixed-wood stand dominated by sugar maple (*Acer saccharum*), eastern white cedar (*Thuja occidentalis*), and white birch (*Betula papyrifera*).

1.2 Justification

Like other bats, silver-haired bats have a life history different from the life history of other small mammals. Individuals are relatively long-lived and have a low reproductive rate, typically giving birth to two young per year (Kunz 1982). Habitat loss and degradation may lead to population decline, which would be aggravated by slow reproductive rates. Silver-haired bats are also of conservation concern in New Hampshire because little is known about their population status. The lack of detailed data on the distribution, habitat use, and life history of silver-haired bats in New Hampshire may be largely due to a lack of research.

1.3 Protection and Regulatory Status

No specific Endangered Species Act (ESA) or RSA 212 regulations govern take, transport, or use of this species. Scientific collection or research requiring capture of individuals requires a permit through NHFG. Possession of live bats requires a permit under NHFG FIS 800.

1.4 Population and Habitat Distribution

Data on the current and historic range of silver-haired bats in New Hampshire are too few to allow a regional comparison. Only one individual has been captured in New Hampshire—Sasse (1995) captured an adult male in the town of Bartlett (Carroll County; D.B. Sasse, Arkansas Game and Fish Commission, personal communication). Reynolds (1999) also recorded echolocation calls at 3 sites: McDowell-Woodcock

(Peterborough, Hillsborough County), Bear Brook State Park (Pembroke, Merrimack County), and Pawtuckaway State Park (Nottingham, Rockingham County) and Krusic (1996) reported an echolocation recording from Bartlett, Carroll County. Existing data indicate that silver-haired bats may have a wide summer distribution in New Hampshire.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

1.7 Sources of Information

Data on species distribution were compiled by searching for specimens deposited in museums and college/university teaching collections and by examining published and gray literature of research on bat populations in New Hampshire.

1.8 Extent and Quality of Data

Data on the distribution of silver-haired bats in New Hampshire are extremely limited, though existing data are believed to be good. Hoary bats are morphologically unique and identifications should be accurate. Echolocation sequences of silver-haired bats are difficult to distinguish from big brown bats (*Eptesicus fuscus*; Betts 1998b), and therefore, such data should be treated with caution.

1.9 Distribution Research

A long-term, statewide mist-netting survey, accompanied by echolocation data (e.g., use of Anabat acoustic survey methods when mist-netting), is needed to determine the summer distribution of silver bats in New Hampshire.

Element 2: Species/Habitat Condition

2.1 Scale

Scale for an appropriate conservation planning unit has not been resolved by the upland forest habitat mapper (Steve Fuller, NHFG).

2.2 Relative Health of Populations

Population trends and viability cannot be inferred from the limited data on summer occurrences in New Hampshire.

2.3 Population Management Status

Silver-haired bats are not currently managed in New Hampshire. Management will require better information on the distribution of silver-haired bats.

2.4 Relative Quality of Habitat Patches

Scale for an appropriate conservation planning unit has not been resolved by the upland forest habitat mapper. Regardless of scale, it will be difficult to determine the relative quality of habitat patches in New Hampshire without first defining how and when silver-haired bats use various habitats.

2.5 Habitat Patch Protection Status

Because a scale for an appropriate conservation planning unit has not been resolved by the upland forest habitat mapper, data on the protection status of upland forest habitat patches are not available.

2.6 Habitat Management Status

Because a scale for an appropriate conservation planning unit has not been resolved by the upland forest habitat mapper, data on the habitat management status of upland forest habitat patches are not available.

2.7 Sources of Information

Because a scale for an appropriate conservation planning unit has not been resolved by the upland forest habitat mapper, sources of information used in determining the scale for conservation planning units are not available.

2.8 Extent and Quality of Data

Scale for an appropriate conservation planning unit has not been resolved by the upland forest habitat mapper. Therefore, the extent and quality of information used in determining the scale for conservation planning units is uncertain.

2.9 Condition Assessment Research

Research priorities for silver-haired bats include a state-wide mist-netting survey, telemetry studies to determine habitat use (roosting and foraging habitat), life history studies to determine breeding status and reproductive patterns, and food habit analyses to determine prey preference.

Element 3: Species Threat Assessment

3.1.1 Development (Habitat Loss and Conversion), Unsustainable Harvest (Forestry Operations and Management)

(A) Exposure Pathway
As forested land in New Hampshire is cleared, silver-haired bats will experience habitat loss and degradation. Bats, particularly non-volant young, may experience direct mortality if the conversion occurs during the parturition/lactation period (late May through mid July). The cumulative result of habitat loss, degradation, and possibly direct mortality will likely reduce the population size.

(B) Evidence
Data indicate that individual roost trees are occupied by bats on a year-to-year basis (Barclay and Brigham 2001) and that individual bats return to the same, small summer roosting area each year (Veilleux and Veilleux 2004). These data are for colonial bat species, and therefore, bat biologists hypothesize that strong fidelity to roost areas (and possibly roost trees) in the landscape allows individuals to relocate colony mates after emerging from hibernation in the spring, or, in the case of silver-haired bats, after their return migration. The removal of roost trees may disrupt the process of colony formation. If individuals are unable to form a colony, it is likely that a corresponding reduction in individual fitness, and therefore population recruitment, will occur.

3.1.2 Energy and Communication Infrastructure

(A) Exposure Pathway

(B) Evidence
Turbine-related bat mortalities at the Backbone Mountain site (Mountaineer Wind Energy) show that non-hibernating migratory bats such as the silver-haired bat are at greatest risk of turbine impact. Mortality rates of silver-haired bats are usually lower than other migratory tree bats, but they are more likely to die at some sites. For example, silver-haired bats represented 56% of the total bat mortality at a site in Washington state (Erickson et al. 2003) and 31% at a site in Minnesota (Osborn et al. 1996).

3.2 Sources of Information

Sources of information on threats to silver-haired bats include peer-reviewed scientific articles, gray literature, and expert review by John O. Whitaker, Jr. of Indiana State University.

3.3 Extent and Quality of Data

The threats described under element 3.1 are relatively well documented. Data describing the long-term negative effect of habitat conversion (development/logging) are not well understood. The fidelity of bats to specific roost areas is fairly well documented, but not for silver-haired bats. It has been assumed that silver-haired bats will behave in a similar fashion to other species. Additional data on how silver-haired bats use roost areas and roost trees on a long-term (interannual) basis are needed.

3.4 Threat Assessment Research

A primary assessment would document areas in New Hampshire with relatively high numbers of silver-haired bats (i.e. roost areas). Radio-telemetry studies would allow managers to determine location of roost areas. Several years of capture and telemetry data at the roost areas would determine whether individual bats are returning to the same roost areas year-to-year. Such data would allow managers to assess the impact of deforestation (due to development or logging) on silver-haired bats.

