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Records of Recovering American Marten, *Martes americana*, in New Hampshire

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Recent and current distribution of state-threatened American Marten (*Martes americana*) in New Hampshire was identified by summarizing 157 occurrence records (1980–2004) in a database and mapped using Geographic Information Systems (GIS). Records included visual observations, snow tracks, road kill, trapper captures, systematic live-trapping locations, and other miscellaneous locations. Marten in New Hampshire are now found throughout the White Mountains north to the Canadian border, with the highest relative abundance in the very northern tip of New Hampshire. The recent expansion in the range of Martens includes reproducing females, but a sex ratio biased towards males in some areas suggests that dispersing individuals might inhabit much of the range.

Key Words: American Marten, *Martes americana*, distribution, New Hampshire.

Historically, American Marten (*Martes americana*) populations were distributed throughout the forests of eastern North America (Seton 1929), but excessive trapping and habitat loss during the late 19th and early 20th centuries resulted in regional population extirpations (Gibilisco 1994). Marten in many areas recolonized naturally, some recolonized through translocations, and others remain extirpated (Powell et al. 2003). For example, Marten populations have recovered and are trapped under protective regulations for their valuable fur throughout Maine, Quebec, northern New Brunswick, and the Adirondacks of New York (Ray 2000*). Yet in places in the Northeast, such as New Hampshire, Vermont, and Nova Scotia, Marten populations are protected and have remained scarce or even absent, despite reintroduction attempts that have had varied success (Slough 1994; Ray 2000*; Moruzzi et al. 2003). At their distributional edge, such as in Maine, New Hampshire and Vermont, unstable populations are often a result of habitat alteration and fragmentation of forested environments (Gibilisco 1994; Kelly 2005). Monitoring the distribution of Marten in these areas can provide insight into the extent and degree of habitat alteration and fragmentation effects not only for Marten, but for a variety of other forest-dependent wildlife species, as well.

American Marten in New Hampshire were considered "quite common in Colonial times except along the sea coast" (Silver 1957*). Historical records indicate Marten were traded as far south as Bedford (present day Manchester), in Hillsborough County in 1754 (Figure 1). Yet virtually all information concerning the distribution of Marten before extensive land clearing comes from Coos County (Figure 1), where Marten were routinely trapped through the first third of the 20th century (Silver 1957*).

During the early 1900s, New Hampshire's American Marten population declined dramatically, most likely due to the cumulative effects of unregulated trapping, the conversion of forest to farmland, and the rapid deforestation of the landscape due to logging (Silver 1957*). In an attempt to protect the remaining population, the New Hampshire legislature eliminated Marten trapping statewide in 1935 (Silver 1957*).

Marten continued to remain scarce through the 1970s, despite two reintroduction attempts. The first occurred in 1953 when two Marten (one male, one female) from Ontario were released in The Second College Grant in northeast New Hampshire (Silver 1957*; Figure 1). There were no surveys or other attempts to evaluate the success or failure of this reintroduction. Then in 1975 the United States Forest Service (USFS) attempted a second reintroduction. Twenty-nine Marten (20 males, 9 females) were acquired from Piscataquis County, Maine, and released on the west side of the Wild River in Shelburne, New

Hampshire (Figure 1; Soutiere and Coulter 1975*). At this time no Marten were thought to exist along the eastern border of New Hampshire or in the bordering area of Maine (J. Lanier, New Hampshire Fish and Game, personal communication). The result of this reintroduction is also unknown due to the limited amount of follow-up information collected on the released Marten (J. Lanier, personal communication).

Before 1979, reports of Marten sightings or sign were very uncommon in New Hampshire. As a result, American Marten were one of the first species added to the state's newly adopted (1979) State Endangered Species Conservation Act (RSA 212-A). Since the early 1980s, evidence of Marten presence has been observed in towns throughout northern New Hampshire (W. Staats, New Hampshire Fish and Game, personal communication). Moreover, within the last 20 years, based on tracks and sightings, the northeastern border of New Hampshire has been an epicenter of Marten activity. Since the early 1990s, biologists have conducted searches for Marten sign during the winter as time permitted (W. Staats, personal communication). Despite these efforts, Marten population status and distribution in New Hampshire remain poorly understood. As a result, the objective of this study was to identify recent occurrence, distribution, relative abundance, and status of Martens in New Hampshire.

