SPECIES PROFILE

Bobcat

Lynx rufus

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

Element 1: Distribution and Habitat

1.1 Habitat Description

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

1.2 Justification

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

1.3 Protection and Regulatory Status

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

1.4 Population and Habitat Distribution

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

1.5 Town Distribution Map

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

1.6 Habitat Map

Methods

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

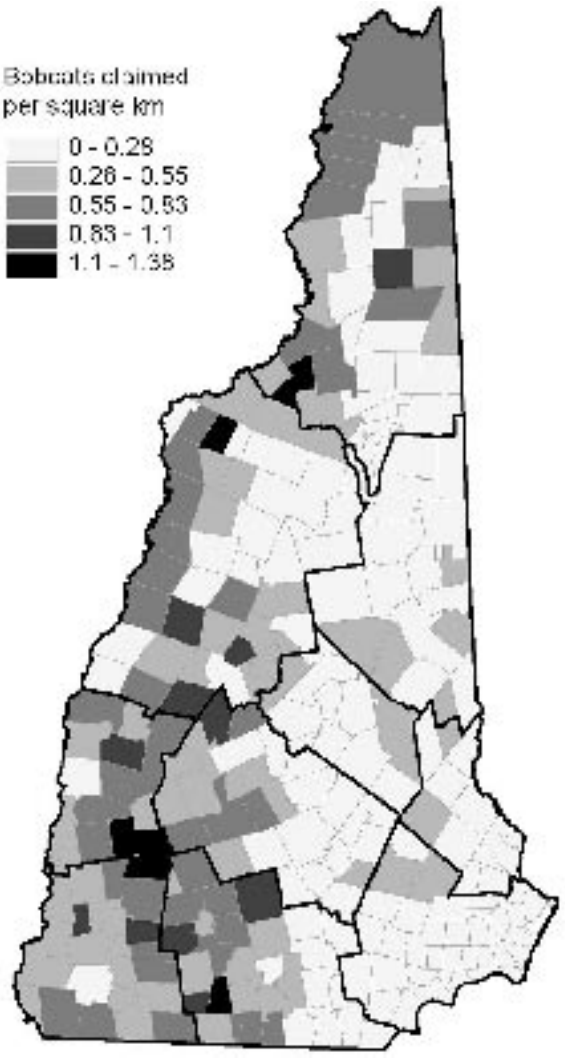

FIGURE 1. Distribution of bobcat harvests by township in New Hampshire from 1931 to 1965.

