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RH: Ecological Factors Affecting Marten Bailey et al.

ECOLOGICAL FACTORS AFFECTING MARTEN DISTRIBUTION ON THE KENAI PENINSULA, ALASKA

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Abstract: We examined ecological factors affecting current marten (*Martes americana*) distribution on the Kenai National Wildlife Refuge (KNWR), Kenai Peninsula (KP), Alaska from 1986 through 1989. We investigated past and current distribution, spatial requirements, habitat and snow characteristics, winter behavior and habitat use, relative abundance of small mammals, and diet of martens in 1 to 5 study areas within and outside the known distribution of martens on the KNWR. Martens are currently found in the mountainous, eastern region of the KP

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and do not occupy forested, low-elevation habitat on the peninsula's western side. Home range sizes of 6 of 11 radiocollared martens were similar to those reported for 2 interior areas of Alaska. Total and coniferous canopy cover in 4 study areas were similar to, or exceeded, canopy cover requirements reported elsewhere for martens. There was significantly more canopy cover but fewer, shorter, and older snags and downed-logs in the only study area without martens compared to 4 study areas supporting martens. Spruce (Picea glauca) mortality from bark beetles (Dendroctonus rufipennis) were responsible for these observed habitat differences in areas used by martens, but more snags and downed logs may benefit martens. Thermal indices derived from snow data in the KP's western, low-elevation habitat revealed values below those recommended for subnivean thermal stability. In mid-winter, radiocollared martens moved to higher elevations with deeper snow. Small mammal capture success was greater in low elevation habitat unoccupied by martens than in higher elevation habitat occupied by martens. Red-backed voles (Cleithrionomys rutilus) were the most common small mammal and their remains appeared most often in marten scats. Martens consumed large and previously unreported amounts of mountain ash (Sorbus scopulina) berries in autumn and winter. We hypothesize that the distribution of martens on the western lowlands of the KP may be seasonally limited by snow cover. However, some previously occupied high-elevation habitats on the KWNR may again support martens if they are reintroduced.

Key Words: Alaska, ecology, distribution, Kenai Peninsula, marten, Martes americana, snow, telemetry, thermal cover

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The few studies of martens in Alaska have been confined to habitats in the interior which are influenced by a continental climate (Lensink et al. 1955, Buskirk 1983, Magoun and Vernam 1986, Vernam 1987). Martens also occur along the southcentral and southeast Alaskan coast which is dominated by a coastal climate. The coastal climate is characterized by moderate winters and cool summers with high precipitation. The continental climate has colder winters and warmer summers with less precipitation. The Kenai Peninsula (KP) in southcentral Alaska lies in the transition zone between these two climatic regions. Marten distribution on the KP appears presently limited to its mountainous eastern portion. It is unknown why martens do not currently inhabit the western KP lowlands and benchlands within the Kenai National Wildlife Refuge (KNWR).

A purpose of the KNWR is to conserve fish and wildlife populations and habitats in their natural diversity. We investigated ecological relationships of martens on the KP, within the KNWR, to determine 1) why vast areas of forested habitat on the KNWR are not occupied by martens, 2) if suitable unoccupied habitat was present, and 3) if introduction of martens into unoccupied habitat might be successful. Specific objectives of the study were: 1) determine distribution of martens on the KNWR from historical and trapper-provided information and from track surveys in snow conducted during this study and related studies, 2) delineate spatial requirements and seasonal movements of martens by radiotelemetry, 3) ascertain characteristics of known KNWR marten habitat and compare with unoccupied habitat, 4) compare snow cover across the KP and determine its role as thermal cover, 5) assess marten winter behavior and habitat use patterns, 6) sample small mammal populations in areas with and without martens, and 7) determine the diet of martens.

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STUDY AREA

The KP is surrounded by Prince William Sound and the Gulf of Alaska on its east side and the Cook Inlet on its west side. Average annual precipitation at Seward on the east side of the KP is 178 cm and at Soldotna on the western side 46 cm. Average temperatures on the KP are moderated by its proximity to the ocean. Monthly January and July temperatures on the western lowlands at Kenai between 1943 and 1987 averaged -10.9°C and 12.3°C, respectively. Although temperatures can drop to -40°C on the western lowlands, they rarely fall below -18°C along the eastern coast. Annual snowfall and snowpack conditions vary across the KP and with elevation. The nearby ocean moderates conditions at low elevations causing inconsistent, shallow, and crusty snow cover, but snow persists above 200-300 m during winter months, especially close to glaciers.

The KNWR (7,972 km^2) is located on the KP (26,000 km^2). Three major landforms characterize the KP: the western lowlands (sea level to 150 m), the Skilak-Tustumena benchlands (250 to 700 m), and the Kenai Mountains which bound the KNWR on the east, contain a major icefield, and rise to 1600 m. Vegetation in the western lowlands is primarily a mixed forest of paper birch (Betula papyrifera), aspen (Populus tremuloides), willow (Salix spp.), and white (Picea glauca) and black spruce (P. mariana) in various stages of forest succession. One area (125,000 ha) was burned by a wildfire in 1947, another (35,200 ha) was burned in 1969, and the remainder is mature forest over 70 years old. Smaller areas (200-800 ha), primarily within the 1947 burn, have since been modified with prescribed fire or mechanical devices. Vegetation in the Skilak-Tustumena benchlands is dominated by white or black spruce and is over 70 years old except for a 8,100 ha area burned by a wildfire in the late-1800's (Spencer and Hakala 1964). About 64% of approximately 314,000 ha of forest on the KNWR is over 70 years old (T. N. Bailey, Tech. Suppl.: KNWR Comprehensive Conserv. Plan, Environ. Impact Statement and Wilderness Review, Soldotna, AK, 1984). Vegetation in the Kenai Mountains varies with elevation. Valley bottoms and lower slopes support forests of black, white, and Sitka (Picea sitchensis) spruce, hemlock (Tsuga heterophylla and T. mertensiana), paper birch, aspen, and willow. A zone above timberline supports subalpine vegetation dominated by alder (Alnus crispa), willow, or dwarf birch (Betula grandulosa). Above this zone vegetation is characterized by creeping dwarf shrubs (Dryas octopetala, Loiseleuria procumbens, and Arctostaphylos alpina) and lichens (Cladina sp., Thamnolia sp., and Alectoria sp.).