Study Area

Marten occurrence and general distribution were assessed throughout New Hampshire (24217 km^2; Figure 1). Statewide, there are large latitudinal and elevational gradients which provide a wide variety of natural communities, including boreal forest in the north and coastal dunes in the southeast (DeGraaf and Yamasaki 2001). Mount Washington, the tallest peak in New Hampshire and the Northeast at 1915 m, is located near the center of the northern half of the state and is surrounded by numerous other peaks >1000 m (Figure 1).

The overall climate of the northern half of the state, our focal study area, is best characterized by warm, wet summers and cold, snowy winters. The mean annual precipitation is 910-1780 mm and the total annual snowfall ranges from 2440 to 4060 mm; both of which increase locally with elevation (McNab and Avers 1994*). The mean annual temperature varies between 3 and 7°C (McNab and Avers 1994*).

New Hampshire is about 86% forested. Low-lying valleys are covered by deciduous forests consisting of Sugar Maple (*Acer saccharum*), Yellow Birch (*Betula alleghaniensis*), and American Beech (*Fagus grandifolia*), with Eastern Hemlock (*Tsuga canadensis*) scattered throughout. Lower elevation mountain slopes and low lying valleys can also consist of a mix of spruce (*Picea* spp.), fir (*Abies* spp.), maple, beech (*Fagus* spp.), and birch (*Betula* spp.). At higher elevations pure stands of Balsam Fir (*Abies balsamea*) and Red Spruce (*Picea rubens*) are most common. Krummholz, defined as stunted deciduous or coniferous vegetation that occurs just below tree line, is often found at the highest elevations.

Disturbance, specifically logging and the conversion of forest to agricultural land, has dramatically affected the forest composition throughout New Hampshire. Agriculture seems to have had the greatest impact on forested landscapes by changing the cover type and soil structure over a wide range of sites (DeGraaf and Yamasaki 2001). Even today, the forests of New Hampshire show signs of being highly affected by historic and current logging, especially of conifers (McNab and Avers 1994*). This is especially evident in northern New Hampshire, where >90% of the area is forested and the landscape remains in large private ownerships which are actively managed for high timber production.

Methods

Distribution data were collected and compiled into a single database to create a known point-distribution map for Marten in New Hampshire. The five primary sources of data and their selection criteria were:

(1) Recent Marten observational data (1980–2000 – New Hampshire Fish and Game Department occurrence data) were compiled from "screened" (i.e., observations that could not be verified from verbal description were not included) sighting and observation records obtained from the state furbearer biologist.

(2) Current observational data (2000–2004) – observations and track identification locations from state and federal natural resource agencies, as well as unpublished field notes and observations from agency biologists, fur trappers, and foresters, and information received from screened observations from the public. Since 2000, a special effort has been made to encourage reports of Martens in New Hampshire to be recorded and passed on to the New Hampshire Fish and Game Department. Occurrence records such as track identification were only included if the tracking ability of the observer had been assessed and the ability to identify Marten tracks had been confirmed by a biologist or conservation officer, or sufficient evidence of Marten sign was presented.

(3) Recent and current incidental captures by fur trappers during the trapping season – Information was collected from post-capture trapper interviews, including the set type used when a Marten was incidentally captured, any evidence of ear tags, and the exact location of kill or capture.