Element 4: Conservation Actions

4.1.1 Documenting roosting habits, Habitat Protection

(A) Development (Habitat Loss and Conversion), Unsustainable Harvest (Forestry Operations and Management)

(B) Justification
- Identifying summer roost areas of silver-haired bats and determining whether individual bats return to specific roost areas on a year-to-year basis will allow managers to better assess the impact of logging and development in silver-haired bat habitat.
- Although no data exist about the scale of the silver-haired bat's summer roosting habitat, Veilleux and Veilleux (2004) observed individual female eastern pipistrelles returning to very small summer roost areas across years; minimum roost areas used by the same bats of this species over two years ranged from 0.6 to 2.3 ha. Where silver-haired bats are found to roost, it is important to manage logging and development at a comparably small scale.

(C) Conservation Performance Objective
Integrate critical roosting habitats into a wildlife database. This will help managers limit and ameliorate activities that threaten silver-haired bat populations. By protecting entire habitat areas, the smaller scale attributes of habitat needs for silver-haired bats (e.g. preferred species of roost tree) will be preserved as well.

(D) Performance Monitoring
To determine whether limiting or mitigating development and logging is beneficial to silver-haired bat populations at specific sites, managers can monitor whether silver-haired bats continue to use the habitat area over a relatively long period (perhaps periodic monitoring over a ten-year period).

(E) Ecological Response Objective
Maintain populations in delineated habitats. Since current data are too few to allow a valid estimate of current silver-haired bat population status at summer roost areas, the minimal ecological response should be the maintenance of populations initially located by biologists.

(F) Response Monitoring
Identify more specific monitoring parameters. A summer survey at a known habitat area should be conducted every three years. This would provide data on silver-haired bats' fidelity to specific roost areas during summer and would allow managers to make better decisions about the maintenance of silver-haired bat populations in areas of logging and development.

(G) Implementation
After summer habitat is defined, the state should coordinate an intensive radio-telemetry study to determine habitat use by individual bats (perhaps six individuals), and establish a long-term monitoring program (ten years, with periodic monitoring every 3 years) to determine if silver-haired bats remain faithful to summer roost areas.

(H) Feasibility
The technical competence to determine general summer habitat areas of silver-haired bats (mist-netting) and the detailed patterns of their roosting habits (radiotelemetry) is available. The overall feasibility of conducting this research is limited by the availability of funding.

4.1.2 Site-Selection and Pre-Construction Regulations, Regulation and Policy

4.2 Conservation Action Research

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SPECIES PROFILE

Eastern Small-Footed Bat

Myotis leibii

Federal Listing: Not listed
State Listing: Endangered
Global Rank: G3
State Rank: S1
Authors: Jacques P Veilleux, Franklin Pierce College; Scott Reynolds, St. Paul's School

Element 1: Distribution and Habitat

1.1 Habitat Description

In winter, eastern small-footed bats (*Myotis leibii*) require cave or mine habitat that provides adequate characteristics for successful hibernation. Such characteristics include low levels of human disturbance and a stable microclimate (i.e. temperature stability). Although their hibernation has not been extensively researched, they appear to arrive at hibernacula later than most other species and leave earlier in the spring (Thomas 1993, Best and Jennings 1997). They also prefer colder temperatures than do other *Myotis* bats (Best and Jennings 1997, Butchkoski 2003, Tuttle 2003). For example, they are often found in the coldest sections of a cave or mine, either utilizing short (less than 150 m in length) adits (Best and Jennings 1997) or choosing roost locations near the entrance of larger hibernacula (Tuttle 2003). It is also believed that they roost in narrow crevices (Best and Jennings 1997), although all of the individuals documented in New Hampshire were found on exposed surfaces (Reynolds, unpublished data).

Few data describe the summer habitat of eastern small-footed bats in New Hampshire. Most suggest that they roost in rock crevices (Whitaker and Hamilton 1998, Chenger 2003). Chenger (2003) captured 11 small-footed bats in Surry, Cheshire County, and radiotagged 3 individuals (2 adult females and 1 adult male). Data from radiotagged bats revealed several roost sites, each within rock crevices in outcrops near the base of the Surry Mountain Lake dam. Although no radiotagged individuals were reproductive females, it is likely that females give birth and wean young within similar rock crevice roosts. No data describe the rock crevices (crevice dimension, temperature profile, height from ground, etc.) that provided roost habitat for these animals.

1.2 Justification

Like other bats, eastern small-footed bats are relatively long lived and have a low reproductive rate, likely giving birth to a single young per year (Best and Jennings 1997). Tuttle and Heaney (1984) found possible evidence of some twinning. Since eastern small-footed bats are found in rare habitats during summer (rocky outcrops) and winter (caves and mines), they are at risk of population declines if such habitats are lost or degraded. Their slow reproductive rate would, in turn, lead to a slow population recovery time.

Eastern small-footed bats have been documented in only 1 of the 7 known hibernacula in New Hampshire (Mascot Lead Mine). Although winter surveys of eastern small-footed bats suggest a stable or even increasing population (Butchkoski 2003, Reynolds unpublished data), total numbers are still extremely low. In fact, eastern small-footed bats are rarer than Indiana bats in most northeastern states that have long-term monitoring data (Trombulak et al. 2001, Thomas, 1993).

During summer, small-footed bats have been captured at 3 locations in New Hampshire, including the White Mountain National Forest (Krusic et al. 1996, Chenger 2005), New Boston (Hillsborough County; LaGory et al. 2002), and Surry (Cheshire County; Chenger 2005). Beyond these few data, the species' status in New Hampshire remains almost entirely unknown.

1.3 Protection and Regulatory Status

No specific ESA regulation governs take, transport, or use of this species. Scientific collection or research requiring capture of individuals requires a permit through New Hampshire Fish and Game (NHFG). Possession of live bats requires a permit under NHFG FIS 800.

1.4 Population and Habitat Distribution

Data that describe the range of eastern small-footed bats in New Hampshire are too few to allow a regional comparison of New Hampshire populations or to indicate distribution patterns. Winter distribution data of eastern small-footed bats is limited to 9 individuals from one locality (figure 1), and summer records are known from only 5 localities: the White Mountain National Forest (Krusic et al. 1996; no specific locality available), Bartlett (Coos Carroll County; Chenger 2005), New Boston (Hillsborough County; Lagory et al. 2002), Peirmont (Grafton County; Chenger 2005), and Surry (Cheshire County; Chenger 2005). Only 1, 1, 2, 2, and 11 records from each locality exist, respectively.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

1.7 Sources of Information

Data on winter distribution were compiled by examining New Hampshire Natural Heritage Inventory – Bat Hibernaculum Record data sheets, and by examining the collection dates of specimens deposited in museum collections and college/university teaching collections. Summer distribution data were determined by examining specimen collections, published literature, and unpublished sources.

1.8 Extent and Quality of Data

Data on the distribution of eastern small-footed bats in New Hampshire are extremely limited (see discussions in elements 1.2 and 1.4). The quality of data is believed to be good, as qualified bat biologists made identifications. Occurrence records and research efforts aimed at determining distribution patterns in New Hampshire are few.

1.9 Distribution Research

Potential hibernacula should be surveyed to determine the winter distribution of eastern small-footed bats. To determine summer distribution, long-term, statewide mist-netting and echolocation surveys (use Anabat acoustic survey methods when mist-netting) should be completed. Initial mist-netting surveys might focus on locations near cliff faces and rock outcrops, and should record all banding records in the Northeast Banding Database developed by the Northeast Working Group on Bats (NEWGB). An intensive banding program using state-issued wing bands would yield data on the summer distribution of all bat species in New Hampshire and might provide insight into where summer populations overwinter.

