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Resting and Denning Sites of American Martens in Northeastern Oregon

Abstract

Resting and denning sites of the American marten (*Martes americana*) are important habitat components because they provide protection from predators, inclement weather, and thermal stress. Resting sites (n = 1184) used by 35 radiocollared martens were in trees with natural platforms (43%), in trees with cavities (23%), subnivean (under snow) (23%), in hollow logs or slash piles (7%), and underground (3%). Thirty natal and post-natal dens were in trees with cavities (40%), in hollow logs (37%), underground (17%), and in slash piles (6%). Resting and denning sites in cavities and hollow logs were typically large-diameter structures with extensive heartwood decay that had created hollow chambers. The majority of platforms used as resting sites were formed by broom rust (*Chrysomyxa arctostaphyli* and *Melampsorella caryophyllacearum*) and dwarf mistletoe (*Arceuthobium* spp.). Incorporating habitat needs of martens in forest management practices by retaining coarse woody debris and trees with brooms is one component necessary for maintaining viable populations of the species.

Introduction

Resting and denning sites are key attributes of American marten (*Martes americana*) habitat that contribute to meeting behavioral and physiological requirements of the species. Martens are highly selective of their microenvironments for thermal cover, protection from predators and inclement weather (Buskirk et al. 1989, Raphael and Jones 1997), and access to subnivean foraging sites (Buskirk and Ruggiero 1994). The thermal relationship of the marten to its environment is a tenuous one, particularly in winter. Because the energetic cost of foraging and resting above the snow surface is high, martens exhibit patterns of habitat selection that are keyed to weather variables (Buskirk et al. 1987). Selection of denning and resting sites may differ in different forest environments (Raphael and Jones 1997) in response to variability in predators, prey, climate, and availability of habitats. The overall objective of the study was to determine the habitat structures that are important to martens so managers can provide appropriate habitat. In this paper we describe the resting and denning sites of the American marten in northeastern Oregon, which has not been previously investigated.

Study Area

The study area encompassed about 400 km^2 in the Blue Mountains in northeastern Oregon. A portion of the study area contained about 53 km^2 of predominantly unmanaged continuous forest, while the surrounding portion was extensively fragmented by timber harvesting and roaded. The landscape was a mosaic of stands in four forest types (Johnson and Hall 1990): lodgepole pine (*Pinus contorta*), subalpine fir (*Abies lasiocarpa*), grand fir (*Abies grandis*), and Douglas-fir (*Pseudotsuga menziesii*). Topography of the study area consisted of moderately steep mountains dissected by drainages. Permanent water in the form of springs and streams was abundant. The elevation ranged from 1320 to 1980 m.

Daytime maxima in summer normally exceeded 24°C, and winter low temperatures were typically below freezing, with extremes of -15°C being common. Annual precipitation averaged 78 cm with about 60% falling as snow depending on the elevation. At the highest elevation, snow was present from November through April each year with maximum depths of 1.5 m. At the lowest elevation, snow was present from December until March, with maximum depths of 0.5 m.

Carnivores that commonly occurred in the study area and were known to prey on martens included coyotes (*Canis latrans*) and bobcats (*Lynx rufus*) (Bull, unpublished data). No evidence of fishers (*Martes pennanti*) was found, and mountain lions (*Felis concolor*) were uncommon. Potential raptorial predators of martens in the study area included the northern goshawk (*Accipiter gentilis*) and great horned owl (*Bubo virginianus*).

Methods

The study began in December 1993 and ended in October 1997. Martens were captured in cage-type steel live traps (model 205, Tomahawk Live-Trap Co., Tomahawk, Wisconsin) with attached plywood boxes. During the winter, we used snowmobiles to check traps daily. Captured martens were immobilized (Bull et al. 1996) and fitted with a radiocollar (Holohil Inc., Ontario, Canada). Transmitters on females and males weighed 28 g (4% of average body weight) and 35 g (3% of average body weight), respectively.

