SURVIVAL, CAUSES OF MORTALITY, AND REPRODUCTION IN THE AMERICAN MARTEN IN NORTHEASTERN OREGON

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ABSTRACT—Survival rates, causes of mortality, and reproduction in the American marten (*Martes americana*) were determined in northeastern Oregon from 1994 until 1997 with radio-collared martens. The probability of survival of martens ≥9 mo old was 0.55 for 1 yr, 0.37 for 2 yr, 0.22 for 3 yr, and 0.15 for 4 yr. The mean annual probability of survival was 0.63 for 4 yr. Twenty-two of 35 radiocollared martens died. Of the 18 martens killed by predators, 8 were killed by bobcats (*Lynx rufus*), 4 by raptors, 4 by martens, and 2 by coyotes (*Canis latrans*), based on necropsies and circumstantial evidence at kills. Three martens died of exposure and 1 of collar entrapment. Of 13 reproductive efforts, 4 females weaned ≥1 kit, 8 efforts failed, and the outcome of 1 was unknown. Predation of adult females prior to weaning was the source of reproductive failure for some efforts.

Key words: American marten, *Martes americana*, survival, mortality, northeastern Oregon, reproduction

Understanding the demography of populations of the American marten (*Martes americana*) provides the opportunity to evaluate the effects of habitat alteration on the species. Habitat alteration, primarily by logging of late-successional conifer forests, has been listed as the primary cause of the population decline in areas where martens have become extinct or are currently threatened (Yeager 1950; Archibald and Jessup1984; Thompson and Harestad 1994). In the western United States, reduced distribution or abundance of the marten has been reported in northern coastal California (Gibilisco 1994) and in the Coast Range in Oregon (Marshall 1996) due to logging. Logging of late-successional conifer forests removes coarse woody debris and large-diameter structures used as rest and den sites, cover from predators, and foraging areas considered essential throughout many parts of their range (Bull and others 1997).

Abundance and population parameters of the American marten are unknown in the Blue Mountains in northeastern Oregon. The National Forest Management Act of 1976 mandates that viable populations of all vertebrate species be maintained on federal land (USDA 1978). Knowledge of survival rates, mortality, and reproduction is necessary to effectively manage marten populations. Our objective was to determine survival, causes of mortality, and reproduction in American martens in our study area.

METHODS

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 unharvested continuous forest, while the surrounding portion was extensively harvested for timber (approximately 80%) and was fragmented by partial cuts, regeneration cuts, and roads. The landscape was a mosaic of stands in 4 forest types (Johnson and Hall 1990): lodgepole pine (*Pinus contorta*), grand fir (*Abies grandis*), subalpine fir (*A. lasiocarpa*), and Douglas-fir (*Pseudotsuga menziesii*). Permanent water in the form of springs and streams was abundant. Topography of the study area consisted of moderately steep mountains dissected by drainages. 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 elevations, snow was present from November through April each year with maximum depths of 1.5 m; at the lowest elevations, snow was present from December until March, with maximum depths of 0.5 m.

Based on winter tracks we observed, carnivores other than martens varied in abundance in the study area. Long-tailed weasels (*Mustela frenata*), ermine (*M. erminea*), coyotes (*Canis latrans*), and bobcats (*Lynx rufus*) were common throughout the study area. Mountain lions (*Felis concolor*) were present but uncommon. We found no evidence of fishers (*Martes pennanti*) or red foxes (*Vulpes vulpes*) based on our snow-tracking observations.

Although commercial trapping had been permitted throughout the area before the study, only 28 martens had been trapped in all of Union County between 1983 and 1993. Commercial trapping was prohibited in the study area during our investigation, so we considered the population we investigated unharvested.

Martens were captured in cage-type live traps with attached plywood boxes for shelter from December to March and during September 1993 to 1997. During December to March about 40 to 50 traps were set for 5 days each week and checked daily. In September we trapped in suspected female home ranges. Captured martens were immobilized (Bull and others 1996), aged, and fitted with radiocollars (Holohil Inc., Carp, ON, Canada). Radiocollars for females weighed 28 g (4% of average body weight), while radiocollars for males weighed 35 g (3% of average body weight). Radiocollars transmitted for at least 18 mo. All surviving martens, except 2 (1 transmitter failed, and 1 marten was never relocated), were recollared each year for the duration of the study. Age was determined by analysis of cementum annuli on the teeth of martens recovered after death (Poole and others 1994). For individuals without a known age (as estimated by cementum annuli analysis), juveniles and adults were distinguished based on degree of tooth wear at capture (Strickland and others 1982).

To monitor survival, radiocollared martens were located and visually observed an average of once per week in winter and twice per week in summer. If a marten remained in the same rest site for >4 to 6 consecutive visits (except females with kits), we attempted to determine if there had been a mortality by accessing the rest site by climbing trees or excavating under snow. The date of death was determined to be the last time the marten moved.