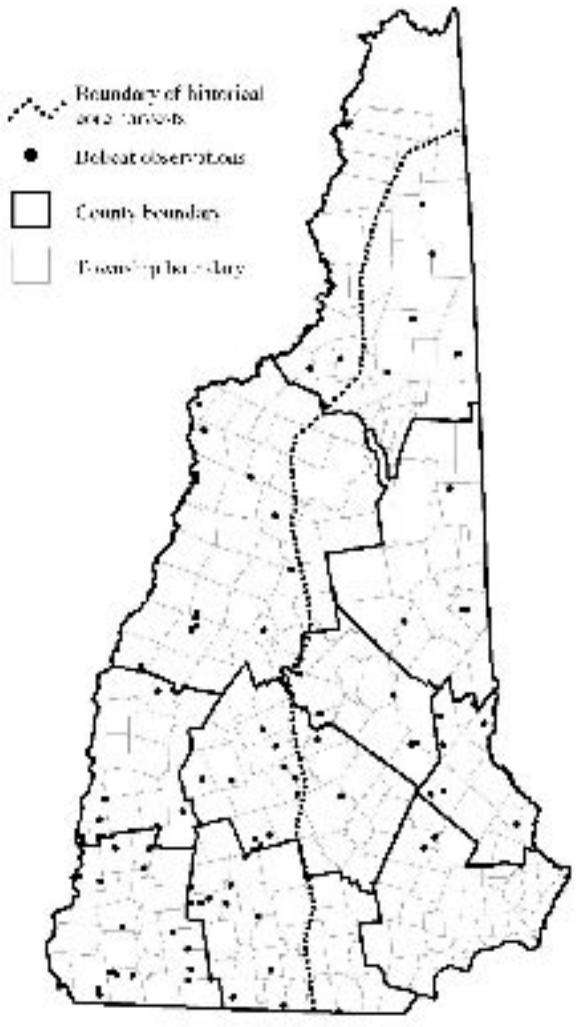

FIGURE 2. Locations of incidental captures, direct observations, and vehicle-killed bobcats (total = 90) during 1990 – 2004. The region to the west of the dashed line represents 49% of the state and it contained 74% of the >9,000 bobcats between 1931 and 1965. Seventy-two percent of the recent observations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

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

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

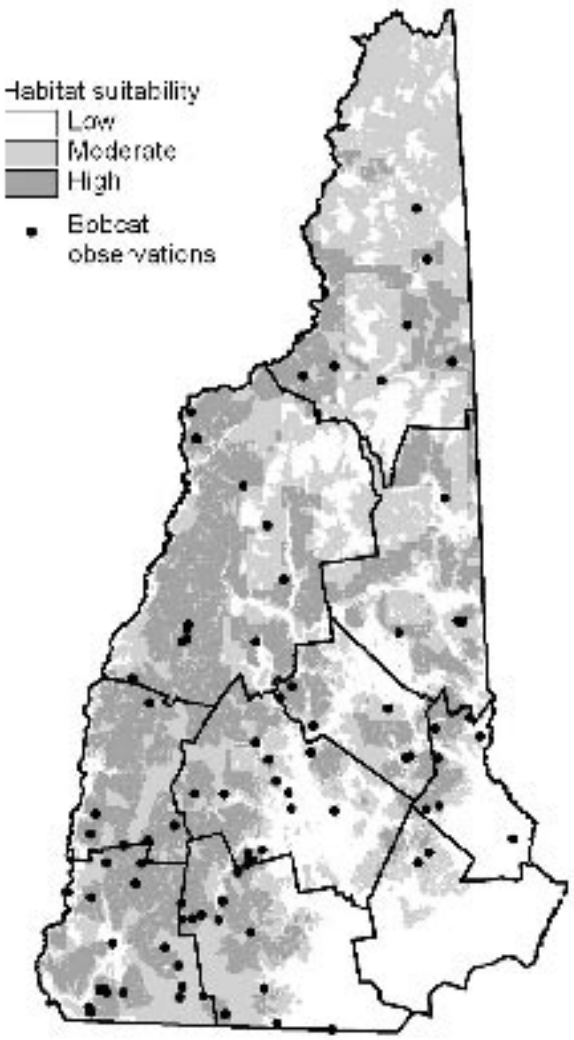

FIGURE 3. Modeled bobcat habitats where suitabilities were based on threshold values of elevation, minimum area of forest or wetland not fragmented by class I or class II roads, and annual snowfall.

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

Results

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

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

1.7 Sources of Information

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

Data on historic harvests (by township) were obtained from the files of C. L. Stevens, deceased professor at UNH, who conducted a long-term investiga-

tion on bobcats during the 1950s through the early 1960s (some of his work was subsequently published by Litvaitis et al. 1984). Stevens compiled a detailed review of bounty records from 1809 to 1965, and when combined with recent information, provides good information on the abundance of bobcats in New Hampshire during the past 200 years.