Radiocollared martens were located on the ground visually, an average of once a week in the winter and twice a week in the summer. The marten or the specific structure (such as tree, log, or underground site) that the marten was using was located to obtain microhabitat data. Characteristics of the transmitter signal were used to determine if the marten was resting or traveling (Raphael and Jones 1997). We believe our presence did not influence behavior of martens in rest sites, because they rarely left a rest site when we approached. If the marten was moving, we followed it until we thought we were within 100 m of the animal, based on the strength of its signal (i.e., the number of MHz above the marten's radio frequency). Based on sightings of traveling martens, we determined we were within 100 m of a marten if we could detect the signal 0.020 MHz above the actual transmitter frequency. For each marten, we recorded date, time, activity, behavior, snow depth, if the marten was actually seen, and characteristics of the rest site.

If a marten was in a rest site, it was classified as a cavity in a tree, a natural platform or branch in a tree, underground, subnivean, slash pile, or a hollow chamber in a log. Each site was assigned an individual number, and subsequent uses by the same marten were classified as re-use. If the rest site was in a standing tree, the species, dbh, height, condition, canopy depth (percentage of the bole that contained live or dead branches), and type of platform or cavity were recorded. Tree condition was classified as living or dead. If the rest site was in a hollow chamber in a log, species, large-end diameter, and length were recorded. If the rest site was in a slash pile, the length, width, and height of the pile were recorded, in addition to the number of logs in the pile and the average diameter of the logs.

Rest sites in platforms were classified as broom rust, mistletoe broom, lichen nest, branches, or unknown. We climbed to 26 platforms to determine type of platform and measure the size of the platform, size of inner nest, and canopy closure (measured with a densiometer).

To locate dens, we located adult females an average of three times each week from the time of parturition until kits were independent. Definitions of natal and post-natal (i.e., maternal) dens are consistent with those by Ruggiero et al. (1998). Although the presence of offspring was not always confirmed, repeated use of a given site in April and May signified a den. Non-denning animals do not typically re-use sites for long periods (Raphael and Jones 1997). Natal dens (supposed parturition sites) were dens where females were first detected and were repeatedly used by an adult female in April or May. Post-natal dens were sites to which females moved the kits after leaving the natal den. Natal dens were more likely to be detected because females were more sedentary here than after kits were moved to post-natal dens. We recorded the same characteristics for natal and post-natal dens as rest sites.

Marten behavior (resting versus traveling) and use of rest sites were compared by month using chi-square analyses. The relationship between snow depth and behavior and between snow depth and use of rest sites was determined by using an analysis of variance and a protected least significant differences test (Snedecor and Cochran 1980).

Results

Rest Sites

Thirty-five martens were located a total of 2353 times between December 1993 and October 1997. Martens were in rest sites at 66% of the locations and traveling at 34%; martens were located only during daylight hours. There was a significant difference in diurnal behavior by month (X^2 = 347.14, 11 df, $P = 0.01$) (Figure 1) and by snow depth (LSD = 4.35, $P < 0.05$). Most of the martens were in rest sites during winter when snow was on the ground, but most of the martens were traveling during summer.

Of 1184 locations at rest sites, 43% were in trees with platforms, 23% in trees with cavities, 23% subnivean, 7% in hollow logs or slash piles, and 3% underground (Table 1). Twenty percent

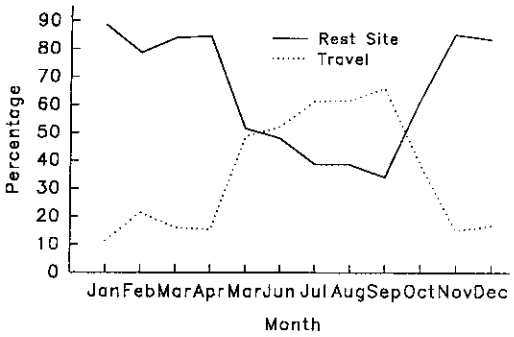

Figure 1. Percentage of martens located during daylight hours that were in rest sites and those traveling by month in northeastern Oregon, 1993-97.

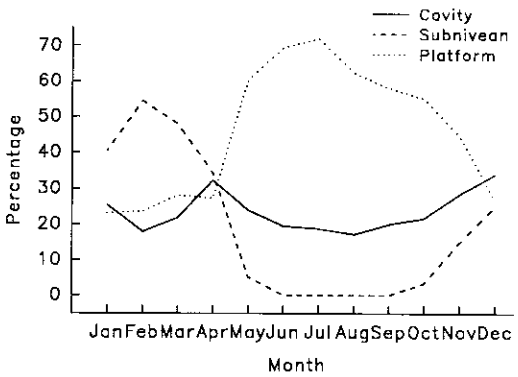

Figure 2. Marten use of three types of rest sites by month in northeastern Oregon, 1993-97.