We compared the number of days martens were alive with a functioning transmitter and when mortality occurred among males, females, adults, and juveniles. We did not include martens that had lost or failed transmitters (as determined from repeated observations of a radiocollared marten without detecting a signal), had died unnatural deaths, or had unknown fates. We classified unnatural deaths as those likely associated with being captured; we believe 1 marten succumbed to hypothermia due to exposure during entrapment. In our survival analysis, juvenile survival was based on the number of days a marten was monitored when ≤16 mo, whereas adult survival was based on the number of days monitored when a marten was >16 mo. Although 12 mo has been used to distinguish juveniles from adults in studies in the northeastern United States (Hodgman and others 1997), we selected 16 mo because all 6 dispersing juveniles that we monitored dispersed until between June and August (14 to16 mo of age) and did not exhibit adult behavior in relation to home range use until 14 to 16 mo.

Survival estimates were calculated at 2-mo intervals for the radiocollared martens, using the Kaplan-Meier method, with modifications for recruitment (Pollock and others 1989), for the duration of the study and for each year of the study. Sample size limited survival estimates to all martens, without separating them by sex or age.

Cause of mortality was determined by inspecting circumstantial evidence found at the mortality site (tracks, fur, feathers) and through necropsy. Martens killed by raptors had the skin neatly peeled back and were partially consumed with the meat picked cleanly from the bones; the skeleton was intact. Mammalian predators were identified primarily by the intercanine width of teeth marks in the muscle and secondarily by evidence at sites of predation. Intercanine widths were measured on skulls from northeastern Oregon of each species and determined to be 22 to 27 mm for bobcats, 26 to 28 mm for coyotes, and 10 to 12 mm for martens (Bull and Heater 1995). Martens killed by bobcats were often buried; Rue (1981) and Rolley (1987) reported that bobcats frequently cache or cover larger prey with grass, dirt, sticks, or snow. Martens killed by

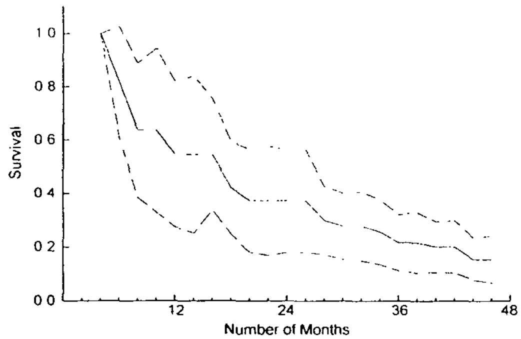

FIGURE 1. Kaplan-Meier survival estimates, calculated at 2-mo intervals, for 35 radiocollared martens ≥9 mo of age in northeastern Oregon, January 1994 to October 1997 (dashed line delimits 95% CI).

TABLE 1. Kaplan-Meier survival estimates on an annual basis, calculated at 2-mo intervals, for 35 radiocollared martens ≥9 mo of age in northeastern Oregon, January 1994 to October 1997. Survival estimate for 1997 includes months from January through October.

Year	No. martens monitored	No. martens killed	Survival estimate	95% CI
1994	14	5	0.5455	0.2731–0.8179
1995	15	4	0.6837	0.4325–0.9349
1996	18	7	0.5803	0.3759–0.7847
1997	14	4	0.7143	0.4777–0.9509
Mean			0.6310	0.3898–0.8721

martens were usually not consumed, but often had broken shoulders, injuries to the head and neck, and recently broken canines (Bull and Heater 1995). All marten bodies attributed to mammalian predators had extensive hemorrhaging, indicating that predators had killed the martens rather than scavenged them.

Reproduction was determined by the repeated use of the same rest site by a female for several weeks in April or May, by the observation of kits, or by evidence of lactation (suckling rings evident) on females captured in September. Survival of kits to weaning was based on their presence with females in August; however, because it is difficult to observe kits, we may have failed to observe some successful reproductive efforts.

RESULTS

During the study we captured 17 adults, 17 juveniles (all captured when ≥9 mo old), and 1 kit (captured when dependent on female), of which 22 were known to have died from predation or exposure, 10 were alive as of 1 October 1997, 1 slipped its collar, 1 transmitter failed, and the fate of 1 was unknown. Of 19 males (adults and juveniles) monitored for a total of 9,341 days, 13 died of natural causes (1 death/719 days). Of 11 females (adults and juveniles) monitored for a total of 4,895 days, 7 died of natural causes (1 death/699 days). Seventeen juveniles were monitored for a total of 2,788 days while they were juveniles, and 6 of them died during that time (1 death/465 days). Twenty-four martens were monitored for 11,448 days during their adult life, and 14 died during that time (1 death/818 days). The similarity in survival between females and males suggests there was little differential mortality between the sexes in this population for the duration of the study. Probability of survival of martens ≥ 9 mo old, for both sexes, was 0.55 for 1 yr, 0.37 for 2 yr, 0.22 for 3 yr, and 0.15 for 4 yr (Fig. 1). Mean annual survival rate was 0.63 (95% CI = 0.39–0.87; Table 1).

