Marten Ecology and Distribution on the Kenai National Wildlife Refuge, Alaska

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Abstract: Marten (*Martes americana*) were studied on the Kenai National Wildlife Refuge from June 1986 through July 1988 to determine factors limiting their current distribution and to define possible reintroduction sites. Eleven individuals were livetrapped in two study areas, radiocollared, and relocated 235 times. Two hundred eleven scats of known age were collected, and 35-37 from each three-month season were analyzed for food habits. Seventy four habitat transects in areas currently supporting marten and 40 transects near a potential release site which no longer appears to support marten were sampled for stand age, canopy cover and composition, snags, downed logs, and forest openings. Small mammal populations were sampled at at four locations including the potential reintroduction site for species presence and relative abundance. Marten at Surprise Creek were snowtracked for 12.2km to determine behavior and habitat associations. Soil Conservation Service 25-year average snow depth and density measurements were combined with snow depth data from one study area to ascertain snow conditions on portions of the Kenai Peninsula which currently support marten, areas where marten lived in the past, and on the lowlands, which has not appeared to support a marten population in recent times. The subspecies designation of Kenai marten was tested by comparing body measurements and pelage characteristics with those from the literature and by genetic comparisons with interior Alaska marten using electrophoresis.

Kenai marten home range sizes were similar to those reported for other Alaskan marten. Food habits were also comparable, except that Kenai marten consumed unusually high amounts of mountain ash (*Sorbus scopulina*) berries in the fall and winter. Some significant differences in measured habitat parameters were observed among the four sampled areas, however, most of these differences could be attributed to the recent phenomenon of the spruce bark beetle (*Dendroctonus rufipennis*) infestation. All sampled parameters compared favorably with the literature, and habitat in the vicinity of Big Indian Creek appeared suitable for a marten reintroduction. Numbers of the marten's primary prey, small mammals, increased during each year of the study, but appeared low relative to densities reported for marten habitat elsewhere. Red-backed voles (*Clethrionomys rutilus*) were most abundant and appeared most often in small mammal remains in marten scats. Kenai marten occur in areas with consistant deep snow, and appeared to orient cold season movements to higher elevations with deeper snow. Telemetry and scat recovery location data showed a significant (P=.05, P=.01, respectively) shift in activity to higher elevations during cold weather months. Suitable marten habitat on the Kenai Peninsula may be limited by winter thermal cover provided by snow. Marten distribution appears linked to areas with consistantly deep winter snow associated with glaciated portions of the Kenai Mountains. Marten in areas away from high precipitation associated with the coastal climate of the eastern peninsula may require habitat with access to higher elevations with deeper snow to satisfy winter thermal needs.

INTRODUCTION

Studies of marten (*Martes americana*) in Alaska have been conducted only in interior habitats influenced by continental climate (Lensink et al. 1955, Buskirk 1983, Magoun and Vernam 1986, Vernam 1987). Significant marten populations also exist along the southcentral and southeast Alaskan coast. Kenai Peninsula (KP) marten range in southcentral Alaska appears presently limited to the mountainous eastern peninsula, which has a coastal climate. It is unknown why marten do not currently inhabit the western Kenai lowlands, where climatic conditions and habitat more closely resemble those of interior Alaska. Coastal and interior climate and habitat types differ greatly. Coastal climate is characterized by moderate winters and cool summers with high precipitation, while continental climate has colder winters and warmer summers with less precipitation. The KP appears to lie at the transition zone between these two climatic regions. This study, conducted on the Kenai National Wildlife Refuge (KNWR) (Figure 1), investigates marten ecology in this climatic transition zone.

Historical marten abundance and distribution on the KP is poorly documented, however it appears that marten may not presently occupy all suitable or historical habitat on the KNWR. Existing information is contained in fragmented and ambiguous fur records from the mid-1800's to the early

1900's. Magoun (Alaska Dep. of Fish and Game, unpublished memo) researched these records and concluded that historically, marten were probably more widespread and abundant on the KP, but evidence was not available in these documents that marten occurred on the Kenai lowlands.

Trapping pressure during the early 1900's may have been partly responsible for reducing Kenai marten numbers and distribution. Marten susceptibility to overexploitation is well documented (Marshall 1951, Quick 1956, Dodds and Martell 1971), and Strickland et al. (1982) felt that even short early trapping seasons could lead to overharvesting. The effects of wildfire and logging, which are thought to have negatively impacted marten elsewhere (Yeager 1950, Edwards 1954, Soutiere 1979), have been negligible on the eastern portion of the refuge. Interviews with several retired trappers suggest that marten were present along the refuge's northeastern boundary in the Big Indian and upper Chickaloon River drainages as recently as the early 1940's (Figure 2). By the late 1950's only occasional tracks were seen on the refuge north of the Kenai River, although one trapper reported taking three marten near American Pass on an adjacent portion of the Chugach National Forest (CNF) during the early 1970's. This area continues to produce sporadic reports of marten sign, but none have been reported caught on GMU 15A in over 40 years. The mountainous northeastern section of the refuge, along with nearby portions of the CNF no longer appear to support a viable marten population.

Nearly 70 years ago declining marten numbers on the KP prompted Culver (1923) to recommend that they be reintroduced. Marten trapping season was closed for a total of 21 years between 1916 and 1960, and low fur prices during the 1960's resulted in relatively light trapping pressure. However, the marten population on the refuge did not appear to increase. Of 75 refuge trappers surveyed in 1980, some with over 10 years experience, 12 reported seeing what they believed were marten tracks, but only two had captured marten. A total of seven marten were trapped on the refuge between 1960 and 1988, all south of the Kenai River in the vicinity of Skilak Lake. During this period a November 10 - January 31 (83 day) marten trapping season was in effect, but peninsula-wide harvest trends are unknown because pelts were not sealed until the 1988-89 season. Sealing results for the 1988-89 season show that at least 38 marten were taken on the KP, all on the CNF adjacent to glaciated areas where marten always appeared to be more abundant. Currently, the only known viable refuge marten population is thought to be restricted to a small area south of the Kenai River, west of the Russian River, and east of Skilak Lake and Cottonwood Creek (Figure 3).

National wildlife refuges in Alaska are mandated to manage for natural diversity in wildlife populations (Public Law 96-487 December 2, 1980). Marten are valuable furbearers (Banfield 1977, Hall 1981) with pelt prices averaging $75-85.00 during the late 1980's. The Kenai NWR also receives significant attention from nonconsumptive users (U.S. Fish and Wildlife Service 1985), some of whom desire to view wildlife and others who are concerned with the aesthetics of complete faunal communities. For these reasons, and since marten may not be occupying all previously used or suitable habitat on the refuge, reintroducing marten would be an attractive proposal to a wide variety of refuge users.

A suitable donor population of marten would be needed for a reintroduction effort. The KP may not support marten in numbers sufficient to act as a donor population without adverse local effects. Dense marten populations in interior Alaska could probably provide enough individuals for a reintroduction effort, but marten from the KP are currently classified within the caurina subgroup as subspecies M. a. kenaiensis (Hall 1981). Elliot (1923) examined six marten collected on the KP and reported they were smaller than the interior Alaska marten subspecies (M. a. actuosa), with generally darker pelage, and four of the six lacked the orange gular patches characteristic of the genus. The validity of this subspecific designation for Kenai marten must be tested before a donor population can be chosen, and modern techniques such as electrophoresis and mitochondrial DNA analysis could provide valuable insight.