Element 2: Species/Habitat Condition

2.1 Scale

Due to the small number of suitable mines in New Hampshire, each mine has been treated as a conservation planning unit under the habitat profile.

2.2 Relative Health of Populations

Eastern small-footed bats are known only from the Mascot Lead Mine (Coos County). The New Hampshire Natural Heritage Survey ranked Mascot Lead Mine as 'B/C', indicating 'fair to good quality and prospects for long-term conservation'. In 2004, 9 hibernating individuals were documented in this mine. Given the small number of surveys, there is not enough data to conduct an analysis of trends and viability of winter populations.

2.3 Population Management Status

There is no management aimed at the conservation of eastern small-footed bats, although the one known winter population is incidentally protected by the bat gat at Mascot Lead Mine. Lack of data on the distribution of eastern small-footed bats prohibits identification of conservation opportunities beyond the need to conduct additional habitat surveys.

2.4 Relative Quality of Habitat Patches

The known winter population of eastern small-footed bats is in the abandoned Mascot Lead Mine. This is a relatively stable mine with multiple levels and two openings, both of which are gated to prevent human disturbance. No microclimate data have been collected within Mascot Lead Mine.

Although several of the potential hibernacula are shallow, there are no winter microclimate data to determine whether they are cold and stable enough to maintain a hibernating population of eastern small-footed bats. Because most of the summer records of eastern small-footed bats occur in southern New Hampshire, it will be important to assess any potential hibernacula in Hillsborough, Merrimack, Cheshire, and Rockingham counties as they are discovered.

2.5 Habitat Patch Protection Status

The Department of Resources and Economic Development (DRED) manages Mascot Lead Mine. The Nature Conservancy (TNC) maintains the gates that restrict access to the mine. The New Hampshire Natural Heritage Survey has given all known bat hibernacula a conservation rank that indicates habitat quality and prospects for long-term conservation. Mascot Lead Mine was ranked as 'B/C', indicating a 'fair to good quality and prospects for long-term conservation'.

2.6 Habitat Management Status

The only ongoing habitat management action occurring in New Hampshire is the bat gate at Mascot Lead Mine. These gates, used over the last 35 years, are steel structures installed in mine or cave entrances to restrict human access without hindering air flow or bat flight. Because many caves and mines are found in remote locations, bat gates are "the only means available for protecting these [colonies]" (Pierson et al. 1991: 31). It is reasonable to assume these bat gates have been highly effective at minimizing human disturbance due to spelunking activities, though surveys in 1993 and 2004 did not indicate significant changes from 1992 populations

2.7 Sources of Information

To determine the winter distribution at known hibernacula, New Hampshire Natural Heritage Survey-Hibernacula Survey Data Sheets were examined. To determine habitat patch protection status of Mascot Lead mine, the site was mapped on the Conservation Lands GIS data layer (GRANIT – 2003 data).

2.8 Extent and Quality of Data

There have been 4 winter surveys at Mascot Lead Mine since 1987; 2 of these surveys were conducted since installation of the bat gate in 1992. Although these surveys were extensive, no microclimate data were collected. Future surveys should be conducted in late winter (December through February) to ensure eastern small-footed bats have begun hibernation (Thomas 1993). Furthermore, surveys should not be done during mild weather periods when eastern small-footed bats are known to temporarily leave hibernacula (Butchkoski 2003).

2.9 Condition Assessment Research

Microclimate data (primarily temperature) must be obtained at Mascot Lead Mine for an entire winter season. Data logging probes should be mounted on rock surfaces near eastern small-footed bat roosts to obtain roost-specific data. These data can then be used to assess microclimate environments at potential hibernacula throughout the state. Summer surveys should include statewide mist-netting to better understand distribution, telemetry studies to determine habitat use, life history studies, and diet analyses.

Element 3: Species Threat Assessment

3.1.1 Recreation

See Caves / Mines Habitat.

3.1.2 Nonpoint Source Pollution

(A) Exposure Pathway

The only known summer roosting site of eastern small-footed bats in New Hampshire is the Surry Mountain Lake Dam, where bats roost in man-made boulder crevices along the southern outflow of the Surry Mountain Reservoir. To limit the amount of plant material (especially woody material) growing in the rock slope, USACE sprays the rock slope with herbicide. It is unknown whether the direct application of herbicide on the roost area of eastern small-footed bats reduces the quality of the roost area or causes mortality of adult and young bats.

(B) Evidence
Vegetation management is part of the regular maintenance at water reservoirs operated by the USACE. Because bats have a high metabolic rate and localized foraging area, they are likely to be sensitive to pesticides (Schmidt et al. 2002). Indeed, data support this (Luckens and Davis 1964) and suggest that most of the exposure risk comes from direct contact at the roost (Clark et al. 1978). However, these studies also suggest that herbicides are less toxic than insecticides (Sullivan 1990).

Many toxic effects of pesticides involve the accumulation of toxins within fat tissue. At high doses, exposure can result in death at the roost site. At lower doses, the toxins may be released during periods of negative energy balance such as hibernation or lactation (Kunz et al. 1977). In adults, the main effect of an accumulating toxin would be increasing over-winter mortality at the hibernaculum as toxins are released into the bloodstream during arousal. For juveniles, the main effect would be a reduction in population recruitment through increased mortality due to the transfer of toxins through milk. It has also been suggested that young bats are at more risk of contact exposures due to their highly vascularized skin and lack of pelage (Kunz et al. 1977).

3.2 Sources of Information

Much of the information on the biology of eastern small-footed bats in caves and mines comes from published literature and from experts such as M. Brock Fenton of York University, Canada. Information on the biology of the foraging habitat of eastern small-footed bats comes from the published literature.

3.3 Extent and Quality of Data

The eastern small-footed bat is the least known of northeastern bats (Thomas 1993). Therefore, most data on threats to this species are based on its morphological and ecological similarity to other hibernating *Myotis* spp. For example, the effect of disturbance on hibernating bats (element 3.1.1) is well documented. In contrast, there are no data on the effects of wind resource development (element 3.1.2) on small-footed bats. Similarly, the effect of herbicides on bats (element 3.1.3) has not been documented in the literature.

3.4 Threat Assessment Research

Surveys should document the prevalence of eastern small-footed bats within the state and should determine the nature of herbicides used near potential maternity roosts. Mist-netting and radio-telemetry studies help locate any core roost habitat for eastern small-footed bats. Several years of capture and telemetry data at roost areas would determine site fidelity and reproductive success.

Element 4: Conservation Actions

4.1.1 Gating, Habitat Protection

See Caves/Mines.