Five marten study areas were located in forest vegetation within the Kenai Mountains landform; 4 south and 1 north of the Kenai River (Fig. 1). Most work occurred between 90 to 730 m in the Surprise Creek Basin study area (SCBSA) on the north slope of Surprise Mountain. A wildfire in 1969 burned the lower portion of the SCBSA approximately between 90 and 300 m. Forest cover above the burn was mature birch and spruce at lower elevations and mature spruce and hemlock at higher elevations. The Pothole Lake study area (PLSA), between 122 and 183 m, was located between the south slope of Surprise Mountain and Skilak Glacier Flats on the east side of Pothole Lake. Topography was rugged with many steep short ridges. Forest cover was a mixture of mature spruce, birch, and hemlock. The Doroshin Bay study area (DBSA), between 90 and 183 m, was located on the southeast side of Surprise Mountain between the shore of Skilak Lake and the mountain slope. This area was characterized by a series of steep, progressively-higher ridges covered with mature spruce and birch on the sides and mature hemlock on the ridge tops. The Cottonwood Creek study area (CCSA), between 90 and 305 m, was centered on Cottonwood Creek on the southeast end of Skilak Lake. It was in a north-facing drainage similar to the SCBSA with mature spruce and birch at lower elevations and mature spruce and hemlock at higher elevations. The Big Indian Creek study area (BICSA), between 122 and 460 m and the only marten study area north of the Kenai River, included 3 separate sites (BI-1, BI-2, BI-3) along drainages near Big Indian Creek on the western slope of the Kenai Mountains. Forest cover at BICSA was similar to the other study sites.

All marten study areas occurred within officially designated or proposed wilderness areas. Wide, swift glacial rivers, large lakes, and a lack of maintained trails or roads restricted human access to all study areas. Forests at the SCBSA, and to a lesser extent, at the PLSA and CCSA had been exposed to, or were undergoing, a spruce bark beetle infestation during the study.

METHODS

Marten Distribution

We determined marten distribution on the KNWR from 1) current and historical reports from trappers, fur dealers, and recreationists, 2) information gathered in conjunction with other KNWR furbearer studies since 1984, 3) snowtrack surveys in areas suspected of supporting martens, and 4) investigations of reported marten sightings. In the northern KNWR lowlands, the high degree of accessibility via roads and seismic exploration trails, and frequent use by the public and refuge employees, assured that any viable marten populations would be detected.

We also conducted snow track surveys from snow mobiles 2 to 4 times each winter from Mystery Creek and North Gas Pipeline Roads adjacent to the BICSA. Other areas were examined on foot between November and April for tracks of martens in snow: Cottonwood Creek Trail in 1987 and the eastern end of Skilak Loop Road, and Resurrection Pass Trail from the Sterling Highway north to Swan Lake (19.4 km) in 1988-89.

Marten Capture and Movements

We live-trapped martens year round from June 1986 through April 1988 in Tomahawk model 202 and 205 traps (Tomahawk Livetrap Co., Tomahawk, WI.). Captured martens were weighed and measured, marked with a size No. 1 aluminum eartag (National Band and Tag Co., Newport, KY.) in each ear, and fitted with a 26 g AVM model SB2 radiocollar (AVM Instrument Co. Ltd., Livermore, CA.). We characterized captured male martens over 1 kg and females with conspicuous mammae as adults. We located radiocollared martens only once each day from the ground or aircraft 254 times during 1,881 functioning radio days using a Telonics TR2 receiver and H-type antennas (Telonics Inc., Mesa, AZ.). Ground locations were triangulated and plotted on 1:63,360 topographical maps. Rugged terrain with steep rocky ravines limited the distance signals could be detected from the ground, and trapline habituation caused at least 1 marten to limit its movements to the trail area during our trapping periods.

We estimated home ranges for martens with 10 or more locations using the minimum polygon method (Mohr 1947) but excluded exploratory movements of 2 male martens (M401 and M476) over 1.6 km from 90 percent of their total locations (5 of 81 locations) and dispersal movements . We defined snow and snow-free seasons as November-April and May-October, respectively, and also pooled mean elevation of scat recovery sites for these seasons for comparisons with a t-test (Sokal and Rohlf 1973).

Marten Habitat Characteristics

We sampled habitat characteristics at the SCBSA, PLSA, CCSA, and at the 3 sites in the BICSA during summer 1987. We sampled forest habitat characteristics along 114, 100 m-line-intercept-transects (Hays et al. 1981) between 4 June and 29 October 1987. Seventy-four transects were in 3 areas (SCBSA, PLSA, CCSA) occupied or visited by martens and 40 were at 3 sites in unoccupied habitat (BICSA). Marten habitat sampling areas were selected to correspond with the known distribution of martens as determined from our track surveys, trapping success, and marten home range assessment. The SCBSA and PLSA supported martens, the CCSA was determined to be used by at least a single marten, and no martens nor their sign were recorded in the DBSA and BICSA. Sample areas were centered on known marten home ranges as determined by radio telemetry in the SCBSA and PLSA and on hemlock-dominated ridges in the CCSA and BICSA because observations in the SCBSA and PLSA suggested martens were often found near mountain hemlock-dominated stands.

Trees had a minimum diameter at breast height (DBH) of 7.7 cm, or were at least 5 m tall. We recorded canopy cover by alder if it occurred in dense pure stands or if it met the criteria of a tree. The eighteenth tree encountered along a transect was core sampled for age. When coniferous and deciduous canopies overlapped, only coniferous canopy was recorded. If coniferous canopies overlapped, the midpoint of the overlap was used as the endpoint of the first canopy and the beginning of the second. All snags within 2.5 m of the transect were sampled. Snag definition and decay classes were those suggested by Maser et al. (1979). Class 3 (new) snags were also recorded as canopy cover if they did not overlap live coniferous cover. Downed logs were defined as having a minimum midpoint diameter (MPD) of 7.7 cm and a length of 1.8 m or greater. Species, intercept length, MPD, and decomposition class (Maser et al. 1979) were recorded for downed logs. We compared differences in frequency distributions of stand age and snag and downed log decomposition classes among study sites with a Chi-square statistic (Ott 1984). Differences in canopy cover and composition and discrete snag and downed log variables were determined using a t-test.

Snow Cover and Thermal Indices

We measured snow depth at 13 stations spaced at approximately 30 m elevation intervals in the SCBSA between 2 February and 25 April 1988. We recorded daily minimum and maximum temperatures above and beneath the snowpack, snow depth, and water content for snow at KNWR headquarters in Soldotna during winter 1988-89. Temperatures above and beneath the snow were measured with Taylor No. 5458 maximum-minimum, self-registering thermometers (Taylor Scientific Instruments, Arden, NC) buried at ground level under the snow and hung about 1 m above the snow surface. We determined water content for each snow layer with a 200 cc cutter and density spring scale (Snow Research Associates, Wilson, WY).

We calculated thermal indices (TI) (Marchand 1982) for snowcover, a measure of its insulating capacity based on depth and density, for the mid-winter snowpack in mountainous areas on the KP known to support martens, for unoccupied KNWR marten habitat at low and high elevations, and for areas within the reported distribution of martens in interior Alaska. Thermal indices were calculated from U.S. Soil Conservation Service (SCS) 25-year average data for February and March and compared with a t-test to determine differences.