TABLE 1. Structures (%) used as resting and denning sites by American martens in northeastern Oregon, 1993-97.

	Resting Sites	Natal Dens	Post-Natal Dens
Platforms	43		
Cavities	23	73	21
Subnivean	23		
Hollow log	6		58
Underground	3	27	10
Slash piles	1		10
Sample size	1184	11	19

TABLE 2. Tree species (%) and tree characteristic means (SD) of three types of resting sites used by American martens in northeastern Oregon, 1993-97.

Characteristic	Platforms	Cavities	Hollow Logs
Tree species			
Grand fir	11	58	58
Western larch	10	32	17
Engelmann spruce	43	5	7
Subalpine fir	25	3	8
Douglas-fir	9	1	3
Lodgepole pine	1		
Ponderosa pine	1	1	7
Tree dbh (cm)	51.7 (20.94)	78.9 (21.22)	66.1 (18.38)
Tree height (m)	26.4 (7.85)	21.2 (9.85)	19.7 (10.68)
Marten height (m)	12.6 (5.99)	11.2 (6.74)	
Canopy depth (%)	89.1 (18.62)	52.4 (39.63)	
Sample size	517	271	67

of the rest sites were used more than once, and not always by the same individual. We saw the marten in 24% of the rest sites, so we are confident we identified the correct sites. A significant difference was found between type of rest site used and month (X^2 = 428.74, 55 df, $P < 0.01$) (Figure 2) and between rest site use and snow depth (LSD = 14.35, $P < 0.05$). Subnivean sites were different from all other types of rest sites because they had the deepest snow ($\bar{x}$ = 101 cm), as one would expect.

Trees with platforms were the dominant rest sites from May until October (Figure 2). We saw platforms in 84% of the trees used by martens; the marten was on a branch in 6%; and a platform was impossible to detect because of dense branches in 9%, but we assumed a platform was present in these trees. The misshapen branches (witches' brooms) used by martens were caused by rust fungi or dwarf mistletoes. In Engelmann spruce (*Picea engelmanni*) and the true firs where 79% of the platforms occurred, broom rust created the platforms (*Chrysomyxa arctostaphyli* in spruce and *Melampsorella caryophyllacearum* in subalpine fir). Dwarf mistletoe (*Arceuthobium* spp.) caused the brooms in western larch (*Larix occidentalis*), Douglas-fir, lodgepole pine, and ponderosa pine (*Pinus ponderosa*) where 21% of the platforms occurred. Most of the trees (92%) were living, and the average dbh was 52 cm (Table 2). Trees typically had branches along the entire length of the bole.

Of 26 trees that we climbed which contained platforms used by martens, 50% were platforms caused by broom rust, 19% were caused by dwarf mistletoe, 19% were constructed nests made of lichen (*Bryoria* spp.), and 12% were in a tree fork or on a group of branches. Twenty of the 26

platforms had 100% canopy closure over the platforms, thus providing the martens with dense cover and protection from weather and avian predators. Ninety-two percent of the platforms contained a smaller nest where the marten appeared to spend time; 85% of these nests had been constructed, presumably by squirrels or martens. Of the 24 platforms with nests, lichens were the dominant component at 75% of the platforms, grass at 8%, sticks at 8%, and needles at 8%. Lichen nests averaged 24 cm long, 22 cm wide, and 15 cm deep and were constructed on one or several branches.

Of the 13 platforms formed by broom rust, all were in Engelmann spruce except one in a subalpine fir. Outside broom dimensions averaged 57 cm long, 67 cm wide, and 78 cm deep. All brooms consisted of branches <1 cm in diameter, and many formed a dense structure used as a rest site.

Mistletoe formed five brooms used by martens, three of which were in western larch and two in Douglas-fir. These brooms tended to be flatter on top than brooms formed by broom rust. Outside broom dimensions averaged 54 cm long, 61 cm wide, and 37 cm deep.