4.1.2 Site-Selection and Pre-Construction Regulations, Regulation and Policy

4.1.3 Herbicide Management, Habitat Protection

(A) Herbicide Exposure at Roost Sites

(B) Justification
- There are no data on the exact effects of herbicides on bats. However, reducing or eliminating exposure to herbicides should be easy and would cost little.
- If rock-roosting bats are being exposed to high levels of herbicides, and that exposure is poisoning bats, then reducing exposure will have an immediate effect on population recruitment through reduced juvenile mortality and increased over-winter survivorship
- Modifying or eliminating herbicide usage at each USACE site is the appropriate scale for action.
- Given that eastern small-footed bats are the least studied bats in the Northeast, and given that the actions suggested will cost little, immediate action is appropriate.
- The exact nature of herbicide use (type, volume,

and timing), and the appropriate responses to it, should be determined.

(C) Conservation Performance Objective
The objective is to regulate herbicide application practices (type, volume, and timing) to minimize exposure.

(D) Performance Monitoring
The conservation action would be conducted at a USACE facility that uses boulder-retaining dams. The most likely location would be the Surry Mountain Reservoir because there are existing eastern small-footed bats using rock roosts at this site (Chenger 2005). Additionally, a control site would need to be established, either using a USACE facility that suspends vegetation management or finding an eastern small-footed colony that is not at herbicide exposure risk. Relative exposure would be compared between populations during the reproductive season (June through August) and in coordination with USACE personnel.

(E) Ecological Response Objective
The desired ecological response to reducing herbicide exposure is an increase in population recruitment within the exposed population.

(F) Response Monitoring
The response indicators required by this action could be collected in conjunction with radio telemetry studies that are focusing on habitat usage patterns in eastern small-footed bats. Therefore, the response measures would be inexpensive and would generate results that could immediately inform management decisions.

(G) Implementation
This conservation action will require having both treatment and control populations of eastern small-footed bats in reasonable proximity. The survey would most likely be done in coordination with radiotelemetry research, and therefore would be concentrated within a two-week time in late June and early August. The researchers would establish a reliable and non-invasive method of collecting data on herbicide loads. Because this action involves a state-listed species on federal land, potential partners include the NHFG, the United States Fish and Wildlife Service, and the USACE. Additional partnerships could be established with local non-governmental organizations (NGOs).

(H) Feasibility
The most difficult component of the conservation action will be finding two populations of eastern small-footed bats in proximity. Because so little is known about their abundance and distribution within the state, it will require extensive landscape-level surveying to find populations, and intensive radio telemetry to adequately understand their core roosting and foraging habitat.

4.2 Conservation Action Research

The conservation action research goal for eastern small-footed bats is to document their existence within the state and protect critical habitats and resources. The primary research action is to survey existing and potential hibernacula. This will include winter surveys of known and potential hibernacula and microclimate measurements at each site. These actions will inform future management decisions about the use of bat gates (element 4.1.1).