Behavior of Marten in Winter and Marten Habitat Use

We snowtracked martens in the SCBSA to relate marten behavior to microhabitat and obtain information on habitat use. Martens were backtracked to avoid disturbance. Older tracks were followed in either direction and data recorded at 50 m intervals along marten trails. At each data point we estimated the distance (%) the marten used of each habitat, if it appeared to be hunting or traveling in a straight line, and numbers of occurrences of rest, prey capture, investigations of cavities, interactions with other animals, and urination/defecation behaviors along the last 50 m segment. We sampled habitat within 10 m of each data point for dominant and secondary tree and dominant shrub species. We visually estimated canopy cover in a 10 m radius circle and total overhead cover in a 1 m radius circle from the data point and assigned them to a cover class. Canopy cover was confined to that provided by trees while overhead cover was the total cover used by martens while traveling on the surface of the snow.

Small Mammal Indices and Marten Diet

We sampled small mammal relative abundance in the SCBSA, PLSA, BICSA, and

DBSA with a single 4 X 15 snaptrap grid set on 4 consecutive nights. The 4 parallel lines were 30 m apart and single traps were set at 5 m intervals. We used Museum Special snaptraps equipped with shrew catchers (Bangs 1979), baited with a mixture of peanut butter, rolled oats, and bacon grease, and checked traps daily. We trapped small mammals in the SCBSA during mid-summer 1986 in mature white spruce-paper birch forest (245 m), in mature white spruce-paper birch-mountain hemlock forest (130 m) in the PLSA during mid-summer 1986 and 1987, in mature spruce-birch-hemlock forest (130 m) in the DBSA in October 1986, and in mature spruce-hemlock forest in the BICSA (100 m) during mid-summer 1987. To sample small mammal populations at higher elevations in the study areas, we set 1 line of 20 traps in mature spruce-hemlock forest (425 m) and 2 lines of 10 traps each in subalpine willow-alder-grass (490 m) for 4 nights in July 1988.

We compared these data to small mammal capture success in the fall (September-October) in mature forest in the KNWR northwestern lowlands (75 m). There, trapping for other projects, 15 traps were either set 5 m apart in 6, 75 m-transects 30 m apart for 3-4 nights (1981-1986) or 40 traps set 10 m apart in a single 400 m transect for 3 nights (1988).

We determined marten diet through scat analysis from only new scats found along trails, near livetraps, and while snowtracking martens. We classified known-age scats to 3-month seasons (spring = March-May, summer = June-August, fall = September-November, winter = December-February). A random sample of 35-37 scats from each season was selected for analysis.

We report the content of marten scats by volume. Scats were weighed to the nearest 0.1 g and volume was estimated by water displacement (Zielinski 1981). We identified mammal remains with the aid of reference collections, microtine dentition patterns (Banfield 1974), and fur characteristics (Moore et al. 1974) and berry remains from reference collections and seed descriptions (Martin and Barkley 1961). We did not identify the species of birds and insects from their remains. Each component of the scat was assigned a volume decile code corresponding to the visually estimated percent it comprised of the entire scat volume (Simon 1980). We compared weight and volume measurements of seasonal scat samples with a t-test. Hargis and McCullough (1984) found the accuracy of visual estimations to be within 5 percent when tested against a gridcounting method.

RESULTS

Marten Distribution

Historical marten abundance and distribution on the KP is poorly documented in fragmented and ambiguous fur records from the mid-1800's to the early 1900's. The little information available is not enough to form any conclusions about the distribution and abundance of martens on the KP before the turn of the century, but there is at least enough information to suggest that possibly martens were more widespread and numerous than they are today (A. J. Magoun, Alas. Dep. Fish and Game, unpubl. rep.). The available evidence is inconclusive whether significant marten populations ever occurred on the KP lowlands.

Interviews with several long-term trappers indicate that martens were once present along the present KNWR's northeastern boundary as recently as the early 1940's. One trapper reported taking 3 martens outside the KNWR boundary during the early 1970's. Within the KNWR boundary, only occasional marten tracks were seen by the late 1950's. Although, this mountainous area continues to produce sporadic reports of martens or tracks, no martens have been reported trapped in the northern KNWR in over 40 years.

Of 75 KNWR trappers surveyed in 1980 (KNWR, unpubl. data), some with over 10 years experience, 12 reported seeing what they believed were marten tracks, but only 2 trappers captured martens. A total of 7 martens were trapped on the KNWR between 1960 and 1988, all south of the Kenai River in the vicinity of Skilak Lake. During this period an 83 day (10 November-31 January) marten trapping season was in effect, but peninsula-wide harvest trends were unknown because marten pelts were not sealed until 1988-89. Alaska Department of Fish and Game sealing records for the 1988-89 season indicated at least 38 martens were taken on the KP, in mountainous habitat outside the boundary of the KNWR where martens have always appeared to be more abundant. Currently, the only known viable refuge marten population on the KNWR inhabits a small area which includes the SCBSA, PLSA, and DBSA. However, we found 5 marten tracks, suspected to be the same individual, in the CCSA in 1987, and tracks of 1 marten about 16 km south of the BICSA and 1 marten track about 6 km northeast of the SCBSA in early 1989.

Marten Captures

We captured 11 martens 56 times in 1,853 trapnights (TN) between June 1986 and August 1988 (Table 1). Four males (2 ad, 2 juv) and 1 juvenile female were captured in the SCBSA (1,204 TN), 4 males (1 ad, 3 juv) and one juvenile female were captured in the PLSA (453 TN), and 1 juvenile female was captured in 12 TN at near Upper Russian Lake 6.4 km southeast of Pothole Lake. No martens were captured (184 TN) and no sign of martens was found in the DBSA. The BICSA was not trapped for martens. Martens escaped from traps 11 times, but based on nearby locations of radiocollared individuals, we believe all were previously tagged. One trap-related mortality of a trap-habituated adult male marten occurred in the SCBSA.

Marten Home Ranges and Movements

Minimum mean home range size for 5 males was 5.3 km^2 (Fig. 2). The average for 3 adult males was 6.5 km^2 and for 2 juvenile males 3.5 km^2. The home range size for 1 juvenile male (M407) was not calculated because he continuously wandered and did not appear to establish a home range during the study. No adult females were captured, but mean home range size for 2 juveniles was 3.1

km^2 (Fig. 2). At least 4 of 7 radiocollared martens with home ranges in the SCBSA or PLSA moved and returned or dispersed eastward into mountainous habitat. In the SCBSA, M401 moved 6.5 km east to the Russian River Valley after his initial capture in late June 1986, but eventually returned to the SCBSA after about a month. M476 lived in the SCBSA for at least 8 months, dispersed in mid-June 1987, and was last located 4.8 km east of Surprise Creek on 19 June 1987. Another marten (M403), intially captured in the PLSA, was caught by a trapper in December 1986 along the Russian River 1.3 km east of his home range. Another male (M407), also captured in the PLSA, moved 6.9 km east. He remained there most of the winter, but by mid-March returned to an area 3.5 km east of the PLSA. Mean maximum distance moved in an easterly direction from the initial capture site for radiocollared martens was 2.7 km while mean maximum distance moved in a westerly direction was only 0.6 km (Table 1). No radiocollared martens moved more than 1.4 km west of their original capture site, but half of them travelled at least 2 km, and up to 10.0 km, to the east.