This project was undertaken to investigate the ecology of marten on the KNWR and determine if unoccupied suitable habitat for marten occurred outside of current known marten range on the refuge. Objectives of this study were: 1) determine distribution of marten on the refuge from historical and trapper provided information, and predator track surveys conducted in conjunction with this and related studies, 2) delineate home range sizes and seasonal movements by radiotelemetry, 3) ascertain characteristics of known refuge marten habitat and compare with the potential reintroduction site, 4) determine Kenai marten food habits from scat analysis, 5) compare snow conditions across the Kenai Peninsula and determine its potential role as thermal cover, 6) sample small mammal populations in areas supporting marten and at the potential reintroduction site, and 7) investigate techniques to evaluate subspecies classification of Kenai marten. This information will be used to prepare recommendations for marten management on the KNWR, and to determine if and where a reintroduction effort might be successful.

STUDY AREA

The KNWR (7972 km^2) is located on the KP (26000 km^2) in southcentral Alaska and lies within Alaska Department of Fish and Game Game Management Units (GMU) 15 and 7. GMU 15 is divided further into subunits 15A, 15B, and 15C that include the northern, central, and southern portions of the refuge, respectively (Kesterson 1988). The KP is characterized by three important landforms: the western lowlands (sea level-150m elevation), the Skilak-Tustumena benchlands (250-700m elevation), and the Kenai Mountains which bound the KNWR on the east, contain a major icefield, and rise to 1600m. The CNF and Kenai Fjords National Park (KFNP) border the refuge on the east and southeast, respectively (Figure 1).

All study sites were located within the KNWR along the western portion of the Kenai Mountains. Forest cover exists from sea level to approximately 500m and blends into subalpine shrubs, mainly alder (*Alnus sinuata*) and willow (*Salix spp.*), at higher elevations. Vegetation above 750m is generally alpine tundra. Primary forest cover on this portion of the refuge is comprised of white spruce (*Picea glauca*), paper birch (*Betula papyrifera*), western hemlock (Tsuga heterophylla), and mountain hemlock (Tsuga mertensiana) with the spruce-birch association more common at low elevation and spruce-hemlock dominant above 200m. Large pure stands of hemlock occupy many north facing slopes above 300m. Black cottonwood (Populus trichocarpa) occurs in creek bottoms and patches of alder are interspersed throughout. Alder and rusty menziesia (Menziesea ferruginea) are dominant shrub species below treeline.

Marten were studied at five sites on the eastern refuge (Figure 2). Most field work occured at Surprise Creek (SC) which was centered on the creek drainage on the north slope of Surprise Mountain. A 1969 wildfire burned the area between the south bank of the Kenai River and approximately 300m elevation. Forest cover above the burn was comprised of mature bich and spruce at lower elevations and mature spruce and hemlock at higher elevations. Pothole Lake (PL) was located between the south slope of Surprise Mountain and Skilak Glacier Flats. All work was done on the east side of the lake. Topography was rugged with many steep short ridges, and forest cover consisted of a mixture of mature spruce, birch, and hemlock. Doroshin Bay (DB) 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 sided progressively higher ridges covered with mature spruce and birch on ridge sides and mature hemlock on ridge tops. Cottonwood Creek (CC) study area was centered on Cottonwood Creek on the southeast end of Skilak Lake. It was a north facing drainage similar to SC with mature spruce and birch at lower elevations and mature spruce and hemlock at higher elevations. The Big Indian (BI) study area consisted of three sites along drainages near Big Indian Creek on the western slope of the northern Kenai Mountains in GMU 15A and 7. Forest cover was similar to the other study sites.

All study sites occured within designated or proposed wilderness areas, and habitat remains unchanged from historical times. Swift glacial rivers, large lakes, and a lack of maintained trails or roads restrict human access to the study sites. Currently, forests at Surprise Creek (SC), and to a lesser extent at Pothole Lake (PL) and Cottonwood Creek (CC), are undergoing a spruce bark beetle (Dendroctonus rufipennis) infestation. The associated white spruce mortality is creating a more open canopy with an abundance of snags and downed logs.

The KP is situated at the boundary of the warm moist coastal climate of southeast Alaska and the cold dry climate of interior Alaska. The mountainous eastern portion of the peninsula appears most heavily influenced by coastal climate, while climatic conditions on the western KP are more similar to that of interior ALaska. Average annual precipitation in Seward on the east side of the peninsula is 178cm, and in Soldotna on the western side it is 46cm. Winter weather is moderated by proximity to the ocean, but temperatures can drop to -40°C in Soldotna. Temperatures rarely fall below -18°C in Seward, but at times of extreme cold, temperature inversions have been recorded in the Kenai Mountains. Annual snowfall and snowpack conditions vary across the peninsula and with elevation. Moderating effects of the nearby ocean often leave low elevations with inconsistent, shallow, and crusty snow cover, while areas above 2-300m, especially those close to glaciers, have deep snow during winter months.

Methods

Marten were livetrapped year round from June 1986 through April 1988 in Tomahawk model 202 and 205 traps (Tomahawk Livetrap Co., Tomahawk, Wisconsin). When using the smaller model 202, two traps were wired together end to end, one treddle was removed, and the other was moved 6cm toward the back of the trap. This modification made the trap long enough to accomodate the entire body and tail of a marten before the door was released. Only larger model 205 traps were used when sufficient numbers were obtained in summer 1987.

Sets were made on the ground or snow along trails, and under large spruce trees or next to downed logs in areas without trails. Traps were covered with plastic, camouflaged with tree bark or other natural materials, baited with jam on a piece of bark placed behind the treddle, and flagged with an aluminum tart tin and white rag scented with anise oil. Both models of traps worked well, but habituated marten learned to escape from the larger model 205. Two stout sticks placed vertically through the trap on either side of the door alleviated this problem.

Captured marten were restrained with a wire mesh handling cone when using model 202 traps, and with a wooden plunger when using the model 205. Immobilization was achieved by intramuscular injection of 0.08cc Ketamine Hydrochloride (Bristol Laboratories, Syracuse, New York). One or two additional 0.03cc injections were usually required during processing, and 0.03cc Acepromazine Maleate (Fort Dodge Laboratories Inc. Fort Dodge, Iowa) was occasionally used to moderate the effects of Ketamine and capture stress.

Once immobilized, a photo of the gular patch was taken, marten were weighed, marked with size No. 1 aluminum eartags (National Band and Tag Co., Newport, Kentucky) in each year, and fitted with AVM model SB2 26 gram radiocollars in the 164 MHz range (AVM Instrument Co. Ltd., Livermore, California). Standard measurements were taken and the animal was placed in the trap to recover. Once marten regained alertness and coordination, they were fed jam and released.

Radiocollared marten were relocated from the ground or light aircraft using a Telonics TR2 receiver and H-type antenna (Telonics Inc., Mesa, Arizona). Ground locations were triangulated, and along with aerial locations were plotted on 1:63,360 topographical maps. Additional information such as date, time, weather, habitat, and activity status were recorded on individual location sheets.

Locations were input into Data General Model 10SP computer using SED Text Editor software (Data General Corp., Southboro, Massachusetts), and converted to UTM coordinates using LEGALMOSS softwear (U.S. Fish and Wildife Service, Anchorage, Alaska). Radio-location data was analyzed for home range size, areas of overlap, and seasonal movements using MOSS version .8509 software (U.S. Bureau of Land Management, Denver, Colorado) and a Visual 500 graphics terminal (Visual Corp., Tewksbury, Massachusetts). Home ranges were determined for marten with ten or more locations using the minimum polygon method (Mohr 1947) and excluded exploratory movements. Snow and snow-free seasons were defined as November-April and May-October, respectively. Mean elevation of scat recovery sites were pooled for these seasons and compared with a t-test (Sokal and Rohlf 1973).