Element 5: References

5.1 Literature

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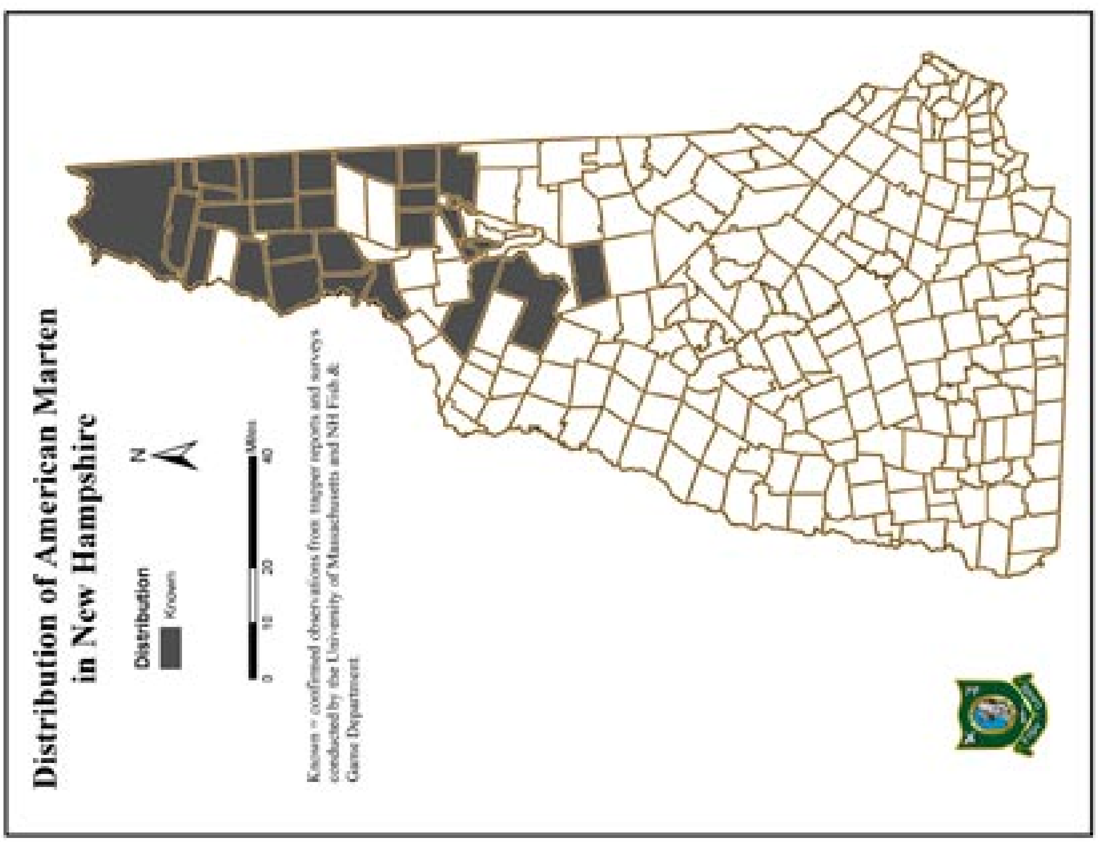
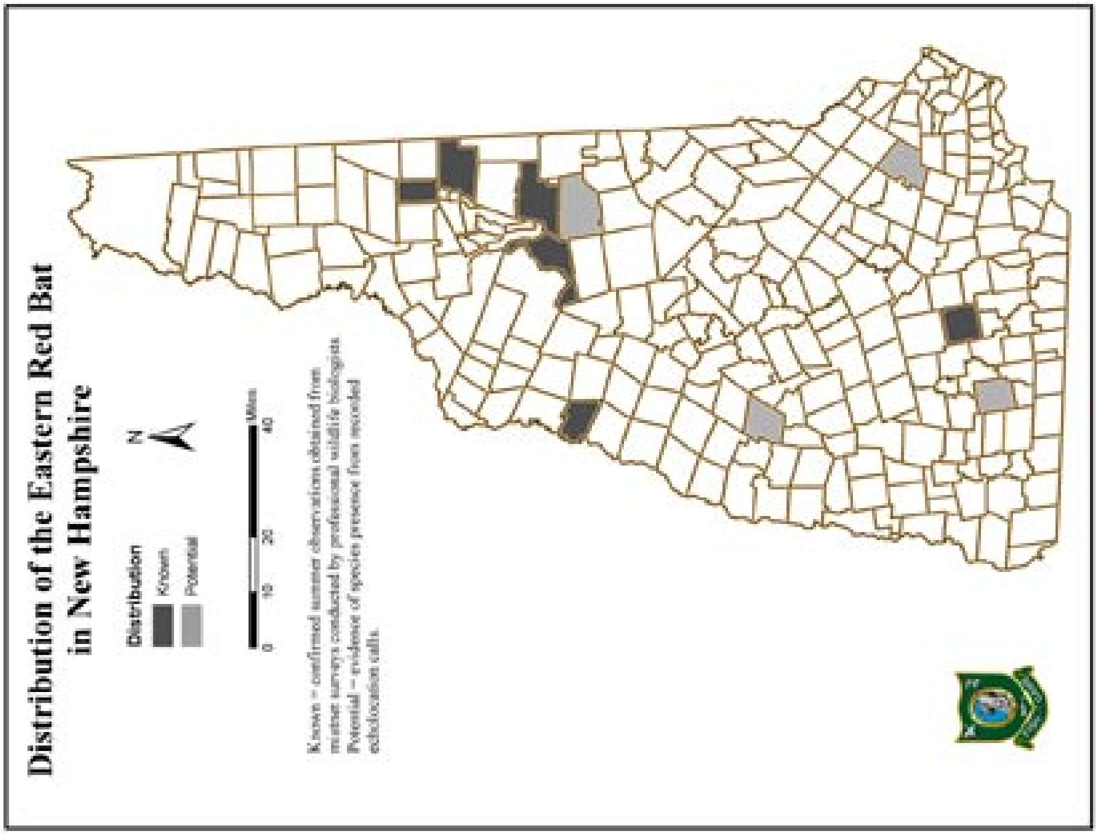
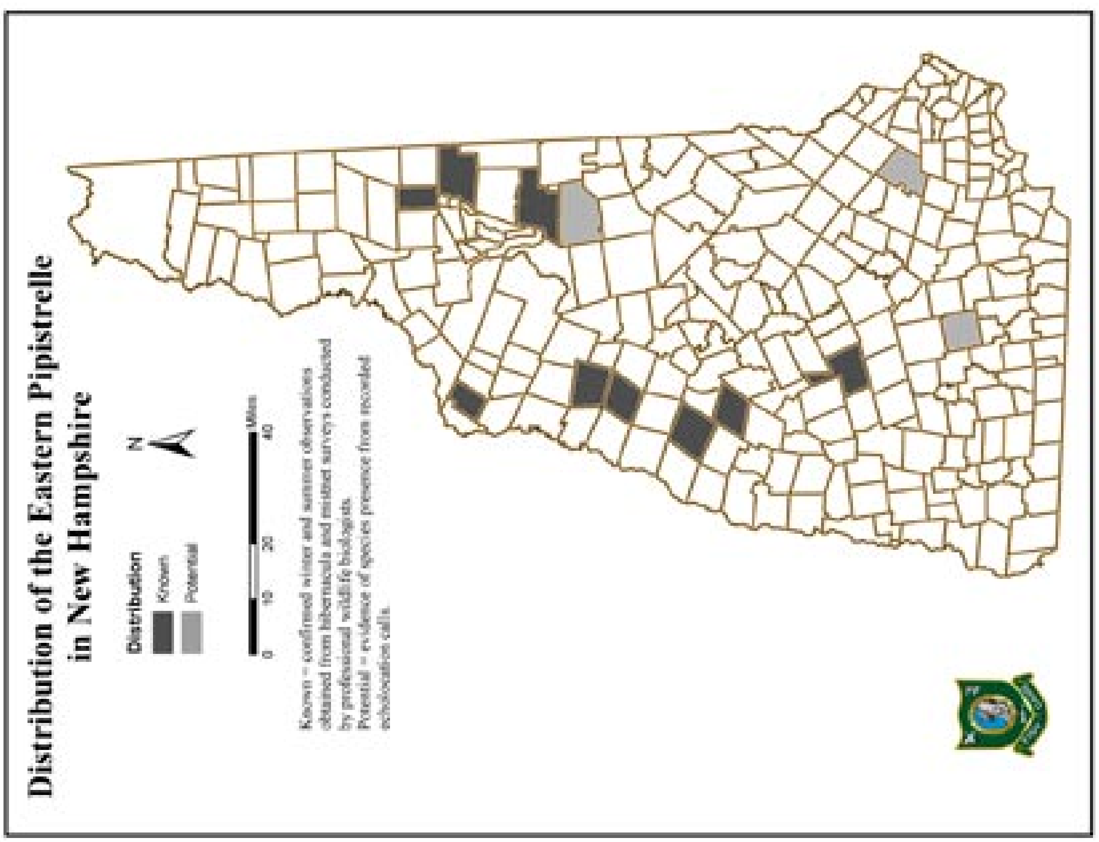
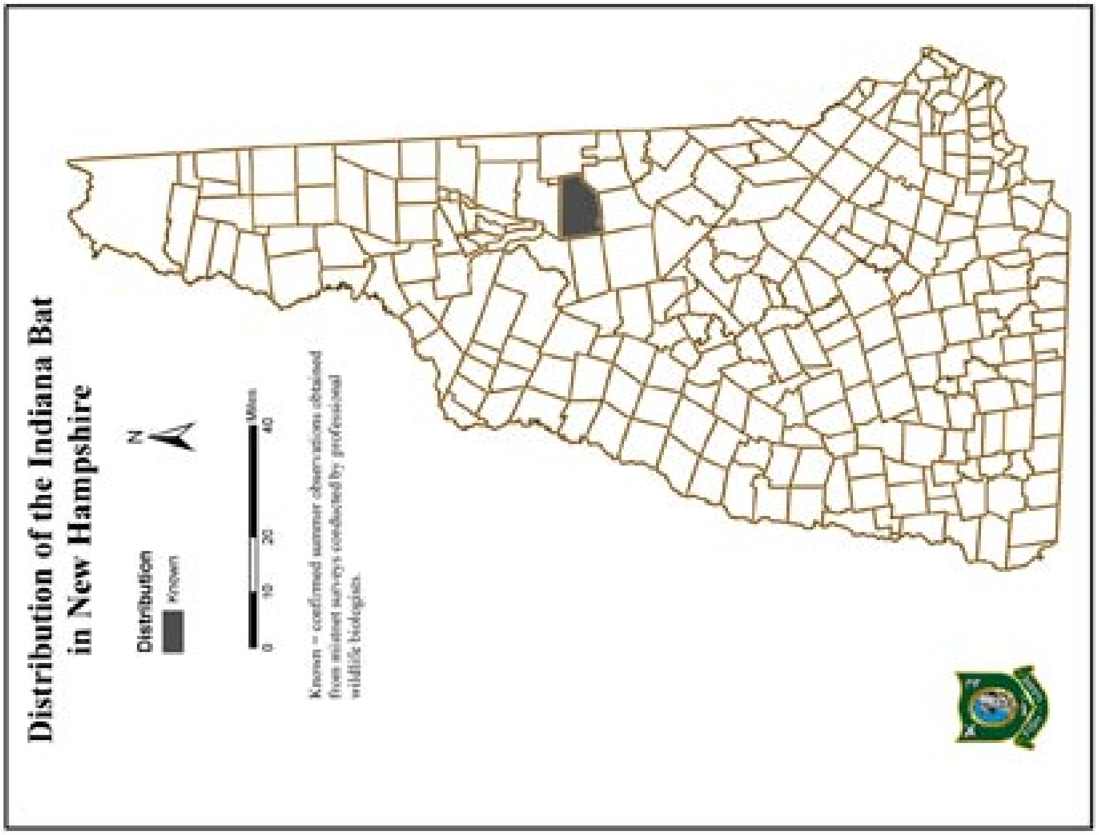
Mammal Maps