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

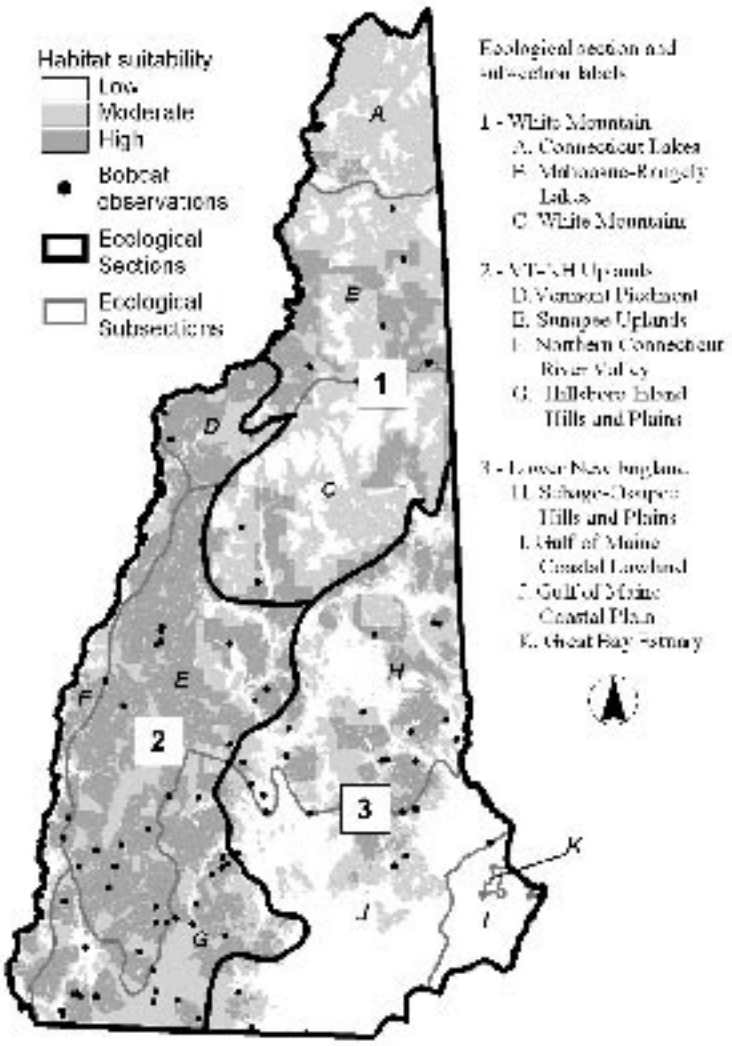

FIGURE 4. Distribution of recent (1990 – 2004) incidental captures and observations in Ecological Sections of New Hampshire.

1.8 Extent and Quality of Data

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

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

Additionally, the process-oriented model only looks at landscape scale variables that may limit bobcat abundance and distribution. However, habitat selection by carnivores occurs at several spatial scales (Brown and Litvaitis 1995). Selection at a local scale is likely influenced by other features, including prey

distribution and stalking cover (e.g., Litvaitis et al. 1986*a*). Information on bobcat selection at a finer resolution (i.e., patch or forest stand) is limited for bobcats in New Hampshire. MacLachlin (1981) investigated habitat selection at the stand scale by snow-tracking bobcats along 76 km of tracks in Sullivan County. Unfortunately, this limited data set could not be analyzed statistically. Ranking habitat use, however, suggested a preference for softwood stands (MacLachlin 1981:20). Some effort should be made to obtain information on factors affecting stand-scale selection by bobcats if we are to understand what may limit the current distribution and abundance of this species.

1.9 Distribution Research

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

Element 2: Species Habitat Condition

2.1 Scale

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

2.2 Relative Health of Populations

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

2.3 Population Management Status

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

2.4 Relative Quality of Habitat Patches

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

2.5 Habitat Patch Protection Status

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

2.6 Habitat Management Status

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

2.7 Sources of Information

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

2.8 Extent and Quality of Data:

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

2.9 Condition Assessment Research

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

Element 3: Species Threat Assessment

3.1 Transportation Infrastructure (Mortality, Fragmentation, Dispersal Barriers)

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

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

3.2 Sources of Information

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

3.3 Extent and Quality of Data

There are no field data on New Hampshire populations.

3.4 Threat Assessment Research

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

Element 4: Conservation Actions

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

See section 3.1.1

Element 5: References

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Element 6: List of Figures

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


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.