Marten Habitat Characteristics

Mean stand age for all sampled habitats was 131 years and no significant differences ($P > 0.05$) were detected between areas with and without martens. Four species of trees (white spruce, mountain hemlock, paper birch, and alder) accounted for over 80% of canopy cover at all sites. Total canopy cover was highest in the BICSA (71.8%) and lowest in the SCBSA (53.1%) (Table 2). There were significant differences ($P < 0.05$) in canopy cover between all individual and grouped study area comparisons except SCBSA vs PLSA and CCSA vs BICSA. Mean canopy cover for study areas with martens was significantly lower ($P < 0.05$) than at the BICSA without martens.

Total (live and dead) coniferous canopy cover was significantly lower ($P < 0.05$) in study areas with martens (40.3%) then in the BICSA without martens (55.9%). In study areas supporting martens, coniferous canopy cover in the

SCBSA (35.1%) and in the PLSA (48.7%) were significantly different ($P < 0.05$), but not from that in the CCSA (43.3%). Live coniferous canopy cover for study areas with martens ranged from 26.4% in the SCBSA to 46.7% in the PLSA. This was significantly ($P < 0.05$) lower then in the study area (BICSA) without martens (55.3%).

The greatest difference among the forest habitat characteristics we measured was among snags. Most (77%) of the 787 snags we encountered were white spruce killed by bark beetles. Areas with martens had more, larger, and newer snags, from the beetle mortality, then the area without martens (BICSA). Mean snag height in study areas with martens (13.6 m) was significantly ($P < 0.05$) greater then in the study area (BICSA) without martens (7.8 m). Mean snag DBH for study areas supporting martens (23.3 cm) was significantly ($P < 0.05$) greater then in the study area (BICSA) without martens (19.7 cm). Significantly ($P < 0.05$) more younger (class 3 and 4) snags occurred in study areas with martens because of the bark beetle infestation. Eighty percent of all snags in study areas with martens were young. In the BICSA, without martens, only 55% of the snags were young (class 3 or 4).

Study areas infested by bark beetles also had more, younger, and larger downed logs. The number of downed logs was significantly ($P < 0.05$) higher in study areas supporting martens (9.7/transect) than in the BICSA without martens (6.6/transect) and there were significantly ($P < 0.05$) more downed logs in the SCBSA than at any other study area. There were no significant differences ($P < 0.05$) in the MPD's of downed logs between study areas with and without martens. The average downed log ground coverage per transect in study areas with martens (288.2 cm) was significantly ($P < 0.05$) higher then that in the study area (BICSA) without martens (91.8 cm). The distribution of log decay classes among study areas with martens was not significantly ($P > 0.05$) different from that in the area (BICSA) without martens.

We encountered 4 types of forest openings 16 times along the 114 transects: 1) Menzeisia-dominated openings in upland white spruce, 2) Sphagnum - Ledum-Eriophorum-dominated openings in black spruce, 3) Calamagrostis

Oplopanax-dominated openings in moist birch-spruce forest, and 4) openings dominated or surrounded by willow and alder. Forest openings accounted for only a small proportion of available habitat and we did not detect any significant differences ($P > 0.05$) in the mean number of openings per transect between any of the study areas.

Snow Cover and Thermal Indices

The winter of 1988-89 had exceptionally deep snow. Since most marten activity during cold weather occurred above 260 m elevation in the SCBSA, we measured snow depth 5 times at stations 30 m above ($x = 59.0$ cm) and below ($x = 53.0$ cm) that point. Mean snow depth above 260 m (59 cm) was significantly greater ($P < 0.05$) than below 260 m (53 cm). Thermal indices calculated for the snow cover at KNWR headquarters, in the western lowlands, remained above 150 for 86 days (28 December-23 March) and above 200 for 61 days (10 January-11 March). Nightly minimum temperatures 1 m above the snow surface fluctuated 33°C (-3° to -36°C), while those in the subnivean environment varied by only 10°C (0° to -10°C). Maximum subnivean thermal advantage was recorded on 30 January 1989 when the minimum temperature 1 m above the snow pack was -36°C while the minimum temperature beneath the snow pack was only -9°C, a difference of 27 degrees. This occurred when the snow was 58 cm deep and had a mean density of 0.26 g/cm^3 and a TI of 223. During 29 nights when minimum temperature above the snow pack fell below -7°C ($x = -17.5^{\circ}$C), average low temperature beneath the snow was only -4.8°C - a mean subnivean thermal advantage of 12.7°C.

Snow along the western Kenai Mountains provided about 75% more insulation than snow on the KP lowlands. The average TI (268) calculated from snow along the north-south transect was significantly higher ($P < 0.05$) than the average TI calculated along the east-west transect (196) during the 1988-89 winter. Measurement stations ($N = 8$) on the east-west lowlands transect had a mean elevation of 73 m compared to 298 m for 4 stations on the north-south transect.

We compared TI's calculated from snow data for February and March for 3 low-elevation areas on the KP and 6 areas within marten habitat in interior Alaska (Table 3). The average TI (122) for the 3 KP stations at low elevation was significantly lower ($P < 0.05$) than that (213) for interior Alaska. The KP lowlands had the only average TI below the 150-200 threshold recommended for subnivean thermal stability (Marchand 1982). Those portions of the KP currently supporting martens had a significantly ($P < 0.05$) higher average TI (314) than the Kenai lowlands, the northwestern Kenai Mountains, and interior Alaska. However, the average TI (202) calculated from snow cover for high elevation areas on the KP (Table 3), did not significantly ($P > 0.50$) differ from the average TI (213) calculated for the 6 areas in interior Alaska where martens occur.

Behavior of Marten in Winter and Marten Habitat Use

We tracked martens in the snow 10.1 km in the SCBSA in 1987-88 and 2.1 km on 1 day in January 1989, north of the Kenai River between Mystery Creek and Chickaloon River. We snowtracked martens on 16 different occasions (0.76 km/occasion) to obtain 244 habitat data points and their associated 50-m track segments. Nearly 98% of marten trails were on top of the snow, 1.2% were in subnivean spaces beneath downed logs, and 0.8% on top of downed logs. Martens visited red squirrel (Tamiasciurus hudsonicus) middens 13 times and climbed trees 4 times (Table 4).

Martens traveled relatively straight lines on 68% of the segments and appeared to be intensively hunting on only 3.6% of the segments. Most hunting occurred around downed trees. Martens entered holes in the snow or ground 67 times (19.9%) but did not appear to capture prey (Table 5). Martens also once visited the remains of a snowshoe hare (Lepus americanus) and spruce grouse (Dendragapus canadensis) and may have been scavenging. Only 1 marten rest site was discovered while snowtracking martens. It was in dry leaves under a 30 cm downed log protruding from the snow. We located 1 radiocollared female in an apparent rest site. In early June, she was in a "witches broom" (Chrysomyxa arctostaphyli) 3 m up a dead spruce tree.