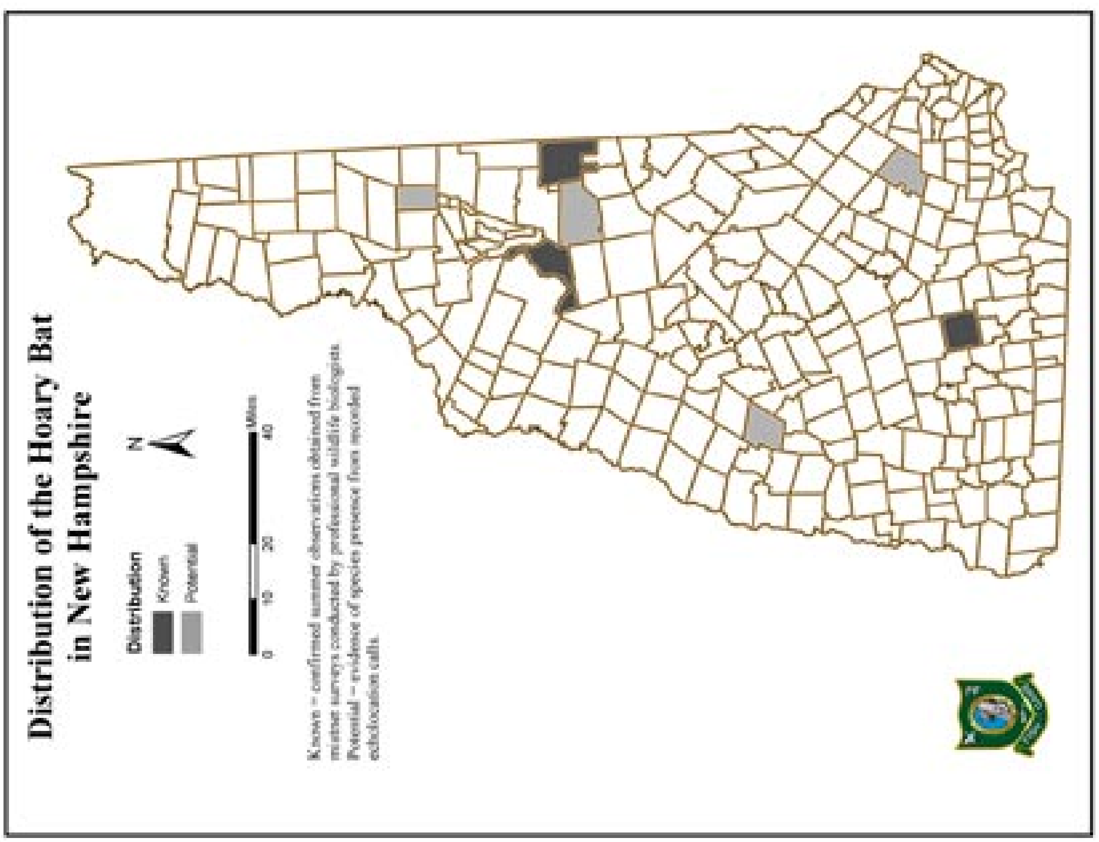

Distribution of Bobcat in New Hampshire
Distribution
Known
N
0 10 20 40 Miles
Known = verified observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and obtained from trapper reports.


Distribution of American Marten in New Hampshire
Distribution
Known
N
0 10 20 40 Miles
Known = confirmed observations from trapper reports and surveys conducted by the University of Massachusetts and NH Fish & Game Department.

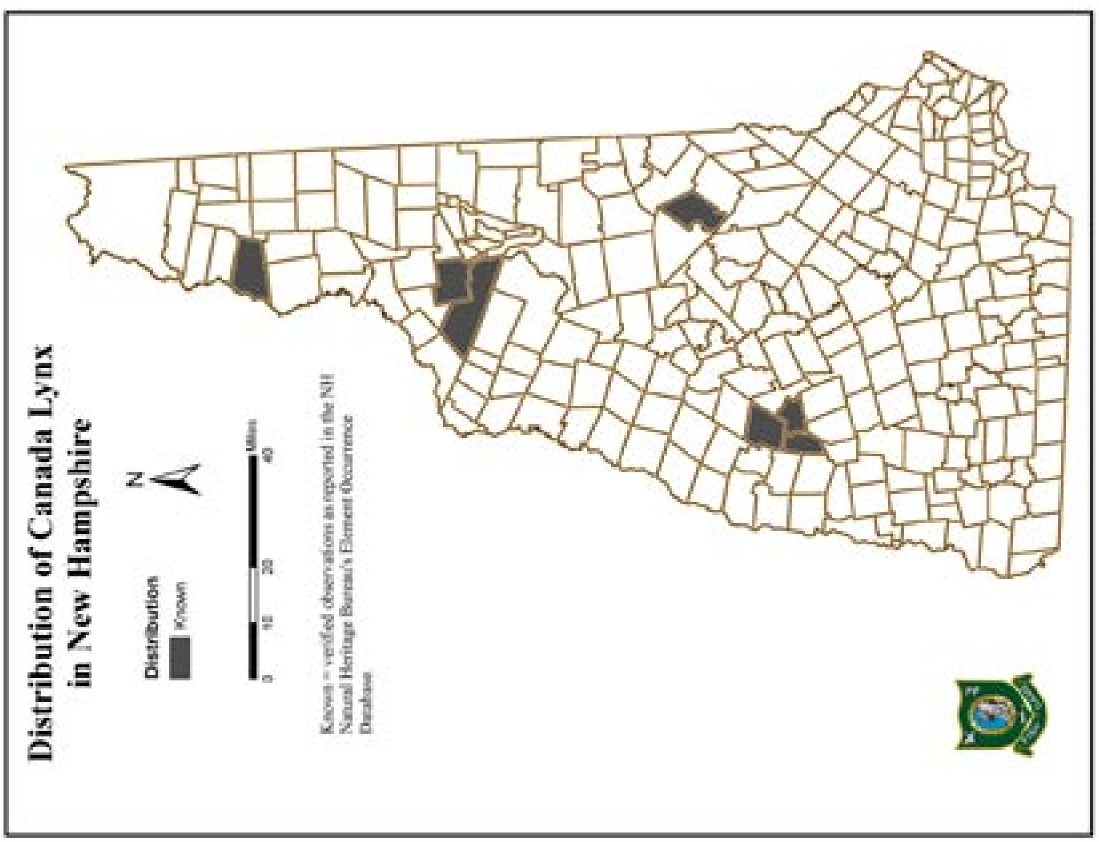

Distribution of the Eastern Red Bat
in New Hampshire
Distribution
Known
Potential
N
0 10 20 40 Miles
Known – confirmed summer observations obtained from mistnet surveys conducted by professional wildlife biologists.
Potential – evidence of species presence from recorded echolocation calls.