Habitat parameters were sampled at SC, PL, CC, and at three sites near BI during summer 1987 using the line intercept method (Hays et al. 1981). SC and PL were known to support marten populations, CC was later determined to support at least a transient population, and BI, a potential reintroduction site, was thought to no longer support marten. Sampling areas were selected to correspond with radio-equipped marten home ranges at SC and PL, and were centered on hemlock dominated ridges at CC and BI. Distribution of marten and mountain hemlock seem related on the KP. Transect starting points and directions were determined using randomized grid and spinning pointer techniques (Hays et al. 1981).

Habitat sampling transects were 100m long and sampled canopy cover and composition, snags, downed logs, and forest openings. Trees were defined as having a minimum diameter breast height (DBH) of 7.7cm, or being at least 5m tall. Alder was treated as canopy cover where it occurred in dense pure stands or met the definition of a tree. For each tree canopy intersecting the transect, length of intercept, species, and DBH were recorded, and the eighteenth tree encountered was core sampled for age determination. If evergreen and deciduous canopies overlapped, only evergreen canopy was recorded. If evergreen 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 2.5m of the transect were sampled. Snag definition and decay classes were those suggested by Maser et al. (1979). Class three snags (new snags) were also recorded as canopy cover if they did not overlap live evergreen cover. Downed logs were defined as having a minimum midpoint diameter (MPD) of 7.7cm and a length of 1.8m or greater. Species, intercept length, MPD, and decomposition class (Maser et al. 1979) were recorded for downed logs. Forest openings encountered were measured and described, and primary shrub and ground cover species along the transect were noted. Berries were not systematically sampled as their abundance and visibility varied throughout the sampling period.

Frequency ditributions of stand age and snag and downed log decomposition classes between the study sites were tested 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.

Marten food habits were determined through scat analysis. Marten scats collected along trails, at traps, and while snowtracking were labelled according to age, location, and date collected. They were later assigned a reference number, cataloged, and stored frozen. Only scats found fresh were analyzed. All known age scats were classified to three month seasons (spring = March - May, summer = June - August, fall = September - November, winter = December - February), and a random sample of 35-37 scats from each season was selected for analysis. Parasites and infectious agents were killed by soaking scats in 70% isopropyl alcohol overnight. They were then dried in a Napco model 630 dessicator (National Appliance Co., Portland, Oregon) at 60°C for 24 hours, and stored at room temperature and humidity before analysis.

Scats were analyzed in six steps: 1) weighed to the nearest 0.1g on an Ohaus model C501 top-loading electric balance (Ohaus Scale Corp., Florham Park, New Jersey), 2) volume was estimated by water displacement (Zielinski 1981), 3) fine matter was washed away using size 2 and 30 (2.0mm and 0.7mm) sieves, 4) scat components were separated in petri dishes using a binocular 15X/30X dissecting microscope and forceps, 5) components of scats were identified, and 6) each component of the scat was assigned a volume decile code (eg. 1=tr-10%, 2=11-20%, ... 10=91-100%) corresponding to the visually estimated percent it comprised of the entire scat volume (Simon 1980). Hargis and McCullough (1984) found the accuracy of visual estimations to be within 5% when tested against a grid counting method. Mammal remains were identified to species with the aid of reference collections, microtine dentition patterns (Banfield 1974), and fur characteristics (Moore et al. 1974). Berry remains were identified to species from reference collections and seed descriptions (Martin and Barkley 1961). Bird and insect remains could not be identified to species. Mean weight and volume measurements of seasonal scat samples were compared with a t-test for seasonal differences.

Content of marten scats has been reported in terms of frequency of occurrence and volume. Frequency of occurrence of a food item has been expressed as the proportion of scats a food item occurred in, or as a percent of total food items found. Volume has also been expressed as an actual volume measurement, or as the relative volume of a food item in proportion to total volume of all food items found. Zielinski (1981) found that frequency of occurrence was a poor estimate of undigested weight of small and large prey, but was acceptable for medium-sized prey, and that volume underestimates the importance of large prey and easily digested foods. Simon (1980) suggested the use of an importance value (Brower and Zar 1977), the sum of percent frequency of occurrence and percent volume, to off-set these biases, but Zielinski (1981) determined from feeding trials that volume was a better overall estimate of prey intake. Results of food habits analysis from this study were summarized as percent occurrence and percent volume.

Small mammal populations were sampled at SC, PL, BI, and DB with 4 X 15 snaptrap grids operated over four consecutive nights. The four parallel lines were spaced 30m apart, and traps on the lines were at 5m intervals. Museum Special snaptraps equipped with shrew catchers (Bangs 1979) and baited with a mixture of peanut butter, rolled oats, and bacon grease were used. Traps were checked daily and rebaited if necessary.

Small mammal trapping at SC occurred during mid-summer 1986 in mature white spruce-paper birch forest (245m elevation). A trap grid in mature white spruce-paper birch-mountain hemlock forest (130m elevation) was operated at PL during mid-summer 1986 and 1987. Small mammals were also trapped in mature spruce-birch-hemlock forest (130m elevation) at DB in October 1986, and in mature spruce-hemlock forest at BI (100m elevation) during mid-summer 1987. In addition, limited trapping was conducted at SC around some intense small mammal activity in October 1987, and to sample at higher elevation, one line of 20 traps in mature spruce-hemlock forest (425m elevation) and two lines of ten traps each in subalpine willow-alder-grass (490m elevation) were operated for four nights in July 1988.

Marten were snowtracked mainly in the SC study area to relate behavior to microhabitat and obtain additional information on marten habitat use. Fresh tracks were backtracked to avoid disturbing the animal. Tracks judged to be older than one day were followed in either direction. Length of individual tracker paces were determined under field conditions, and data were recorded at 50m intervals along marten trails. At each data point the percent distance the marten used each habitat feature (eg., 70% on snow + 20% under snow + 10% on log = 100%), whether it appeared to be hunting or travelling in a straight line, and number of occurrances of five behaviors (rest, prey capture, investigate hole, interaction with other animal, and urination/defacation) over the last 50m segment were recorded. Habitat within a 10m radius circle of each data point was sampled. Dominant and secondary tree species and dominant shrub species were noted. Canopy cover in a 10m radius circle and total overhead cover in a 1m radius circle from the data point were visually estimated and assigned to a cover class (eg., 1=tr-25% ... 4=76-100%). Canopy cover was that cover provided by trees, and overhead cover was all cover available to marten on the snow surface.

Snow depth was measured at 13 marked stations at approximately 30m elevation intervals in the SC study area between February 2 and April 25, 1988. More intensive monitoring of the snowpack began after it appeared that Kenai marten distribution may be related to winter thermal cover provided by snow. Field work on the marten study was officially terminated in August 1988, but information on daily minimum and maximum temperatures above and beneath the snowpack, snow depth, and water content was recorded for snow at refuge headquarters in Soldotna during winter 1988-89. Temperatures above and beneath the snow were measured with Taylor No. 5458 max-min self registering thermometers (Taylor Scientific Instruments, Arden, North Carolina) buried at ground level under the snow and hung about 1m above the snow surface. Water content for each snow layer was determined with a 200cc cutter and density spring scale (Snow Research Associates, Wilson, Wyoming).

Thermal indexes (TI) (Marchand 1982) of the mid-winter snowpack for portions of the KP known to currently support marten, areas near the reintroduction site, areas at low elevations, and areas supporting high marten densities in interior Alaska were calculated from U.S. Soil Conservation Service (SCS) 25-year average data for February and March. Data from earlier in the winter were not avialable. These indexes were compared with a t-test to determine if significant differences in thermal cover provided by snow existed. In addition, a late winter snow profile for the western KP was obtained by measuring depth and water content near lakes along an east-west transect line across the northern lowlands, and on a north-south transect line along the western edge of the Kenai Mountains. TI's were calculated and means for the transects were compared.