(4) Recent and current road kills – collected from Marten recovered by New Hampshire Fish and Game staff, and

(5) Live-trapping data – collected during summer 2003 and 2004 throughout the Connecticut Lakes and Mahoosuc-Rangeley ecological subsections (Figure 2), as defined by Keys et al. (1995*). Live-traps were placed

on a home-range-sized grid (Raphael 1994: Gese 2001) over a reclassified cover type map that had been stratified to sample deciduous, coniferous, and mixed deciduous coniferous cover types equally (Kelly 2005). To maximize the number of cells that could be sampled, traps were all placed along roads that were within randomly selected cells. Specific trapping locations were selected based on natural topographic features such as elevation gradients and proximity to water. Two traps were placed at each sampling location to maximize the opportunity of capturing a Marten. The protocol for capturing and marking Martens was reviewed and approved by the University of Massachusetts at Amherst Institutional Animal Care and Use Committee (Protocol #24-02-02).

From the collected occurrence data and live-trapping captures, a known point-distribution database was then created in Microsoft Access (Microsoft Inc., Seattle, Washington). The majority of records for this study occurred in the three most northern subsections within the White Mountain Ecological Section: Connecticut Lakes, Mahoosuc-Rangeley, and White Mountain (Keys et al. 1995*; Figure 2). All records were mapped as latitude, longitude points to the nearest second. The majority of the recent points (before 2000), were derived from hand drawn maps, with ≤152–m accuracy. Current points (collected after 2000) were mapped at much finer resolutions (≥12–m accuracy).

Recorded historical Marten captures and occurrences that could not be verified, or did not have specific locations identified, were excluded from the database. Therefore, the results presented herein are a sample (>85%) of identified records and should not be considered an inventory of all Marten records statewide.

Population structure variables were recorded for each ecological subsection where Marten were documented; these include age (juveniles and subadults/adults) and sex ratios, and evidence of breeding indicating local resident populations (Strickland et al. 1982). Tooth sectioning and aging from cementum annuli were conducted commercially (Matson's Lab, Milltown, Montana). Age categories included juveniles (<1 years old), non-breeding sub-adults (1–2 years old), and adults (>2 years old).

Catch per Unit Effort (CPUE) was calculated as the number of individuals per 100 trap-nights, a trap-night being equal to one trap set for 1 night, assuming that each trap night was an independent event (i.e., 10 trap-nights = 10 traps set for 1 night = 1 trap set for 10 nights). Traps that were closed during the night or were occupied by non-target species were counted as 0.5 trap nights. To assess CPUE, a constant effort model was used to estimate population abundance (Lancia et al. 1996).

Results

The distribution information collected from 1980–2004 resulted in about 180 records, of which 157 (87%)

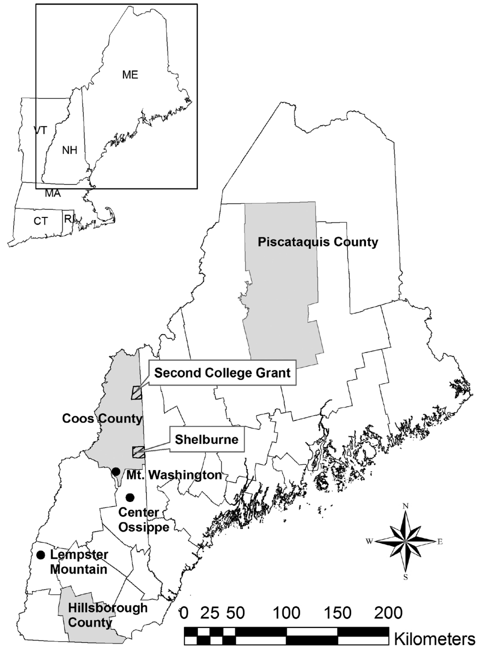

FIGURE 1. Location of various sites in Maine and New Hampshire identified in the text.

were considered reliable documentation of Marten occurrence in New Hampshire (Figure 2). These included 22 visual observations, 57 records of snow tracks, 2 roadkills, 37 trapper captures, 37 live-captures, and 2 miscellaneous reports. The Connecticut Lakes ecological subsection contained 57% of the collected records whereas the Mahoosuc-Rangeley and White Mountains ecological subsections contained 27% and 16%, respectively. Furthermore, 10% of the occurrence records were made before 1999, whereas 90% were documented after 2000.