Of 22 martens that died, 18 were killed by predators, 3 died from exposure (hypothermia) during the winter, and 1 marten died when the collar caught on a wood splinter inside a hollow tree. Eight martens were killed by bobcats, 4 by raptors, 4 by martens, and 2 by coyotes. No predation occurred between December and February, and the majority (67%) of predation occurred between May and August.

Bobcats killed 4 males and 4 females including 1 juvenile of each sex. Radiocollared martens were killed by bobcats between April and November. Four of the 8 martens killed by bobcats were buried, and the other 4 were partially consumed. Coyotes killed 2 adult martens, 1 in April and 1 in August. Most of 1 marten and about 1/4 of the other were consumed by coyotes.

Raptors, either northern goshawks (*Accipiter gentilis*) or great horned owls (*Bubo virginianus*), killed 2 males and 2 females, 1 of which was a juvenile female. Raptors killed martens in March, June, July, and August.

Martens killed 4 males, of which 2 were juveniles. Necropsies revealed extensive hemorrhaging on the back of the head, neck, and shoulders in all cases. Three had recently broken canines, and 3 had broken shoulders. Mortality from marten predation occurred in May, June, and July. In 3 of the cases, we knew resident radiocollared males were in the areas where the males were killed.

We observed 2 males fighting in a tree in July; 1 of the males was radiocollared and was 2 to 3 yr old. The males were facing each other on a branch and had their jaws locked together. The uncollared male was thrown off the branch or fell, somersaulting through the branches to the ground. The broken shoulders we found in the dead martens could have resulted from falling or being thrown out of trees. The broken canines could result from using their teeth to fight.

We monitored 13 reproductive efforts: 4 successfully weaned ≥1 kit, 8 efforts failed, and the outcome of 1 was unknown.. Six females had litters 1 yr, 2 females had litters for 2 consecutive years, and 1 female had litters for 3 consecutive years. Six females did not have litters, but they were presumably <2 yr old. Four reproductive efforts were assumed to have failed due to lack of observation of females with kits during August, and 4 were known to have failed because adults died between April and July, prior to kit independence. Reproductive success varied annually: 1 of 2 reproductive efforts was successful in 1994; neither of 2 efforts was successful in 1995; 2 of 4 efforts were successful in 1996; and 1 of 5 efforts was successful (1 unknown) in 1997. Of the 4 successful efforts, 2 kits were seen with 1 female and 1 kit with each of the other females. Two of the females were 2 yr old when they had kits; the other females were older.

Discussion

Few studies have determined survival rates for martens in areas without trapping; no studies have published survival rates from the Pacific Northwest. Hodgman and others (1997) found annual survival rates of 0.87 for adult males and 0.53 for adult females in unharvested populations in Maine. Rates of natural mortality have been estimated at 0.39 for juveniles and 0.28 for adults per year in Quebec (Potvin and Breton 1997). In Newfoundland, 13 of 40 radiocollared martens died during a 19-mo study with mortality concentrated in the fall and late winter (Fredrickson 1990). Encephalitus caused the deaths during the fall, while starvation and predation caused the mortality in late winter in Fredrickson's study. The juveniles we monitored had higher rates of mortality than adults as reported by Potvin and Breton (1997).

Our study is 1 of few studies to document predation of martens by raptors. Although there has been speculation about such predation (Strickland and Douglas 1987), it has rarely been verified. Only Hodgman and others (1997) found 1 case of raptor predation in Maine, Fredrickson (1990) found 1 case in Newfoundland, and Thompson (1994) found 1 marten killed by a great horned owl in Ontario.

No other studies have documented bobcats as the predominant predator of martens. Red foxes preyed on martens in Newfoundland (Fredrickson 1990; Drew and Bissonette 1997) and in Ontario (Thompson 1994). Foxes and coyotes were predators in Wyoming (L. F. Ruggiero, Rocky Mountain Research Station, Missoula, MT; pers. comm.), and coyotes and fishers in Maine (Hodgman and others 1997). Trapping accounted for 90% of the marten mortality in an intensively trapped marten population in Maine (Hodgman and others 1994). Observations in Canada and Maine suggest that other populations have intraspecific predation such as we observed. Strickland and Douglas (1987) reported trappers who found frequent scarring on male marten pelts but none on female pelts. Hodgman and others (1997) found 2 martens killed by other martens.

The lack of predation we observed during the winter was surprising because other studies reported higher mortality in winter in Maine (Hodgman and others 1997) and in Newfoundland (Fredrickson 1990). In Maine, the highest mortality occurred when the deciduous trees lacked leaves and provided less cover. A prey shortage in Newfoundland probably contributed to the poor survival of marten (Fredrickson 1990). The lack of winter predation on martens in our study may have been a result of their reduced activity in the winter, particularly during daylight hours, and their extensive use of rest sites under the snow (Bull and Heater 2000). The reduced activity we observed could have been influenced by thermoregulation and prey availability and vulnerability, as well as risk of predation (Zielinski, in press).

Predation was the major cause of mortality in the population we investigated, and predation of females before weaning kits resulted in low reproductive rates. Additional research is warranted to determine if reproduction exceeds mortality over the long term and if a viable population is being maintained in marten populations in northeastern Oregon.

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