Marten distributuion on the KNWR was delineated in four ways; 1) current and historical reports from trappers and other recreationalists, 2) information gathered in conjunction with other refuge studies, primarily investigations of lynx (1984-present) and wolverine (1988-present), 3) snowtrack surveys in areas suspected of supporting marten, and 4) attempting to confirm sightings reported by agency personnel and the public. The high degree of accessability, via roads and seismic exploration trails, and use by the public and refuge field workers virtually assured that any marten viable population outside known areas would be detected.

Snow track surveys were conducted by snow machine mainly on Mystery Creek and North Pipeline Roads adjacent to the potential release site at BI. Other areas examined included Cottonwood Creek Trail (GMU 15B) in 1987 and the eastern end of Skilak Loop Road (GMU 15A) and Resurrection Pass Trail (GMU 7) from the Sterling Highway north to Swan Lake (19.4km) in 1988-89. Surveys occurred between late November and early April.

The subspecies classification of Kenai marten was evaluated in two ways. A comparison of body measurements and pelage characteristics, on which the original classification was based, was made between 11 Kenai study animals and those reported for interior Alaska and other parts of North America. Characteristics of genetic material from liver and skeletal muscle tissues of two Kenai marten and 40 interior Alaska marten from the Tok area were compared using horizontal starch gel electrophoresis. Small sample sizes are permissible with this technique as long as numerous loci within the genetic material are tested (Becky Everett, pers. comm.). Mitochondrial DNA analysis was also considered, but found to be too expensive for the scope of this study.

RESULTS

Capture

Eleven marten were captured 56 times in 1853 trapnights (TN) between June 1986 and August 1988 (Table 1). Four males (2 Adults, 2 Juveniles) and 1 juvenile female were captured at SC (1204 TN), four males (1 Adults, 3 Juveniles) and one juvenile female were also captured at PL (453 TN), and one juvenile female was captured in 12 TN at Upper Russian Lake (UR). No marten were captured (184 TN) and no sign of marten presence was found at DB.

One trap-related mortality of a trap-habituated adult male marten occurred at SC on February 25, 1987. Adult male M401 was captured on two consecutive nights in adjacent traps, and apparently did not eat or drink between captures.

Marten escaped from traps 11 times, but all were believed previously marked. Seven marten shed eight radio collars from one day to over three months postcapture. Two of these animals were recaptured and fitted with tighter collars. Seven of eight shed collars were recovered. The three collars shed in summer were found in an active squirrel midden, a hollow log, and wedged in the door of a trap, respectively. Of four collars shed in winter, two were found in old inactive squirrel middens, one in a crack near the top of a 6m tall birch snag, and one in a subnivean burrow in snow covered alders. All locations except the trap-site appeared to be rest sites. Female F470 was radiotracked to another rest site in a "witches broom" 3m up a dead spruce tree in early June 1986.

Transmitter life averaged about 4.5 months with a maximum of eight months, and no premature radio failures were recorded. Two hundred and fifty five radio locations (155 ground, 100 aerial) were amassed in 1881 radio days, but 205 locations were of 5 animals. Most ground locations were obtained in the SC study area from a trail which paralleled the creek, and therefore, telemetry data from this area may not truly reflect home range size or patterns of use. Rugged terrain with steep rocky ravines limited the distance signals could be detected from the ground, and trapline habituation caused at least one marten to limit movements to the trail area during trapping periods. Home range of adult male M401 changed from 6.61 km^2 (n=14) during summer-fall 1986 when little trapping occurred, to 0.67 km^2 (n=16) during winter 1986-87 when the area was intensively trapped. For these reasons, home range sizes from the SC study area should be regarded as minimum estimates. Most locations of study animals at PL and UR were obtained from fixed-wing aircraft and are thought to more accurately represent true home range dimensions .

Mean home range size for all males was 5.33 km^2 (n=5). Adults averaged 6.51 km^2 (n=3) and juveniles 3.55 km^2 (n=2). No adult females were captured, but mean home range size for juvenile females was 3.14 km^2 (n=3), and ranged from 0.82 km^2 (n=10) to 5.46 km^2 (n=64). Juvenile male M407 captured at PL, covered an area of 23.1 km^2 (n=14) and did not appear to establish a home range while his transmitter was functioning. Mean snow (November - April) and snow-free (May - October) seasonal home range sizes for instrumented marten of each sex were compared with a t-test, and no significant differences were found (P=.05).

Radiocollared Kenai marten did not appear to defend discrete territories among or between sex and age groups. However, no adult animals of the same sex with adjacent home ranges were monitored concurrently. Juveniles of both sexes overlapped ranges with adult males. Ninety seven percent of juvenile male M403's home range was within that of adult male M451, and 53% of juvenile female F470's home range was within adult male M498's home range. Home ranges of juvenile marten also overlapped. Eighty three percent of juvenile male M476's home range was within that of juvenile female F470.

Radio-collared marten appeared to move to higher elevations during the snow season. Mean radio location elevation was 340m (n=144) for snow season and 281m for snow free season (n=109). In addition, mean elevation for scat recovery sites was 326m during snow season (n=162) and 273m during snow-free season (n=63). Both radio location and scat recovery site elevation data were significantly higher (P=.05) during snow season, indicating that Kenai marten selected for higher elevations in winter.

Four of seven collared marten with home ranges in the SC or PL study areas dispersed or made exploratory movements to the east. In the SC study area, M401 moved 6.5 km east to the Russian River Valley immediately after his initial capture in late June 1986, and eventually returned to the study area over a period of one month. M476 resided in the SC study area for at least eight months, then dispersed in mid-June 1987 and was last located 4.8 km east of Surprise Creek on 19 June 1987. This marten's transmitter apparently failed soon after this time, and he was not recaptured or located again. In the PL study area, M403 was killed by a trapper along the Russian River 1.3km east of his documented home range in December 1986, about one month after radio contact was lost, and in the week after his capture in late September 1987 at PL, M407 moved 6.9km east to Upper Russian Lake. He remained in that area through most of the winter, but by mid-March had moved to an area 3.5km east of PL. Mean maximum distance moved east of initial capture location for seven marten at SC and PL was 2.68km while mean maximum distance moved to the west was only .57km (Table 2).

Food Habits

Two hundred twenty five known age scats were collected, and 143, 35-37 from each season, were selected for food habits analysis. Five scats selected came from PL, and the remainder were found at SC. Thirteen analyzed scats were found in live traps, and 130 were collected along a hiking trail or while snowtracking study animals. Summer season (June - August) scats were significantly (P=.05) lighter and smaller than those from other seasons. A direct relationship between weight and volume, especially for scats containing mammalian remains, was noted (Zielinski 1981). Amounts of each food item in the Kenai marten diet will be reported as percent volume (Table 3).

Two hundred and seventy one individual food items of 23 foods were found for an overall average of 1.9 items/scat. Greatest diet diversity (2.1 items/scat) occurred during fall (September - November) when seven species of berries were eaten.

Mammals, primarily red-backed voles, made up 63.6%, berries 30.4%, birds and eggs 5.8%, and insects 0.3% of the Kenai marten diet. Both frequency of occurrence and volume techniques probably overestimated the importance of insects, of which there were only six occurrences.

Six species of mammal remains were identified. Four species of small mammals made up 77.7% of all mammal remains and were the most important staple food item throughout the year. Small mammals were most frequently utilized in spring and summer, comprising 50.9% and 81.9% of the respective seasonal diets. Red squirrels (Tamiasciurus hudsonicus) and snowshoe hares (Lepus americanus) became important food sources during winter and spring seasons, but did not occur in summer or fall scats. Squirrels made up 5.0% of winter diet and 21.2% of spring diet, while hares accounted for 17.2% of winter and 8.0% of spring diet. These larger prey accounted for 22.2% of winter diet and 29.2% of spring diet. Unidentified mammal remains constituted 1.7% of total diet.