Martens utilized dense cover in the study areas. Live or dead white spruce was the dominant canopy cover at 50.8% of the 244 sampling points along trails made by martens. Mountain hemlock canopy cover was dominant at 14.3% and black spruce at 18% of the sampling points. Dominant canopy cover in the area used by the single marten we tracked north of the Kenai River was black spruce. Live and dead white spruce was also the most common (49.2%) secondary canopy component in habitats used by martens. Mountain hemlock (14.3%) and birch (4.5%) ranked second and third in secondary canopy importance. Secondary canopy components were absent at 27.9% of the sampled points because the points occurred in homogenous forest stands or at timberline where tree cover was sparse. Shrub cover in marten-selected habitat was dominated by rusty menziesia (Menziesia ferruginea) (39.9%) and alder (33.3%). Shrubs were absent within 10 m at 20.6% of the sampling points. Remaining shrub cover was made up of young mountain hemlock and black spruce too small to be classified as trees.

The average canopy cover was about 45% at all sites used by martens. Seventy-five percent of all canopy cover classes in habitats used by martens were class 1 and 2, 17.6% class 3, and 3.7% class 4. There was no canopy cover within 10 m at 2.9% of the sample points. The average overhead cover in habitat used by martens was 50% (class 2). Fifty-eight percent of all overhead cover classes were class 1 and 2, 28.3% class 3, and 8.6% class 4. Overhead cover was absent within 1 m at only 4.9% of the sample points.

Radiocollared martens in our KP study areas moved to higher elevations during the snow season. During winter, martens in the SCBSA did not use a low elevation (100-300 m), 20-yr-old burn, but we often found their tracks in open subalpine habitat at higher elevations. Average radio-location-elevation of martens during the snow season (340 m) was significantly higher ($P < 0.05$)

than during the snow-free season (281 m). The average elevation at marten scat recovery sites during snow seasons (326 m) was also significantly ($P < 0.05$) higher than that for scats recovered during snow-free periods (273 m).

Small Mammal Indices and Marten Diet

We captured 4 species of small mammals (Clethrionomys rutilus = 67%, Sorex cinereus = 29%, Microtus oeconomus = 3%, Synaptomys borealis = 2%) in the marten study areas from 1986 through 1988 (Table 6). Average capture success was 6.1 small mammals/100 TN. Average capture success between 1981-1985 in lowland mature forest was 12.2/100 TN (KNWR, unpubl. data). Average small mammal capture success in the mature forest in the lowlands in 1986 and 1988 was 5.3 and 49.2/100 TN, respectively, compared to 1.6 and 21.7/100 TN, respectively, for the same years in marten habitat (Table 6). When we trapped small mammals in the same habitat and season during consecutive years in the PLSA, we recorded a 22-fold increase in trapping success between 1986 and 1987. We were unable to trap small mammals in lowland mature forest in 1987 for a comparison to capture success in 1986. We did not compare annual capture success between marten study areas because each area was trapped in a different season or year because of personnel constraints.

We collected 225 known-age marten scats from the SCBSA (n = 250) and PLSA (n = 5) and used 143 scats (35-37/season) for food habits analysis (Table 7). Summer (June-August) scats were significantly ($P < 0.05$) lighter and smaller than those from other seasons. We found 271 individual food items representing 23 different foods (1.9 items/scat). The greatest diet diversity (2.1 items/scat) occurred during fall (September-November) when martens ate 7 species of berries. The diet of martens was comprised mainly of small mammals (63.6%), berries (30.4%), birds and eggs (5.8%), and insects (0.3%).

Four species of small mammals comprised 77.7% of all mammal remains and they appeared to be the most important marten food in the study areas throughout the year. Most small mammal remains occurred in summer (81.9%) and spring

(50.9%) scats and most red squirrel remains in spring (21.2%) and winter (5.0%) but not in the summer or fall scats. Red-backed voles were eaten throughout the year (26.9% of annual diet), but mainly in the spring (34.9%). Berries were the second-most important food in the diet of KP martens. Berry remains comprised the highest proportion of marten scats in the fall (65.8%) and winter (35.4%). Mountain ash (Sorbus scopulina) berries comprised 65.8% of all berry remains and 52.8% and 22.2% of the volume of fall and winter marten scats, respectively.

DISCUSSION

Historical Marten Distribution

Historical records provided little conclusive evidence about the historical distribution or abundance of martens on the KP. The western side of the KP has a history of man-caused wildfires (Spencer and Hakala 1964) which appears related to the arrival of settlers and goldseekers at the turn of the century (Lutz 1960). Natural wildfires are rare on the KP. The effects of wildfire on forest habitat used by martens can be detrimental to martens (Yeager 1950, Edwards 1954, Soutiere 1979) but whether martens previously occurred in areas burned by wildfires on the western KP remains unknown. Trapping at the turn of the century may also have influenced marten numbers and distribution on the KP. Marten susceptibility to overexploitation is well documented (Marshall 1951, Quick 1956, Dodds and Martell 1971). However, when the marten trapping season was closed 21 years on the KP between 1916 and 1960, the marten population on the KNWR did not appear to increase. Since martens have apparently inhabited some high-elevation habitats on and adjacent to the KNWR within the past 50 years, it appears marten distribution may have once been more widespread, at least in higher-elevation habitats, than today. However, since past wildfires nor trapping can conclusively explain the current absence of martens in the forested lowlands, other factors must be considered.

Marten Movements and Distribution

The directional movements of radiocollared martens suggested that the SCBSA and PLSA may have been at the extreme western edge of suitable marten habitat on the KP. Many travel corridors available to martens were oriented east and west. At the PLSA, the Skilak River and glacier flats may have restricted their movements south and open, alpine tundra movements north. Impediments to movements of martens in the SCBSA included extensive (> 6 km) alpine tundra to the south and the Kenai River, which normally remains ice-free in winter, to the north.

The tracks of 2 martens we observed north of the Kenai River in 1989 were the first confirmed there in 16 years. We speculate that 2 consecutive winters of the complete freezing of the Kenai River bordering the SCBSA allowed martens to disperse northward across the seldom-frozen river. The direction of movements of martens could have been influenced by such physical barriers and the lack of suitable environmental conditions to the west. However, social factors, such as a lack of breeding opportunities in areas to the west, cannot be ignored as an explanation for the lack of viable marten populations. Finally, since the minimal home ranges of martens we monitored were comparable in size to those reported for martens elsewhere in Alaska (Buskirk 1983, Magoun and Vernam 1986, Vernam 1987), martens of the KP did not appear to require unusually large areas to survive.