Trees with cavities were used as rest sites all year, although April and December had the greatest use (Figure 2). The majority of cavities were in grand fir and western larch (Table 2). Sixty-seven percent of the trees were dead, and the rest living. Most of the trees with cavities used by martens were hollow, based on the presence of fruiting bodies of Indian paint fungus (*Echinodontium tinctorium*) on grand fir, and of brown trunk rot (*Fomitopsis officinalis*) and red ring rot (*Phellinus pini*) on western larch. Martens entered these hollow trees through broken tops, holes excavated by pileated woodpeckers (*Dryocopus pileatus*), or through natural cavities usually created when a branch broke off. Cavities occurred in large-diameter trees, although not necessarily tall (Table 2) because an average of 30% of the bole was broken off.

During the winter martens spent most of their time in subnivean rest sites (Figure 2), in the open spaces created when horizontal structures (usually logs) kept the snow off the ground. Some of the subnivean sites had extensive systems of tunnels under logs where the martens could travel for >30 m, based on observations at these sites when the snow was melting. The martens presumably both hunted and rested under the snow. Use of these sites tapered off in late winter or early spring even though snow remained.

We revisited 93 subnivean rest sites after the snow had melted and found an accumulation of logs (42%), a hollow log (20%), a single large log (>60 cm in diameter) (16%), an underground site (13%), or a slash pile of logs (9%). Most of the underground sites were accessed through tunnels 5-15 cm in diameter in the soil. At least 75% of the subnivean rest sites had evidence of red squirrel (*Tamiasciurus hudsonicus*) middens with either tracks or cone scales.

During the snow-free months, hollow logs comprised 6% of the rest sites, but 20% of the revisited subnivean rest sites were also hollow logs. The majority of hollow logs were grand fir and western larch (Table 2), no doubt because of the heartwood decay responsible for the hollow chambers.

Slash piles left from harvesting or road building comprised 1% of the snow-free rest sites, and 9% of the subnivean rest sites. The mean dimensions of the piles were 12 m long, 7 m wide, and 3 m high. The mean number of logs in the piles was 62, with an average diameter of 28 cm.

Thirty-eight rest sites were underground: 53% were in tunnels, 37% in rocks, and 10% in root wads. The underground tunnels appeared to have been excavated. The rest sites in rocks were in talus, boulder fields, or isolated clusters of rocks.

Dens

Eleven natal and 19 post-natal dens were located for 8 females (11 female-years) during 1994-97. Natal dens were either in a cavity or underground, while post-natal dens also included hollow logs and slash piles (Table 1). The trees with cavities used as dens were grand fir (84%), western larch (8%), and subalpine fir (8%); a third of these trees were alive. We believe all of these cavities consisted of hollow chambers because a woodpecker cavity would not be large enough to contain the kits. The dens in grand fir and western larch were entered through pileated woodpecker holes or broken off tops. The den in the subalpine fir was entered through a natural cavity in the base of the dead tree and appeared to go underground. The trees averaged 83 cm dbh and 23 m tall. Most of the trees had branches along the majority of the bole.

Hollow logs used for dens were grand fir (55%), western larch (27%), Engelmann spruce (9%), and subalpine fir (9%). The logs averaged 73 cm in diameter at the large end and 24 m long. All the logs had hollow chambers, and the five that could be measured were 20-25 cm in diameter inside. Two slash piles served as post-natal dens. One pile of five logs was on the edge of a closed road and was 10 m long, 2 m wide, and 1 m high. The second pile contained more than 200 logs and was 16 m long, 10 m wide, and 6 m high.

Five of the dens were underground. One natal den was in an underground system of rock fissures that extended more than 7 m underground into a complex structure of cracks and fissures. Another den was in a boulder field. Root wads served as the entrance to two dens, and squirrel middens appeared to be the entrance hole to another den.

Discussion

The reduced diurnal activity of martens in winter that we observed has been observed by other researchers as well (Buskirk (1983), Drew and Bissonette (1997), and Zielinski et al. (1983). This reduced activity could be a behavioral strategy to reduce their vulnerability to predation due to their increased visibility with snow contrasting against their dark pelage. Thermal stress is most significant in winter, and the dietary shift we observed to larger prey items (Bull, unpublished data) could have resulted in the martens' spending less time foraging or synchronizing their periods of activity with that of their prey.