Total live-trapping effort for Marten in the Connecticut Lakes and Mahoosuc-Rangeley subsection was 4095 trap nights. In the Connecticut Lakes subsection 86 individual locations were sampled using 172 traps whereas in the Mahoosuc-Rangeley subsection 91 individual locations were sampled using 182 traps. Catch per unit effort (captures/100 trap-nights) for live-trapped Marten in the Connecticut Lakes and Mahoosuc-Rangeley subsections was 2.03 (34 captures) and 0.14 (3 captures), respectively, and 1.05 overall.

Of the 76 killed or live-captured Marten noted above, we could assess age for 47. Most of these (41) were males, including 10 juveniles (<1.0 yr), 13 subadults, and 24 adults (≥2.5 yr). Of the six aged, female Martens, three were juveniles (all captured in the Connecticut Lakes ecological subsection), and three were adults (≥2.5 yr), two of which were live-trapped in the

Connecticut Lakes subsection and were confirmed to be breeding according to age, and the presence of enlarged or crusted teats, or expressed milk (Fuller and Harrison 2005).

Discussion

Although anecdotal reports from as far south as Center Ossipe and Lempster Mountain in Sullivan County (Figure 1) could not be confirmed due to the lack of verifiable information, our occurrence data suggest important temporal and spatial trends in Marten occurrence in New Hampshire. First, many more incidental reports (not our systematic live-trapping) were reported during the 5 years of 2000-2004 (n = 105) than in the previous 20 years (n = 15); this could suggest that the Marten population is expanding numerically, but as noted above, a special effort was made to encourage reports of Martens in New Hampshire after 2000. Second, the distribution of Martens is likely uneven, with more occurring in the Connecticut Lakes (CL) region than in the Mahoosuc-Rangeley (MR), as indicated by our systematic live-trapping/CPUE (>14 times more in CL than MR), and from observational or incidental trapper capture records (n = 56 for CL vs. 25 for MR). We recognize that the documentation of Marten distribution based solely on the results of observations (i.e., reports from the public or directed searches) could be biased, but they do match the trend in results of our systematic live-trapping/CPUE surveys. In addition, we note that many occurrences were also documented in the White Mountains subsection where we did not live-trap due to time and access constraints, but where it seems likely that Marten occur in some numbers (39 records).

In most of the past half century, Marten in New Hampshire were considered scarce, if not extirpated, despite a ban on trapping in 1953 and several reintroduction attempts. Potential factors leading to the slow recolonization of New Hampshire by Marten, and their rapid increase recently, include (1) depressed initial population size and limited source populations, (2) delays in forest maturation, (3) changes in carnivore communities, and (4) climate change (cf. Carroll 2007).

Sixty years ago, Marten populations in states adjacent to New Hampshire also were low. By 1941 Marten in Maine were considered extremely rare and were restricted to the northern and northwestern areas of the state (Aldous and Mendall 1941*). Yet, over time and with a state-sponsored Marten-transplant program in the early 1980s (W. Jakubas, Maine Division of Inland Fisheries and Wildlife, personal communication) Marten in Maine increased in number throughout the mid-1900s and expanded into western and eastern Maine (Silver 1957*). In 1985, the Marten population in western Maine (bordering New Hampshire) may have numbered 624, or 6.1/100 km^2 (W. Jakubas, personal communication), and likely served as the primary source for recolonization of northern New Hampshire. Marten populations to the north of New Hampshire in Canada (Figure 1) are also considered moderate to low (H. Jolicoeur, Quebec Ministry of Natural Resources, personal communication), and an abundance of adjacent agricultural land likely limits Marten dispersal to northern New Hampshire.