Small mammal use peaked in the summer season at 81.9% of total food intake, and declined to 31.6% in the fall. Red-backed voles were most heavily utilized throughout the year, and made up 26.9% of the annual diet. Use of this species was highest in spring at 34.9% of the diet. Tundra voles (Microtus oeconomus) and bog lemmings (Synaptomys borealis) comprised 8.9% and 6.4% of the annual diet, respectively. Tundra vole use peaked in the summer at 21.8% of the seasonal diet, but no remains of this species were found in winter scats. Bog lemming use also peaked during the summer at 13.8%, and continued to be consumed at low levels ($\bar{x}$=3.9%) throughout the rest of the year. Masked shrew (Sorex cinereus) remains were found in three scats (1 winter, 2 spring), and do not appear to be an important component of the Kenai marten diet.

Berries were the second most important class of foods eaten by Kenai marten. In addition to bait (blackberry jam) remains and two scats which contained only lichen (Bryoria spp.), ten species of berries were detected. Berry use peaked in the fall at 65.8% of seasonal diet, and continued at a high level (35.4%) through the winter. Mountain ash (Sorbus scopulina) was the most heavily utilized species accounting for 65.8% of all berry remains, and 52.8% of fall and 22.2% of winter diet. Crowberry (Empetrum nigrum) was of secondary importance, forming 8.9% of fall and 5.5% of spring diet. Marten also made use of blackberry jam bait remaining in unset traps which comprised 4.2% of annual diet.

Birds and eggs were the third most important class of foods eaten by Kenai marten. Use peaked in the spring (8.7%) and summer (6.8%) with the availability of eggs and nestling birds, but continued throughout the year and comprised 5.8% of the annual diet. One marten was snowtracked to a spruce grouse (Dendragapus canadensis) carcass, but it is unknown if the marten killed or scavenged this bird.

Insects were available only during the short summer season, and made up 1.3% of summer and 0.3% of annual diet. Remains found consisted of larval cases and leg parts, neither of which were identified. It is unknown if the larval cases were consumed by marten, or if eggs were layed and developed on the scats before they were collected.

Habitat Surveys

A total of 114 habitat transects were sampled between 4 June and 29 October 1987. Seventy four transects were in three areas currently inhabited by marten, and the remaining 40 transects were in three areas near a potential reintroduction site at Big Indian Creek. Transects were randomly distributed between 70m and 460m elevation. Forests in the Kenai Mountains were undergoing a spruce bark beetle (*Dendroctonus rufipennis*) infestation at the time (1986-1988) of the study. White spruce mortality resulting from the infestation was high at SC, medium at PL and CC, and low at BI.

Increment borings for aging trees were taken on all transects where agreeable trees were present. In areas of high beetle infestation, such as SC, no agreeable trees were found along 16 transects. Mean stand age for all areas inhabited by or potentially suitable for marten was 131 years, and no significant differences in stand age were detected (P=.05) when grouped and individual areas were compared.

Four species of trees (white spruce, mountain hemlock, paper birch, and alder) accounted for over 80% of canopy cover at all sites sampled. Total canopy cover was highest at BI (71.8%) and lowest at SC (53.1%) (Table 4). Significant differences existed between all individual and grouped site comparisons except SC vs PL and CC vs BI (P=.05). Mean canopy cover for areas supporting marten was significantly lower (P=.05) than at BI, a potential reintroduction site.

Trends were similar when total evergreen (includes class 3 beetle-killed white spruce snags) and only live evergreen canopy cover were compared. Total evergreen cover was significantly different (P=.05) between areas supporting marten (40.3%) and BI (55.8%). Among areas supporting marten, SC (35.1%) and PL (48.7%) were significantly different (P=.05) from each other, but not from CC (43.3%). Live evergreen cover for areas supporting marten ranged from 26.4% at SC to 46.7% at PL, while live evergreen cover at BI averaged 55.3%. Live evergreen cover values were significantly different between areas supporting marten and BI. PL vs CC was the only comparison not significantly different at P=.05, and PL and CC were statstically similar to BI at the P=.01 level.

Snags exhibited the greatest differences between areas of any habitat feature sampled. A total of 787 snags were encountered in the four areas. A majority (77%) were white spruce, most of which had been killed by bark beetles. As a result of the beetle infestation, areas supporting marten had more, larger, and newer snags (Table 4). BI had significantly fewer snags/ha than areas supporting marten when areas were compared individually or in different between areas supporting marten and BI at P=.05. SC had significantly more downed logs than all other areas, while PL, CC, and BI were statistically similar (P=.05) when compared individually.

Mean midpoint diameter for downed logs in areas supporting marten was 7.0cm (n=721), while mean diameter at BI was 6.8cm (n=263). Log diameter was significantly different (P=.05) between individual areas with the exception of PL vs CC, but no significant differences (P=.05) were found when data were combined into areas with and without marten.

Average downed log ground coverage per transect in areas supporting marten was 288.2cm (n=74), and mean ground cover per transect provided by downed logs at BI was 91.8cm. Significant differences (P=.05) between areas with and without marten, and between all individual areas except CC vs PL and CC vs BI (P=.05), and PL vs BI (P=.01) were detected. Amounts of ground cover provided by downed logs at PL and CC were more similar to those at BI than SC.

Downed log decay class did not reflect the relative rates of beetle-kill in each area. Mean decay class was 1.95 (n=477) at SC and 1.92 (n=263) at BI. The distribution of decay classes between areas with marten and BI, or between SC and BI was not significantly different (P=.05). Comparisons between other study areas were significantly different (P=.05).

Sixteen openings of four types were encountered in 114 transects: 1) menzeisia - opening in upland white spruce dominated by shrub menzeisia (n=6), 2) muskeg - moist opening dominated by moss (Sphagnum spp.), Labrador-tea (Ledum groenlandicum), cotton grass (Eriophorum spp.), and surrounded by black spruce (Picea mariana) (n=5), 3) grass/devil's club -

groups, but individual areas supporting marten were statistically similar (P=.05). Mean snag height averaged 13.6m (n=614) for areas supporting marten, and mean snag height at BI was 7.8m (n=173). All grouped and individual comparisons were significantly different (P=.05). Mean snag DBH for areas supporting marten was 23.3cm, and mean snag DBH at BI was 19.7cm. Significant differences were found (P=.05) between areas currently supporting marten and the potential release site at BI. Significant differences were also found between all individual areas except PL vs BI (P=.05) and CC vs BI (P=.01). Mean snag DBH's at PL and CC were more similar to BI than to SC, the third area supporting marten.

As a result of the bark beetle infestation, more class 3 and 4 snags were found in areas supporting marten. Eighty percent (n=491) of all snags in areas supporting marten were class 3 or 4, while 45% (n=78) of all snags at BI were class 6 or 7. Mean snag class in areas with marten was 3.78, and in areas without marten it was 4.78. Decomposition class distribution between areas supporting marten and the potential reintroduction site at BI was significantly different (P=.05), as it was between individual areas with the exception of PL vs CC (P=.05) and SC vs PL (P=.01).

The number and condition of downed logs was also influenced by the spruce bark beetle infestation. Areas with a high infestation rate had more numerous, newer, and larger downed logs (Table 4). Mean numbers of logs per transect was 9.7 (n=721) for areas supporting marten, and BI had a mean of 6.6 downed logs per transect (n=263). Number of downed logs was significantly moist opening in birch-spruce forest dominated by bluejoint grass (Calamagrostis canadensis) and devil's club (Oplopanax horridus) with many downed logs (n=4), and 4) willow - some standing water surrounded by willow (Salix spp.) and alder shrubs (n=1). In all areas forest openings accounted for a relatively small proportion of habitat sampled (Table 4), and no significant differences (P=.05) in the amount of opening per transect between any of the areas were detected.