Obvious patterns of resting site use emerged over the course of the study. As soon as deep snow accumulated, martens rested in subnivean spaces formed by coarse woody debris. Use of subnivean resting sites has been well documented in other areas (Sherburne and Bissonette 1994, Buskirk and Ruggiero 1994, Buskirk and Powell 1994, Chapin et al. 1997). These subnivean sites provided good thermal regulation because the ground was often not frozen under these sites (based on excavations at several sites); whereas, the ambient air temperature could be as cold as -15°C. In addition, most subnivean sites were inaccessible to predators, and many were occupied by red squirrels at their middens; red squirrels were a prey item in the winter in our area. The access to many of these resting sites were tunnels through the snow which appeared to have been made by the squirrels. This association between martens and squirrel middens has also been reported by Buskirk (1983), Sherburne (1992), and Sherburne and Bissonette (1994). Use of subnivean sites tapered off in April before snow disappeared, which suggested that melting snow may have saturated the ground making these sites undesirable.

Cavity use peaked in April and from November to December. During these time periods the weather was cold with frequent precipitation, making use of platforms undesirable. Snow accumulations were often not sufficient by December to form subnivean resting sites, and the ground was likely saturated in April. Cavities provided dry, insulated sites that were inaccessible to their predators. We believe the majority of cavities used in our study area were hollow chambers based on a previous study in which 60 trees with similar characteristics were climbed; 95% were found to be hollow (Bull et al. 1992). Typically, only large-diameter trees contain a hollow chamber large enough for a marten to use because the chamber forms only when the former heartwood has decayed and slumped downward (Bull et al. 1997). The high use of living trees occurred because hollow chambers caused by heartrot fungi are created while the tree is still alive (Bull et al. 1997). This decay process can take decades to develop, and trees may be several hundred years old. Typically, these hollow trees occur in forest stands of grand fir in late-successional stages, which now occupy only about 3% of the landscape in northeastern Oregon (Bull et al. 1997). The use of cavities in large-diameter trees that we observed has been reported by Steventon and Major (1982), Spencer (1987), Martin and Barrett (1991), Buskirk and Ruggiero (1994), and Raphael and Jones (1997); however, these studies did not specify if the resting sites were vacated woodpecker cavities or hollow chambers.

Our study was unique in observing a dominant use of platforms as resting sites during the summer. Only Campbell (1979) and Buskirk et al. (1987) reported use of witches' brooms by martens, although other studies (Martin and Barrett 1991, Raphael and Jones 1997) reported use of live trees which may have contained brooms not visible to observers. The brooms formed by broom rust in spruce and firs in our study presented dense spheres of branches that would be impenetrable

to predators. Brooms also are readily used by squirrels as resting sites (Parks et al. 1999), so they may have provided martens with a source of prey as well as a secure resting site.

Dens differed from rest sites in being more secure. Natal dens were in structures (hollow trees and underground) that were dry, insulated, and inaccessible to any predator other than another marten. Post-natal dens were less secure than natal dens, presumably to accommodate for movement of kits; nevertheless, the majority were still inaccessible to most mammalian predators. In one situation a bear had ripped open a portion of a log that contained kits. The common feature we observed among natal and post-natal dens was the large diameter of the structure. Buskirk and Ruggiero (1994) reviewed 14 studies and provided a summary of den structures: 70% of dens were in trees, logs, and rocks, and the dens in trees were always in large structures associated with late-successional forests. Ruggiero et al. (1998) described 18 natal dens and 97 post-natal dens in Wyoming. Large-diameter trees were a critical feature in dens in Washington and Oregon (Raphael and Jones 1997).

The findings in our study can be used by managers to retain the appropriate structures to provide martens with rest sites and dens. Large-diameter hollow trees and logs, accumulations of coarse woody debris, and trees with brooms provided important habitat for resting sites. The silvicultural practices of removing trees with brooms, removing hollow trees, and reducing fuels (coarse woody debris) to lower the risk of or damage by wildfire may negatively alter marten habitat. Incorporating the habitat needs of martens into forest management plans can ensure the maintenance of viable populations across landscapes.

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