Forest fragmentation and change in composition may affect Marten population viability (Carroll 2007), and during the late 1800s and early 1900s timber harvesting concentrating on softwood for pulp was extensive in New Hampshire. Extensive salvage harvesting of deciduous and coniferous stands also resulted from the hurricanes of 1938 and 1950, as well as the spruce budworm outbreak of 1973. As a result, historic coniferous stands regenerated to deciduous cover due to the lack of established coniferous regeneration. Coniferous and mixed wood cover can be very important to Marten in eastern North America, especially during winter months (Raine 1983; Buskirk et al. 1988; Fuller and Harrison 2005; Gosse et al. 2005), and in combination with low numbers, Marten population expansion may have stalled. Over the past 40 years, however, large blocks of forest have been conserved and are being managed to better provide for a variety of wildlife species including Marten.

Another potential factor contributing to the slow recolonization of New Hampshire by Marten would be an overall change in the carnivore communities. Fishers (*Martes pennanti*) have been identified as a potential limiting factor for Marten (Krohn et al. 1995; Kelly 2005). As Fisher populations in New England have expanded into highly disturbed (developed) habitats (Ray 2000*), there may be competition limiting further Marten dispersal and colonization.

Lastly, 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 (Kelly 2005). Marten have specific morphologic features such as relatively large feet compared to their overall body size and weight (Raine 1983), which gives them an advantage in areas with deep snow. It is suspected that Fisher populations may be more limited than Marten in areas with deep snow, because they are less adapted to such conditions (Krohn et al. 1995). Changes in snow depth and distribution over the past 100 years have been well documented in New Hampshire and may inflence Marten distribution (Carroll 2007).

The limited data we collected on Marten reproduction and age structure suggest that population recovery is occurring, albeit perhaps somewhat slowly. Reproductively active females and occurrence of juvenile animals indicate successful reproduction (Strickland and Douglas 1987; Buskirk and Ruggiero 1994; Powell et al. 2003), and a good number of sub-adults suggests that juveniles are surviving and/or immigration and dispersal from adjacent populations (Thompson 1994) are occurring, as well. Male Marten and other

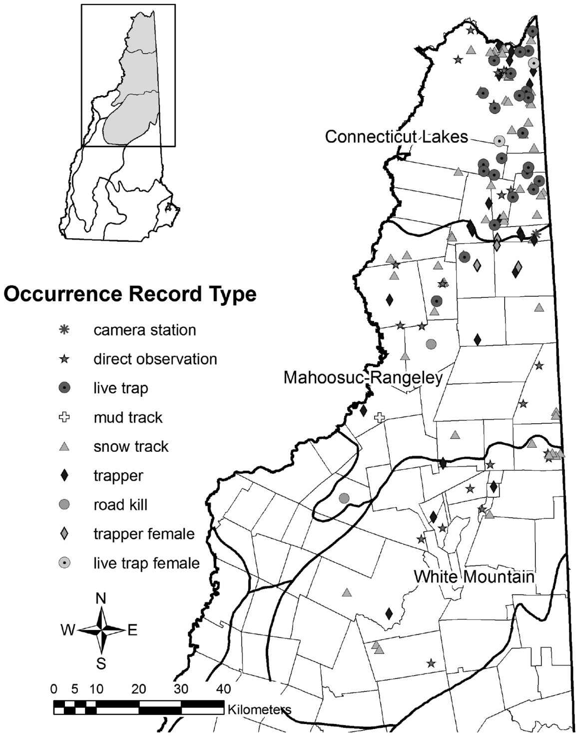

FIGURE 2. Overall distribution of confirmed marten observation/occurrence records relative to ecological subsections (Keys et al. 1995*) in New Hampshire (1980-2004).

mustelids are, in general, more easily trapped than are females (Martens – 52-62% males; Buskirk and Lindstedt 1989), but the lopsided proportions we found (87% of 47) are difficult to interpret because sex ratios of unharvested Marten populations are difficult to determine, especially when only a small sample of the total population is available (Powell 1994).

Although Marten recovery cannot be confirmed based solely on our findings, a better understanding of distribution allows managers to identify goals and objectives to further Marten recovery in New Hampshire. Consideration of historical and current land use practices will be extremely important as land use values change throughout the primary distribution of Marten in New Hampshire.

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