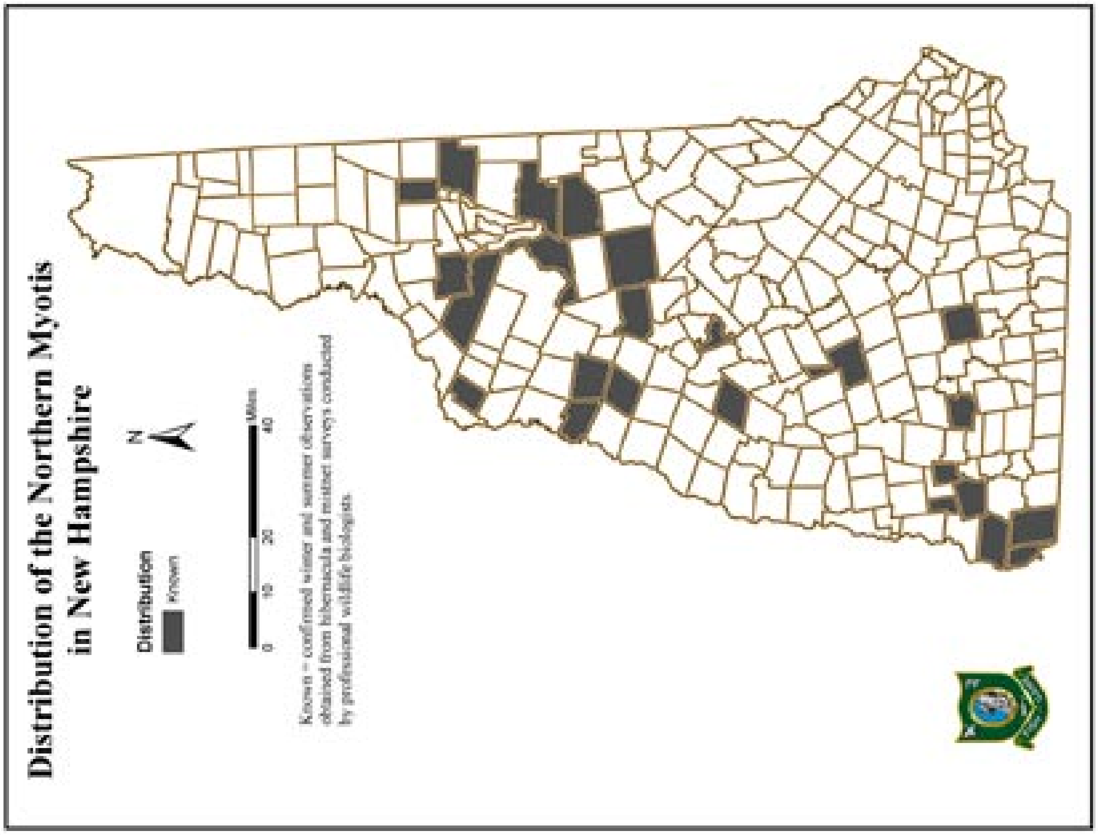

Distribution of the Eastern Pipistrelle
in New Hampshire
Distribution
Known
Potential
N
0 10 20 40 Miles
Known – confirmed winter and summer observations obtained from hibernacula and mistnet surveys conducted by professional wildlife biologists.
Potential – evidence of species presence from recorded echolocation calls.

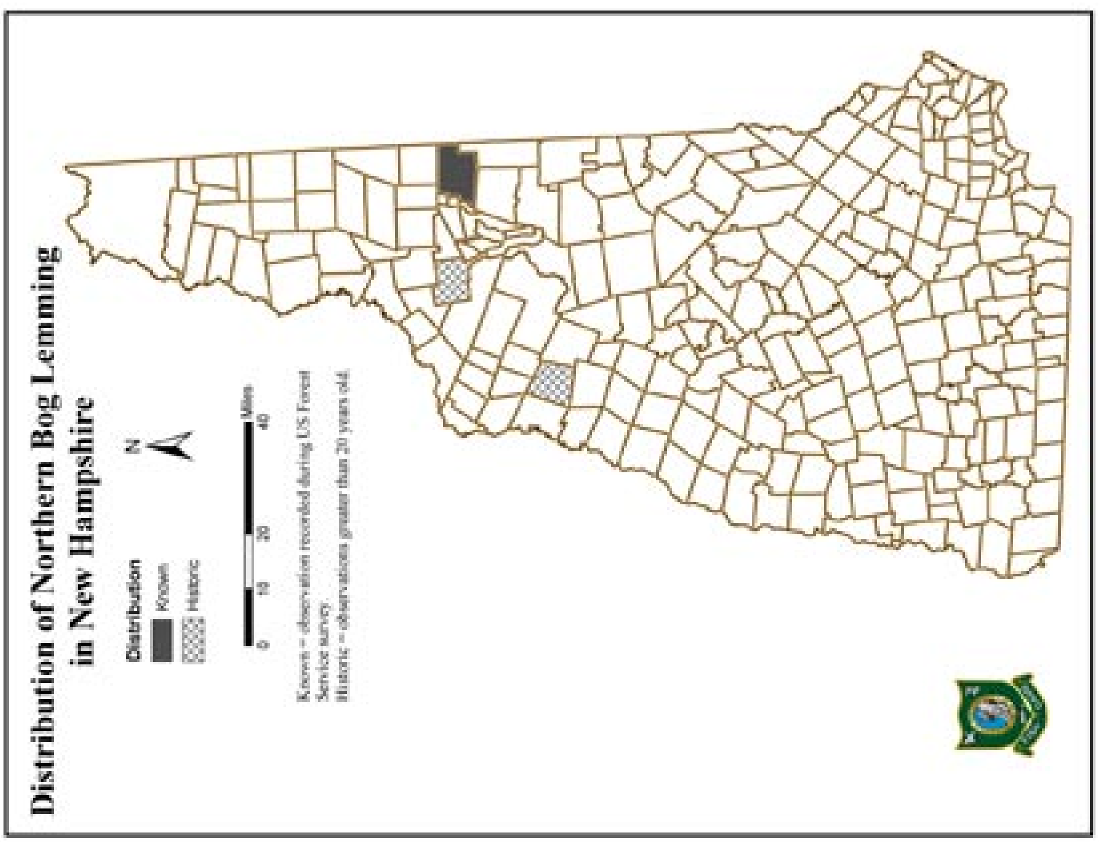

Distribution of the Indiana Bat
in New Hampshire
Distribution
Known
N
0 10 20 40 Miles
Known = confirmed summer observations obtained from mistnet surveys conducted by professional wildlife biologists.