Small Mammal Trapping

A total of 1325 TN were accumulated between June 1986 and August 1988, and four species of small mammals were captured (Table 5). Overall trapping success in the study areas increased nearly eleven fold between 1986 and 1988, and the vole:shrew capture ratio increased over 15 fold from 0.5:1 in 1986 to 7.7:1 in 1988. Mean success rate for all trapping was 4.98 captures/100 TN. Visual observations indicated a marked increase in small mammal numbers over the entire KNWR during 1987, but no trapping was done on the lowlands that year. Trapping conducted on the Kenai lowlands in fall 1988 (38.6 captures/100 TN) indicated a 278% increase over mean capture rates for 1979 through 1986 (USFWS unpublished data). PL was the only study area where a 4X15 240 TN capture grid was operated in the same habitat and season during consecutive years, and the data for 1987 showed a nearly 22-fold increase in trapping success over 1986. The trap grid at BI in 1987 was apparently placed in poor small mammal habitat, and few captures were recorded. Relative capture rates between study areas could not be determined because each area was not trapped in the same manner, season, habitat type, or year.

Snow Tracking

Marten were snow tracked for 10.1km at SC in winter 1987-88 and 2.1km on one day in January 1989 in GMU 15A between Mystery Creek and Chickaloon River. Sixteen tracking sessions (0.76km/session) yielded 244 habitat data points and 50m 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% of trails were on top of downed logs. Marten visited red squirrel middens 13 times, and four instances of tree climbing were recorded (Table 6).

Sixty-eight percent of the trails indicated marten were travelling, or hunting while travelling in relatively straight lines. Only 3.6% of the distance tracked showed intensive hunting behavior, and this was generally localized around a group of downed trees. Many similar aged tracks entering and exiting snow covered downfalls indicated this was hunting behavior, and probably not a rest site. Holes in the snow or ground were investigated or entered 67 times (19.9%), but no evidence of prey capture was found (Table 7). Marten were also tracked to the remains of a snowshoe hare and spruce grouse, but it could not be determined if they were taken as prey or scavenged.

The tree species providing the most canopy cover at 123 (50.8%) of the 244 snowtracking data points was live and/or beetle-killed white spruce. Hemlock was dominant at 35 (14.3%) points and black spruce provided a majority of the canopy cover at 44 (18.0%) of the sampling points. Most black spruce was encountered when marten were tracked in GMU 15A.

The most common secondary canopy component was also live and beetle-killed white spruce (49.2%). Hemlock and birch were the second most dominant canopy component at 14.3% and 4.5% of the data points, and 27.9% of the data points had no secondary canopy component indicating they occurred in pure stands or near timberline where tree cover was sparse.

Shrub cover was dominated by menzeisia at 97 data points (39.9%) and alder at 81 data points (33.3%). No shrub cover was found within 10m of 50 (20.6%) of the sampling points, and much of the remaining shrub cover was made up of young hemlock and black spruce not large enough to fit the description of a tree.

Mean canopy cover class for all 244 sampling points was 1.8, or about 45% cover. Class 1 (n=85) and Class 2 (n=100) canopy cover catagories accounted for 75.8% of the observations. Forty three (17.6%) points had Class 3 cover, and only 9 (3.7%) were designated Class 4. No canopy cover was present within 10m of 7 (2.9%) of the data points.

Mean overhead cover class was 2.0, or 50% cover. Class 1 (n=95) and Class 2 (n=47) cover catagories comprised 58.2% of the observations. Sixty nine (28.3%) data points had Class 3 cover, and 21 (8.6%) were classified as Class 4. No overhead cover was present within 1m of 4.9% (12) of the sampling points. During winter marten at SC did not use a 20-year-old burn (100-300m elevation), but tracks were often found in open subalpine habitat which offered a similar amount of cover.

Small sample size made it difficult to establish relationships between microhabitat and behavior. The only association noted was that between hunting and brushy downed logs. This was indicated by several sets of similar aged tracks entering and leaving the subnivean environment beneath the logs and then moving on. It appeared that marten also hunted under snow covered alder patches and around the bases of large evergreen trees where snow cover was sparse.

One rest site was found while snow tracking. It was located in dry leaves under a 30cm downed log which protruded from the snow at a 30 degree angle. Many different aged tracks lead to and from the area, and one scat was found on top of the log. Kenai marten rest site preference can also be inferred from shed radiocollar recovery sites. Three of seven recovered radiocollars were found in squirrel middens. Two shed in winter were in old or seldom used squirrel middens, and one recovered in late summer was in an active midden indicating year round use of these habitat features. Two other radiocollars shed in winter were found in a crack near the top of a 6m high birch snag in late November, and in a subnivean hollow under snow covered alders in January. One collar shed in summer was found inside a 40cm hollow birch log. The other recovered collar was shed in fall and found wedged in the door of a trap. This was the only shed collar found outside of an apparent rest site.

Marten Distribution/Snow Track Inventories

Marten sign was confirmed at two sites on the refuge outside of known marten habitat at SC and PL. Five track crossings, suspected to be from the same marten, were found on the Cottonwood Creek Trail (60-180m elevation) at the southeastern end of Skilak Lake on 24 November 1987, and nine track crossings from one marten were found north of the Kenai River in GMU 15A along the North Pipeline Road (120m elevation) between Mystery Creek and Chickaloon River on 23 January 1989. Outside of the refuge, a single marten track was also found on the Resurrection Pass Trail (275m elevation) 3.2km north of the Sterling Highway during February 1989 (Figure 2).

Snow Studies

Snow depth was measured five times in the SC study area at 13 stations at 30m elevation intervals from the Kenai River to treeline between 2 February and 25 April 1988. Most marten activity during cold weather occurred above 260m elevation, and mean snow depth for five readings taken at stations 30m above (x=59.0cm) and below (x=53.0cm) that point were significantly different (P=.05).

The winter of 1988-89 was one of unusually deep snow, and snow pack thermal indexes (TI) at refuge headquarters remained above 150cm*cm^3/g for 86 days (28 December - 23 March) and above 200cm*cm^3/g for 61 days (10

January - 11 March). Nightly minimum temperatures 1m above the snow surface fluctuated by 33^{o}C (-3^{o} — -36^{o}C), while those in the subnivean environment varied by only 10^{o}C (0^{o} — -10^{o}C). Maximum subnivean thermal advantage was recorded on 30 January 1989 when the minimum temperature 1m above the snow pack was -36^{o}C and minimum temperature beneath the snow pack was -9^{o}C, a difference of 27^{o}C. This occurred with a snow depth of 58cm, mean density of 0.26g/cm^{3}, and a TI of 223cm*cm^{3}/g. During 29 nights when minimum temperature above the snow pack fell below -7^{o}C ($\bar{x}$=-17.5^{o}C), average low temperature beneath the snow was -4.8^{o}C for a mean subnivean thermal advantage of 12.7^{o}C.

Snow survey transects across the northern lowlands from the western coast near North Kenai east to the edge of the Kenai Mountains, and north-south along the western edge of the mountains were sampled in mid-March 1989 to obtain a profile of relative snow depths and densities across the refuge. TI's derived from these data showed relative thermal cover provided by snow on the lowlands and western slope of the mountains. Stations on the east-west lowlands transect (n=8) had a mean elevation of 73m and mean TI of 196cm*cm^{3}/g, while stations on the north-south transect (n=4) had a mean elevation of 298m and mean TI of 268cm*cm^{3}/g. TI's from the north-south transect were significantly higher (P=.05) than those from the east - west transect, and during winter 1988-89, snow on the western Kenai Mountains provided about 75% more insulation than snow on the lowlands.