Forest Habitat Characteristics and Marten Distribution

Forest canopy cover in KP marten habitat was similar to, or exceeded, canopy cover requirements reported elsewhere for martens (Koehler and Hornocker 1977, Burnett 1981, Spencer et al. 1983). Total coniferous cover equaled or exceeded 40% at all 4 of our study areas and live coniferous cover exceeded 40% in all study areas except the SCBSA. The relatively closed forest canopy with few openings characteristic of our current marten study areas might suggest lower quality marten habitat because edges are important foraging areas for martens (Koehler and Hornocker 1977, Simon 1980, Buskirk 1983, Spencer et al. 1983). However, this previously closed canopy should open as a consequence of spruce mortality from bark beetles.

The white spruce mortality caused by bark beetles has the potential to provide benefits for martens in our study areas. Unlike some wildfires or clear cutting, which appear detrimental to martens (Yeager 1950, Edwards 1954, Dodds and Martell 1971, Steventon and Major 1982), the effects of spruce mortality may be comparable to selective logging which has little impact on marten habitat quality (Soutiere 1979, Steventon and Major 1982). Spruce mortality also creates many snags and downed logs that could benefit martens as additional foraging areas and denning and resting sites (Martin and Barrett 1983, Spencer 1987). Downed logs serve as hunting and denning areas, rest sites, and provide access to the subnivean environment (Spencer et al. 1983, Hargis and McCullough 1984, Bateman 1986, Buskirk et al. 1989).

Although total canopy cover in the SCBSA may fall below the 30% recommended by Koehler and Hornocker (1977) because of the spruce mortality, numerous unaffected hemlock and immature spruce stands still remain. These stands could function like unburned inclusions which appear important to martens in large burns (Vernam 1987). Alder, which invades openings in our study areas, may also provide cover for martens.

Snow Characteristics, Marten Behavior in Winter and Marten Distribution

Martens are small nonhibernators with high metabolic demands (Buskirk et al. 1988) living in seasonally-cold environments (Formozov 1946, Strickland et al. 1982). They are lean-bodied, store little fat (Buskirk and Harlow 1989) and have short fur which provides relatively little insulation (Scholander et al. 1950). Their long, thin, body-shape loses heat to the environment much faster than normally-shaped mammals of the same size (Brown and Lasiewski 1972, Iverson 1972). Because of this, martens have behavioral and physiological strategies (Brown and Lasiewski 1972, Buskirk et al. 1988) to minimize their heat loss. One important winter survival strategy is the use of subnivean rest sites. Insulated winter rest sites are critical in marten habitat (Stordeur 1986, Buskirk et al. 1987, Buskirk et al. 1989). Marten rest sites are almost exclusively subnivean when snow cover is complete (Steventon and Major 1982, Spencer 1987). Marten rest sites are most often associated with coarse woody debris or cone bracts of squirrel middens (Buskirk 1984, Buskirk et al. 1989). Both snow and woody matter insulate, but woody debris provides a dry surface. If martens rested in contact with snow, body heat would cause snow to melt resulting in wet fur with decreased insulating value (Buskirk et al. 1989).

Most of the insulation at marten rest sites in winters appears to be provided by snow. On the KP, snowfall in lowland forest habitat may not always be adequate, as determined by calculated thermal indices, to provide the necessary winter insulation for martens. In the KP lowlands, there also appears to be more deciduous than coniferous trees compared to mature forest in upland habitats. Because of this, there may be fewer, large, squirrel middens to serve as possible rest sites for martens.

Adequate snow cover may even be limiting in some upland forest habitats in our marten study areas. We hypothesize that martens in our study areas moved to higher elevations during cold weather to take advantage of the greater thermal cover provided by the deeper snow. Martens in Washington moved to elevations below 1,040 m in winter (Newby 1951) and martens in southeastern Alaska move to lower elevations to avoid extremely deep snow and to feed in tidal zones (Lensink et al. 1955). Martens in the upper Susitna Basin, Alaska, used the lowest elevation portions of their home ranges in mid-winter, then moved upward in spring to find sunlit, snow-free valley rims where food was more accessible (Buskirk 1983). Buskirk gave no explanation why martens might move to low elevations at the coldest time of year when temperature inversions would make this strategy thermally disadvantageous. However, Buskirk (1983) also reported that interior-Alaska-trappers believed martens moved to higher elevations in mid-winter and returned to lower areas in the spring.

Food and Marten Distribution

During 1986 and 1988, 2 years when concurrent data between higher and lower elevation mature forest habitats were available, small mammal capture success on the KP lowlands was 2-3 times higher than that in higher elevation marten habitat. Average small mammal capture success in KP marten habitat during our study appeared low compared to small mammal capture success reported in other marten habitats. Buskirk (1983) captured 20.3 small mammals/100 TN in the upper Susitna Basin, Alaska, and Vernam (1987) caught 29.4 small mammals/100 TN in the Bear Creek Burn, Alaska. We did not have comparable success trapping small mammals except during one (1988) of 3 years. In western Newfoundland marten habitat, Bateman (1986) reported a small mammal capture rate of only 4.0/100 TN but over 80% where shrews. This was lower than in our study areas, but Newfoundland martens fed on snowshoe hares even though hares occurred at low population levels. Although the small mammal data from the KNWR suggests that the presence of small mammals is not the limiting factor influencing marten distribution in the lowlands, minimum small mammal densities and availability required to support a viable marten population are unknown.

The overall diet of martens on the KP was similar to that reported for many other marten studies (Lensink et al. 1955, Buskirk and MacDonald 1984, Douglass et al. 1983, Quick 1955, Thompson and Coglan 1987, Bateman 1986, Soutiere 1979, Koehler and Hornocker 1977, Weckwerth and Hawley 1962) where microtine rodents were important prey. Snowshoe hares, which can also be important marten prey (Raine 1986), were scarce in our marten study areas. Martens on the KP ate fruit, mainly mountain ash berries, to a greater extent in the fall and winter, than usually reported. Marshall (1942) and Zielinski (1981) found fruit in only 6.5% and 1.1% of winter marten scats, respectively.

In interior Alaska, berries occurred in only 9.3% (Lensink et al. 1955) of winter scats and 13.3% of fall and 8.8% of winter scats (Buskirk and MacDonald 1984). Fruit was not reported in the diets of marten by Quick (1955), Douglass et al. (1983), and Thompson and Coglan (1987).

Mountain ash grows as an erect shrub or small tree 1-6 m high (Viereck and Little 1972) with persistent berries above snow. Their berries would be available to martens throughout winter. Deep snow could make them even more accessible to martens. Martens did not appear to digest mountain ash berries well. Entire, relatively intact mountain ash berries were often found in marten scats suggesting the berries had not been chewed and that little nutritive value was derived from them. Over one-third of the KP marten winter diet was berries which appeared little digested when marten metabolic requirements are the greatest (Buskirk et al. 1988). A high metabolic rate may be one way martens have adapted to cold temperatures (Buskirk et al. 1988). If martens derived little nutritional value from feeding on mountain ash berries in winters, they may have experienced food stress during this critical part of the year. Food stress can limit reproduction in martens (Thompson and Coglan 1987).