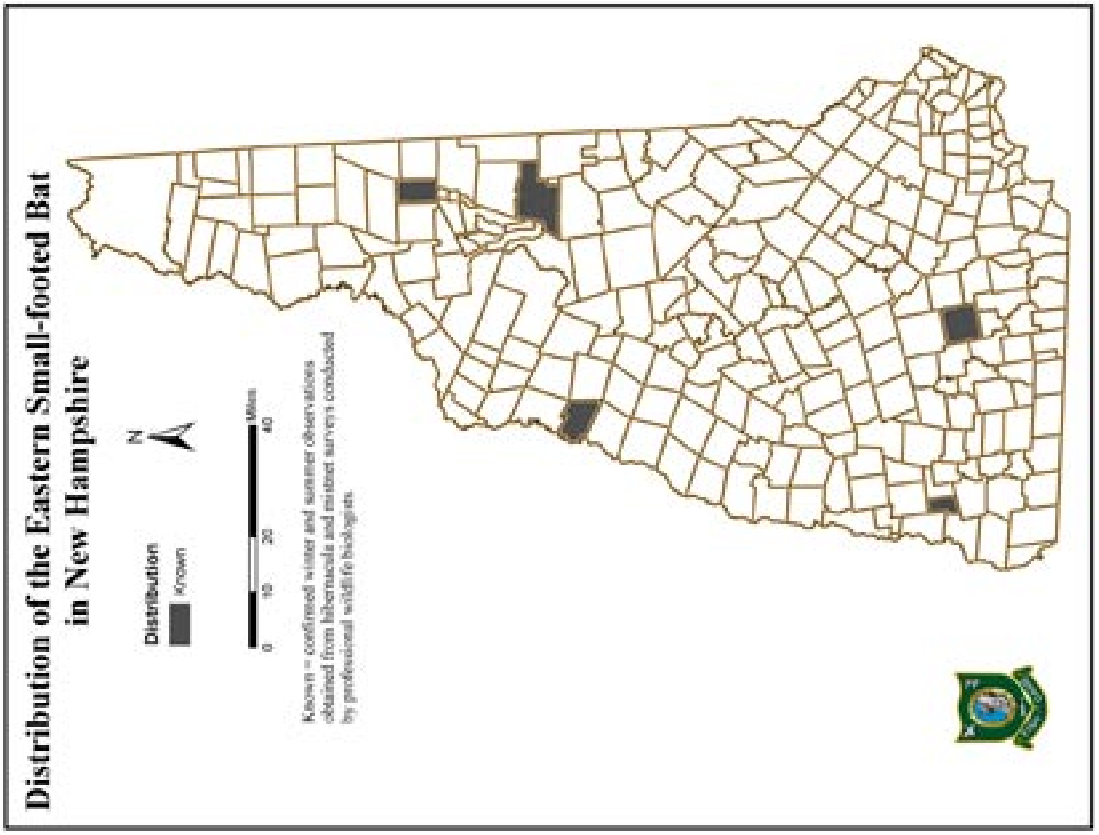

Distribution of the Hoary Bat
in New Hampshire
Distribution
Known
Potential
N
0 10 20 40 Miles
Known = confirmed summer observations obtained from mistnet surveys conducted by professional wildlife biologists.
Potential = evidence of species presence from recorded echolocation calls.


Distribution of New England Cottontail
in New Hampshire
Distribution
Known
N
0 10 20 40 Miles
Known = verified observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and obtained from University of New Hampshire surveys.

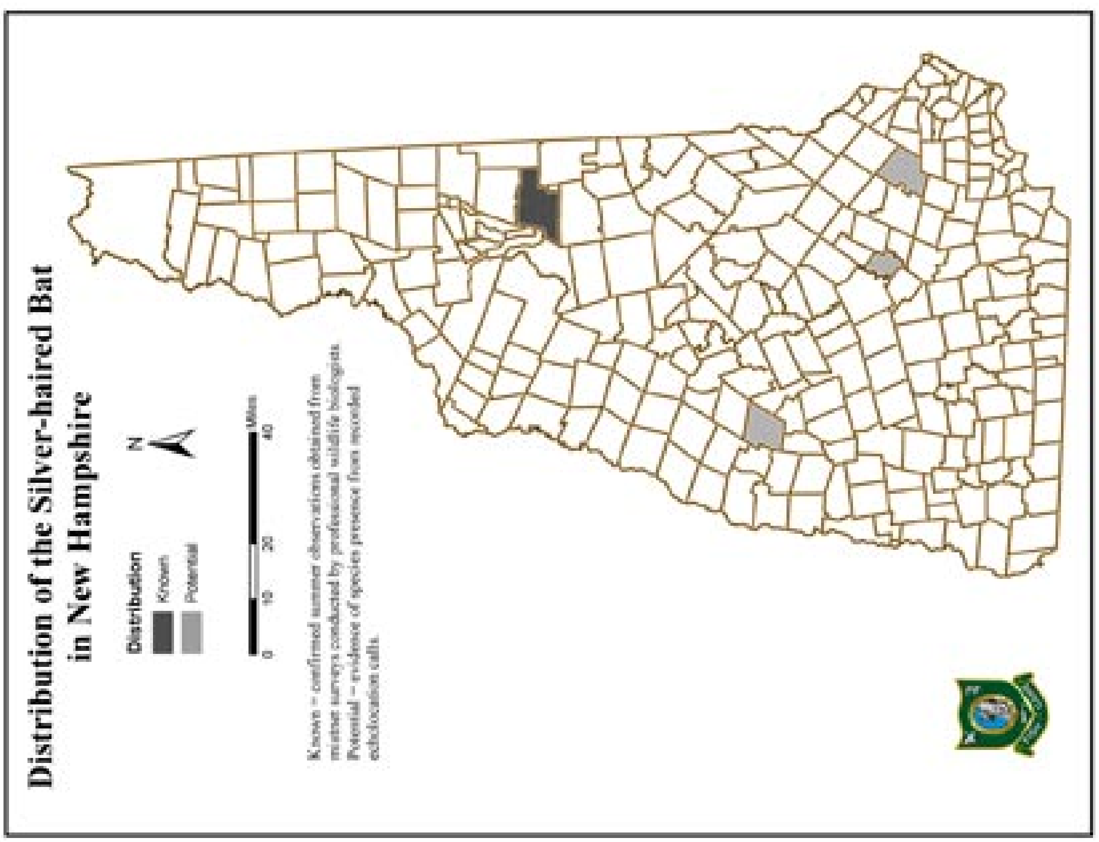

Distribution of Canada Lynx
in New Hampshire
Distribution
Known
N
0 10 20 40 Miles
Known = verified observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database


Distribution of the Northern Myotis
in New Hampshire
Distribution
Known
N
0 10 20 40
Miles
Known = confirmed winter and summer observations
obtained from hibernacula and mistnet surveys conducted
by professional wildlife biologists.


Distribution of Northern Bog Lemming
in New Hampshire
Distribution
Known
Historic
N
0 10 20 40
Miles
Known = observation recorded during US Forest
Service survey.
Historic = observations greater than 20 years old.



Distribution of the Eastern Small-footed Bat
in New Hampshire
Distribution
Known
N
0 10 20 40 Miles



Distribution of the Silver-haired Bat
in New Hampshire
Distribution
Known
Potential
N
0 10 20 40 Miles