Long-term snow depth and density data for three areas on the Kenai Peninsula and interior Alaska were obtained from Soil Conservation Service 25-year averages (Table 8). Mean TI's for February and March data were similar for individual sites. Data for early winter were not available. Mean TI for the three stations in the Kenai lowlands (122cm*cm^3/g) was significantly lower (P=.05) than the three other areas, and was the only group with a mean TI below the 150-200cm*cm^3/g threshold for subnivean thermal stability suggested by Marchand (1982). Portions of the KP currently supporting marten had the highest mean TI (314cm*cm^3/g) and were significantly different (P=.05) from sites on the Kenai lowlands, northwestern Kenai Mountains, and interior Alaska. No significant differences were found when samples obtained from four areas on the KP close to or under similar climatic conditions as the potential release site at BI and six high marten density areas of interior Alaska were compared, however both differed significantly from the Kenai lowlands and current KP marten habitat.

Subspecies

Mean weight for eight male marten of all ages was 991g. Mean total body length was 60.6cm and hind foot length averaged 8.8cm. Average weight of three juvenile female marten was 731g, mean total body length was 57.9cm, and average hind foot length was 7.6cm. Pelage varied from light brown with reddish blonde highlights to uniform dark brown. Generally, adult males had darker coarser fur. Contrary to Elliot's (1923) observations, all marten handled had the characteristic gular markings which ranged from light yellow to dark orange. In addition, sealing records for the 1988-89 trapping season did not mention the lack of a gular patch on any of the 38 marten harvested.

Horizontal starch gel electrophoretic analysis of 20 enzymes from liver and skeletal muscle of two Kenai marten and 40 interior Alaska (Tok area) marten revealed no significant subspecific differences in genetic composition. Of 26 loci tested, two variant alleles in high frequency, one in low frequency, and one of questionable variability (isocitrate dehydrogenase) were found (U.S. Fish and Wildlife Service, unpublished data). Mammalian subspecies generally have at least 23% variability from the main genetic stock, but Kenai marten showed only 8-15% divergence and could not be confirmed as a distinct subspecies by this method.

DISCUSSION

Home Range Size and Movements

Home range sizes of marten vary widely (Wynne and Sherburne 1984, Bateman 1986) and may be influenced by habitat and food availability (Thompson and Coglan 1987). For these reasons it may be most valid to compare home range sizes of marten in similar habitats and geographic regions. Kenai marten home range sizes compare favorably with those reported for interior Alaska (Buskirk 1983, Vernam 1987) and Yukon Territory (Archibald and Jessup 1984).

Opinions on the minimum number of radio locations needed to determine home range size vary. Buskirk (1983) used a minimum of eight locations for seasonal home ranges, and Thompson and Coglan (1987) set minimums at 10 locations for seasonal and 20 locations for total home range estimates. A minimum of 10 locations was used for total home range calculations in this study, but when total home range size was plotted against number of locations, asymptotes were not reached until about 30 locations were collected. For two marten with 48 and 64 locations, true asymptotes were not reached until about 50 locations had been obtained. False asymptotes appeared during seasons when animals were located infrequently, and home range size increased when individuals were located more often. These increases appeared to be uniform on all sides of the home range, and did not represent seasonal shifts in activity.

Several sources of bias are inherent in radio locations obtained from the ground (Springer 1979). Garrott et al. (1986) found 52% of non-line-of-sight telemeterred signals to be inaccurate or imprecise due to signal reflection. Locations of instrumented marten at PL and UR were obtained from aircraft, but 84% of locations at SC were triangulated from a trail paralleling the creek. Steep rocky ravines in the area could have reflected or blocked signals, and marten may have occasionally been out of transmitter range. Both these factors could have distorted portions of marten home ranges, and therefore, home range sizes at SC should be regarded as minimum estimates.

Seasonal vertical movements by marten have been previously recorded. Newby (1951) found marten in Washington moved to elevations below 1040m in winter, and Lensink et al. (1955) reported marten in southeastern Alaska concentrated winter activities at lower elevations to avoid extremely deep snow and take advantage of food resources in tidal zones. Buskirk (1983) felt that marten in the upper Susitna Basin, Alaska utilized the lowest elevation portions of their home ranges in mid-winter, and moved upward in spring to find sunlit snowfree valley rims where food was more easily accessible. Unfortunately, he had little winter telemetry data and offered no explanation of why marten would move to low elevations at the coldest time of year when temperature inversions would make this thermally disadvantageous. In contrast, Buskirk (1983) also reported that interior Alaska trappers believed marten moved to their highest elevations in mid-winter and returned to lower areas in spring.

Telemetry and scat collection site data indicated Kenai marten moved to higher elevations during snow season (November - April) and concentrated activities at lower elevations during snowfree months. In the more moderate climate of the KP, temperature inversions occur rarely, and are not as severe as those of interior Alaska. However, snow depth and hence thermal cover do vary greatly with elevation. We believe Kenai marten moved to higher elevations during cold weather to take advantage of thermal cover provided by the deeper snow found there.

It has been widely reported that adult males and juveniles of both sexes make much greater exploratory movements than adult female marten (Yeager 1950, Lensink et al. 1955, Burnett 1981). Movements of juveniles usually occur from August to November and are related to dispersal from natal home ranges (Stordeur 1986), while forays of adult males generally occur during mid-summer and are probably associated with breeding. All but one juvenile marten marked during this study were first captured during the late summer and fall dispersal period. Exploratory movements of M401 and M476 occurred during the mid-summer breeding season and were probably related to the lack of breeding opportunities at SC. There is little certainty of when female marten reach sexual maturity, and it may vary with habitat quality (Strickland et al. 1982). SC female M470 probably did not reach breeding age until summer 1988, and it is unknown why adult male M498 apparently moved into the area during summer or fall 1987. The territory vacated when M476 emigrated from the area may have been an attractant.

Movements of radiocollared marten also indicated that the SC and PL study areas were situated on the extreme western edge of suitable marten habitat. Corridors along which marten could travel were oriented east to west. AT PL the Skilak River and glacier flats restricted movements to the south while alpine tundra was a barrier to the north. Barriers at SC included alpine tundra to the south and the Kenai River, which normally remains open in winter, to the north. No marten moved more than 1km to the west of their original capture site, but all travelled at least 2km and up to 9km east. We suspect the direction of these movements were most heavily influenced by a lack of suitable habitat to the west, but social factors such as a lack of breeding opportunities may have also played a role.

Small Mammal Trapping

Small mammal capture rates during the study increased dramatically. PL was the only area trapped in a consistent manner over consecutive years, and thus, was the only individual study area where year to year changes in capture success were documented. Capture rates at SC during 1988 were 2.4 times greater than the 22 fold increase recorded at PL from 1986 to 1987. Small mammal numbers on the Kenai lowlands mirrored this trend, and capture success in mature forest in 1988 was double the highest rate recorded over the previous ten years (Bangs 1979, U.S. Fish and Wildlife Service, unpublished data). There appears to be some evidence that small mammal numbers on the KP peak about every four years, but the reason densities were so high in 1988 is unknown. These periodic increases seem to occur within the red-backed vole population, and it is unknown whether other microtine rodents on the KP cycle in this manner. Marten may be required to have an extremely flexible winter diet to compensate for periodic lows in this apparent cycle.

Small mammal numbers on the KNWR appeared to be lower in habitat supporting marten than on the Kenai lowlands, even though they were the mainstay of the Kenai marten diet. Mean capture success for small mammals in mature forest on the Kenai lowlands for 1979-1986 (U.S. Fish and Wildlife Service, unpublished data) was about 2.8 times greater than mean capture rates in the marten study areas during this investigation (1986-1988). During 1986 and 1988, the two years when concurrent data were available, capture success on the lowlands was about twice that of refuge marten habitat. These data demonstrate that Kenai marten occupy areas adjacent to habitat with substantially higher densities of their principal prey, yet fail to colonize this habitat.