CONCLUSIONS

The KP has had a long history of human impacts on wildlife populations. Exploitation of wildlife populations and major changes in forest habitat on the KP at the turn of the century were significant (Bangs et al. 1982). For example, caribou (Rangifer tarandus) on the KP were extirpated in the early 1900's, primarily by overhunting (Davis and Franzmann 1979). Shortly thereafter, wolves (Canis lupus) were extirpated by hunting and the use of poisons (Peterson and Woolington 1979). Caribou had to be reintroduced beginning in the 1960' and 45 years elapsed before a breeding pack of wolves became established naturally on the KP (Peterson and Woolington 1982). Moose (Alces alces) were apparently scarce on the KP before the mid-1800's but became abundant after man-caused fires altered forest habitat (Lutz 1960). Coyotes (Canis latrans) became abundant and red fox (Vulpes fulva) rare during the absence of wolves (Bangs et al. 1982). Lynx (Felis canadensis) numbers became low in some accessible habitats after their populations were intensively harvested in the 1970's (Bailey et al. 1986).

Although martens may have once been more widespread on the KP, specifically in forested valleys along the western flank of the Kenai Mountains north of the Kenai River, the information we collected during this study was inclusive in regards to the affects of man on KP marten populations. The factors which influence martens on the KP are complex, interrelated, and vary by region. In the western KP lowlands, we hypothesize that the absence of martens may be influenced by the lack of reliable, persistent snow cover which appears essential for winter thermal cover. The numbers of small mammals do not appear to be a limiting factor in the lowlands. However, the ecological availability of these small mammals to martens is unclear in view of the wet, crusty snow conditions characteristic of the lowlands. The role of past wildfires on marten habitat in the western KP lowlands also remains unclear. Much of the lowland area since the 1900's has been in early- to mid-stage forest succession. Transplanted martens in the Yukon Territory favored late seral or climax coniferous forest, although they traversed large rivers and an extensive burn with abundant deadfall (Slough 1989). The beneficial versus detrimental effects of fire on marten populations and habitat in Alaska are not yet well understood and probably vary greatly with size and nature of the fire, local snow cover and small mammal populations, and marten populations available for recolonization from surrounding, undisturbed marten habitat.

In contrast to the western lowlands, ecological conditions appear suitable for martens in forested areas of the northeastern region of the KNWR along the western flank of the Kenai Mountains. Snow cover, forest habit, and prey appear favorable for martens and past reports suggest the martens once occurred there. Martens already occupy comparable habitats south of the Kenai River. Ecological factors important to martens in the KNWR benchland areas remain unclear. Their higher elevation, greater snow depths, vast tracts of relatively-undisturbed forest, and presumed adequate numbers of small mammals would appear favorable to martens, yet martens are absent or scarce. Immigration of martens into the benchlands may be limited. The role of impediments to marten dispersal and the time required for successful natural establishment of populations remains unknown on the KP. Unlike some rivers in interior Alaska that do not present a barrier to marten movements (Magoun and Vernam 1986), major rivers which may be obstacles to movements of martens on the KP are wide, swift, extremely cold because of their glacial origin, and often remain ice-free in winters near currently-occupied marten habitat. Two rivers (Skilak and Tustumena) occur in wide (> 1.0 km), open, glacial flats which have little snow cover when the rivers seasonally diminish in volume or freeze over. If most of the occasional martens which periodically overcome these obstacles are males (Yeager 1950, Lensink et al. 1955, Hawley and Newby 1957, Burnett 1981, this study), the time necessary for a marten populations to become naturally established may be extremely long.

The viability of the current marten population on the KNWR is uncertain. Several observations suggest that the only known marten habitat on the KNWR could be marginal or "sink" (Van Horn 1983) habitat. These observations were 1) the absence of captured adult females in the study area, 2) the preponderance of captured individuals that appeared to be juveniles, 3) the limited movement of martens to the west, 4) relatively low small mammal capture success, and 5) the high proportion of berries found in marten scats in the fall and winter. The eastward movements of dispersing or exploratory radiocollared martens and the fact that most marten pelts sealed by trappers were taken in the eastern Kenai Mountains suggest the habitat there may be more favorable to marten productivity.

MANAGEMENT IMPLICATIONS

Ecological studies should be conducted before marten reintroductions are conducted in habitats with a long history of marten absence. The importance of adequate snow cover should be one of the factors evaluated. In our situation, a reintroduction of martens in the western forested lowlands of the KNWR may not be successful under present habitat and snow conditions. However, a reintroduction of martens into unoccupied, upland, forested habitat in the northeastern corner of the KNWR could be successful. Additional surveys to verify the presence or absence of a small, isolated, remnant population of martens in this area are first needed. Finally, because of their possible geographic isolation from existing marten populations on the KP and from mainland Alaska marten populations, an introduced marten population and the existing KP marten population, respectively, will have to be carefully managed.

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Table 1. Marten captures, number of locations, minimum home range (km^2) and maximum distances (km) moved east and west from initial capture location in study areas on the Kenai National Wildlife Refuge, Alaska, June 1986-August 1988.

Date of first capture	Marten number	Study area	Sex	Age	Number of captures	Number of daily re-locations	Minimum home range size	Maximum distance from initial capture location	
								East	West
25 Jun 86	M401	SCBSA	M	ad	10	33	6.6	0	6.5
29 Jul 86	M451	PLSA	M	ad	3	25	9.2	0.8	2.4
31 Jul 86	M403	PLSA	M	juv	4	17	3.6	0.6	2.7
26 Aug 86	M426	PLSA	M	juv	1	2			
11 Sep 86	M876	URL[1]	F	juv	1	10	0.8	1.1	0
31 Oct 86	M476	SCBSA	M	juv	12	48	3.5	1.1	4.0
15 Nov 86	M472	SCBSA	M	juv	1	2		0	0.9
23 Jan 87	M470	SCBSA	F	juv	17	64	5.5	1.2	1.0
16 Sep 87	M405	PLSA	F	juv	1	4		0	0.7

Table 1 (continued). Marten captures, number of locations, minimum home range (km^2) and maximum distances (km) moved east and west from initial capture location in study areas on the Kenai National Wildlife Refuge, Alaska, June 1986-August 1988.

Date of first capture	Marten number	Study area	Sex	Age	Number of captures	Number of daily re-locations	Minimum home range size	Maximum distance from initial capture location East	West
17 Sep 87	M407[2]	PLSA	M	juv	1	14		0	10.0
5 Nov 87	M498	SCBSA	M	ad	5	35	3.7	1.4	1.2
Total					56	254			
Mean								0.6	2.7

[1]M876 captured along western shore of Upper Russian Lake approximately 6.4 km southeast of Pothole Lake study area.

[2] Marten M407 constantly wandered over a large area during the monitoring period and did not appear to have a home range.

Table 2. Habitat features in marten study areas on the Kenai National Wildlife Refuge, 1986-1988.

Habitat feature	Study areas					Total
	Marten present				Marten absent	
	SCBSA	PLSA	CCSA	Sub-total	BICSA	
MEAN AGE (Years):	129	138	113	128	135	131
CANOPY COVER (%):						
Live evergreen	26.4	46.7	43.1	35.0	55.3	42.1
Dead spruce	8.7	2.0	0.2	5.3	0.6	3.6
Total evergreen	35.1	48.7	43.3	40.3	55.9	45.7
Total canopy cover	53.1	59.2	69.4	58.0	71.8	62.7
SNAGS:						
Mean/transect	9.3	7.2	7.0	8.3	4.3	6.9
Mean height (m)	15.6	11.7	8.8	13.6	7.8	12.4
Mean DBH (cm)	25.6	21.0	17.4	23.3	19.7	22.5
Mean basal area (sq m/ha)	9.6	5.0	3.3	7.1	2.6	5.5
Mean decay class[1]	3.6	3.9	4.2	3.8	4.8	4.0
DOWNED LOGS:						
Mean/transect	11.9	7.2	7.1	9.7	6.6	8.6
Mean MPD (cm)	7.0	6.3	6.0	7.0	6.8	6.9
Mean ground coverage/transect (cm)	430.2	141.1	92.5	288.2	91.8	218.1
Mean decay class[1]	2.0	1.6	1.4	1.8	1.9	1.8
MEAN # FOREST OPENINGS/TRANSECT	2.8	2.9	1.6	2.6	3.2	2.8

[1] See Maser et al. 1979 for snag and log decay classification.

Table 3. Average February snow depths, densities (g/cm^3), and calculated thermal indices (Marchand 1982) on the Kenai Peninsula and interior Alaska. (Source: U.S. Soil Conservation Service 25-year average data (1961-1985)).

Sample sites	Elevation (m)	February		
		Snow depth (cm)	Snow density	Thermal index
KENAI PENINSULA:				
Marten absent at low elevation:				
Moose Research Center	91	23	0.24	96
Jean Lake	189	33	0.21	157
Snug Harbor Road	152	26	0.23	113
Mean	144	27	0.23	122
Marten absent at high elevation:				
Fox Creek	457	56	0.25	224
Pass Creek	366	51	0.25	204
Cytex Creek	381	51	0.23	222
Upper Deep Creek	183	38	0.24	158
Mean	347	49	0.24	202
Marten present:				
Upper Russian Lake	213	95	0.30	317
Cooper Lake	366	95	0.30	317
Skilak Lake	213	95	0.31	307
Mean	289	95	0.30	314
INTERIOR ALASKA:				
Marten Habitat:				
Lake Minchumina	223	33	0.27	122
McGrath	104	49	0.18	272
Shaw Creek Flats	299	36	0.17	212

Table 3 (Continued). Average February snow depths, densities (g/cm^3), and calculated thermal indices (Marchand 1982) on the Kenai Peninsula and interior Alaska. (Source: U.S. Soil Conservation Service 25-year average data (1961-1985)).

Sample sites	Elevation (m)	February		
		Snow depth (cm)	Snow density	Thermal index
Melozi Hot Springs	305	46	0.17	271
Totchaket	107	19	0.16	119
Colorado Creek	213	51	0.18	283
Mean	208	39	0.19	213

Table 4. Habitat features used by marten during winters on the Kenai National Wildlife Refuge, Alaska, 1986-1988

Habitat Feature	Meters of tracks (m)	Percent use (%)
On Trail	145	1.2
On Snow	11,770	96.5
Under Snow	39	0.3
On Log	97	0.8
Under Log	141	1.2
In Tree	2	
In/On Midden	6	
Total	12,200	100.0

Table 5. Occurrences of behaviors of marten observed while snowtracking marten on the Kenai National Wildlife Refuge, Alaska, 1986-1988.

Behavior	Occurrences (N)	Percent occurrences (%)
Traveling	149	44.3
Traveling/Hunting	82	24.4
Hunting	12	3.6
Resting	1	0.3
Prey Capture	0	0.0
Investigating Hole	67	19.9
Interaction	1	0.3
Urination/Defecation	24	7.1
Total	336	100.0

Table 6. Small mammal capture success (captures/100 trap nights) in marten study areas and in lowland mature forest on the Kenai National Wildlife Refuge, Alaska, 1986-1988.

Year	Small mammal capture success							
	Marten study areas						Lowland mature forest	Trap nights
	SCBSA	PLSA	DBSA	BICSA	Mean	Trap nights		
1986	0.8	0.4	3.7	--	1.6	720	5.3	360
1987	--	9.2	--	1.2	5.2	480	--	--
1988	21.7	--	--	--	21.7	120	49.2	120

Table 7. Seasonal diet (% volume of scats) of marten on the Kenai National Wildlife Refuge, Alaska, 1986-1988.

Food item	Season				Total
	Spring	Summer	Autumn	Winter	
MAMMAL:					
Clethrionomys rutilus	34.9	27.7	19.4	26.2	26.9
Microtus oeconomus	10.8	21.8	3.2	0.0	8.9
Synaptomys borealis	4.3	13.8	3.8	3.7	6.4
Sorex cinereus	0.6	0.0	0.0	0.3	0.2
Unknown *Microtus*	0.0	3.7	0.5	0.0	1.0
Tamiasciurus hudsonicus	21.1	0.0	0.0	5.0	6.4
Lepus americanus	8.0	0.0	0.0	17.2	6.1
Unknown small mammal	0.3	14.9	4.7	4.2	6.0
Unknown mammal	2.7	1.0	0.3	2.8	1.7
Total	82.8	82.9	31.9	59.4	63.6
BIRDS:	8.7	6.8	2.5	5.3	5.8
VEGETATION:					
Berries of:					
Sorbus scopulina	2.7	0.0	52.8	22.2	20.0
Empetrum nigrum	0.6	5.5	8.9	0.0	3.8

Table 7 (continued). Seasonal diet (% volume of scats) of marten on the Kenai National Wildlife Refuge, Alaska, 1986-1988.

Food item	Season				Total
	Spring	Summer	Autumn	Winter	
Ribes laxiflorum	0.0	2.6	0.0	0.0	0.6
Rubus sp.	0.0	0.0	1.0	0.0	0.3
Vaccinium vitis-idea	0.0	0.3	0.3	0.3	0.2
Sambucus callicarpa	0.3	0.0	0.5	0.0	0.2
Amelanchier florida	0.0	0.0	0.0	0.8	0.2
Vaccinuim uliginosium	0.0	0.6	0.3	0.0	0.2
Echinopana horridum	0.0	0.0	0.3	0.0	0.1
Unknown *Vaccinium*	0.0	0.0	0.0	0.3	0.1
Bait	4.7	0.0	1.7	10.3	4.2
Lichens	0.3	0.0	0.0	1.5	0.5
Total	8.6	9.0	65.8	35.4	30.4
INSECTS:	0.0	1.3	0.0	0.0	0.3