Small mammal trapping in marten study areas occurred from mid-summer to fall while sampling in the lowlands took place only in the fall. Microtines usually reach their highest densities in the fall so data from different seasons may not be directly comparable. However, sampling conducted in marten study areas in summer and fall of the same year show little difference, and data collected at DB in fall 1986, concurrent with trapping on the lowlands, shows capture success to be over 60% less than on the lowlands. It appeared that this difference in small mammal densities was real and not a result of sampling during different seasons.

In comparison to small mammal densities in marten habitats with similar prey bases, mean small mammal densities in Kenai marten habitat during this study appeared low. Buskirk (1983) captured 20.26 small mammals per 100TN in the upper Susitna Basin, Alaska, and Vernam (1987) caught 29.43 small mammals per 100TN in the Bear Creek Burn, Alaska. Only during the small mammal high of 1988 did small mammal captures in Kenai marten habitat approach these levels. In western Newfoundland, Bateman (1986) reported a small mammal capture rate of only 4.03 captures per 100TN with over 80% shrews. This rate was lower than that for this study, but Newfoundland marten were reported to make heavy use of snowshoe hares even though they occurred at low levels. Minimum small mammal densities required to support a healthy marten population are unknown. However, the lack of reproduction in refuge marten habitat and high proportion of fruit in the winter diet may indicate that small mammal and alternate food densities were near the minimum required to support a marten population.

Food Habits

Content of the Kenai marten diet was similar to that reported for marten in interior Alaska (Lensink et al. 1955, Buskirk and MacDonald 1984), Northwest Territories (Douglass et al. 1983), British Columbia (Quick 1955), Ontario (Thompson and Coglan 1987), Newfoundland (Bateman 1986), Maine (Sourtiere 1979), Idaho (Koehler and Hornocker 1977), and Montana (Weckworth and Hawley 1962). Microtine rodents, primarily red-backed voles, were the most important prey item on a yearly basis.

Marten often display a strong seasonal variation in diet (Weckworth and Hawley 1962, Simon 1980, Buskirk and MacDonald 1984), and composition of Kenai marten seasonal diet was generally similar to other Alaskan marten. Microtine rodents were more important to Kenai marten in summer than at other times of year. Lensink et al. (1955) also found microtines to occur more often in summer than winter scats. Buskirk and MacDonald (1984) determined small mammal use to be highest during fall, but a fall berry crop failure occurred during one year of their study, and microtines may have been the only alternate food available. In addition, they did not sample known summer season scats.

Kenai marten appeared to prey selectively on *Microtus* and *Synaptomys* rather than the more abundant *Clethrionomys*, particularly during summer. Most small mammal trapping occurred during summer. *Microtus* and *Synaptomys* comprised 4.2% and 2.1% of the catch, respectively, but made up 21.8% and 13.8% by volume of the summer diet and 9.9% and 6.4% of the yearly diet, respectively. Similar results have been recorded in Montana (Weckworth and Hawley 1962), Northwest Territories (Douglass et al. 1983) and interior Alaska (Buskirk and MacDonald 1984). Weckworth and Hawley (1962) suggested that *Microtus* were less catchable than *Clethrionomys*, and that small mammal trapping efforts would not reflect their true abundance, but would give the appearance of prey selection. Buskirk (1983) thought marten were opportunistic foragers and took *Microtus* only when they were abundant in specific habitats, but switched to the more numerous habitat generalist *Clethrionomys* when *Microtus* numbers fell. Douglass et al. (1983) felt that marten did indeed select for Microtus. Our data suggest that marten probably did select for these species in summer, but perhaps due to habitat preference differences, they may not be as available to marten as Clethrionomys when snow cover is present.

Birds made up a relatively small proportion of the Kenai marten diet, but were most often taken in the spring. Buskirk and MacDonald (1984) found birds to be most heavily utilized during winter as did Lensink et al. (1955), but their sample included scats from May. Relatively few bird species inhabited SC in winter. Woodpeckers (Picoides spp.) appeared numerous due to the spruce bark beetle infestation, and spruce grouse were present, but densities were unknown. Many more bird species were available in spring and summer along with eggs and nestlings, which occurred regularly in scats. Therefore, it makes sense that birds, especially the eggs and young of ground nesting species, would comprise a greater portion of the marten diet at this time of year.

Large prey such as snowshoe hares and red squirrels were most important to Kenai marten during winter and spring. Scat analysis techniques may underestimate the importance of large prey in the diet (Zielinski 1981), and hare populations were at the cyclic low during our study (U.S. Fish and Wildlife Service, unpublished data). For these reasons it may be reasonable to assume that hares were more important than the data suggest and would be further exploited at times of abundance. Squirrels appeared numerous, but relative densities were unknown. Lensink et al. (1955) and Buskirk and MacDonald (1984) found similar patterns of use for large prey. Buskirk (1983) felt sciurids were a nonpreferred alternate prey when microtine numbers were lowest, but Zielinski (1981) suggested a preference for larger prey in winter because they provide more energy per capture and are usually accessible above the snow. We believe marten use of larger prey in winter and spring may be in response to both these factors.

Marten may forage for berries during winter in years of abundance, especially those species held above the snow, or when other food sources are not easily obtained. Kenai marten utilized fruit, mainly mountain ash berries, to a greater extent than has been previously reported. Marshall (1951) recorded marten use of mountain ash berries in Idaho, and Marshall (1942) found fruit to occur in 6.5% of winter scats. Simon (1980) reported that plants and seeds comprised 27.9% by volume of winter marten scats in California, but Zielinski (1981) working in an adjacent area found vegetable matter to make up only 1.1% by volume of winter scats. In interior Alaska Lensink et al. (1955) found berries to occur in 9.3% of winter scats, and Buskirk and MacDonald (1984) determined fruit to make up 13.3% of fall and 8.8% by volume of winter scats. Quick (1955), Douglass et al. (1983), and Thompson and Coglan (1987) reported no fruit in the winter diet of marten. Our data suggest that either mountain ash berries were very numerous, or other food sources of presumably higher caloric value were not available during the study. The high percentage of fruit in the winter diet of marten in the SC study area may indicate nutritional stress.

Mountain ash grows in the form of an erect shrub or small tree 1-6m high (Viereck and Little 1972) with persistent berries held above the snow. These berries would be available throughout winter, and deep snow may make them more accessible. Marten did not appear to digest mountain ash berries well. Entire intact berries were often found in scats indicating that they had not been chewed and marten had probably derived little nutrition. Over one third of the Kenai marten winter diet consisted of berries of apparently low nutritional value at a time of year when metabolic requirements were presumably increasing (Buskirk et al. 1988). Brown and Lasiewski (1972) found that even moderately cold stressed weasels required more energy than animals with less elongated bodies of the same size to live, and Buskirk et al. (1988) cited a high metabolic rate as one way marten have adapted to deal with cold temperatures. The high percentage of low nutritional value foods consumed in winter suggests that Kenai marten in habitat similar to SC were subject to food shortages during cold weather. Thompson and Coglan (1987) believed food stress could limit reproduction in marten, and reduced caloric intake may require Kenai marten to seek greater thermal cover than marten elsewhere.

Subspecies Classification

Currently two phenotypes of North American marten are recognized. The caurina group occupies the Pacific coast from Alaska to northern California, and the americana group occurs to the east (Giannico and Nagorsen 1989). Hall and Kelson (1959) and Hall (1981) described 14 subspecies, seven in each phenotype. Hagmeier (1958, 1961) did not believe the patterns of variation reported supported the seven subspecies assigned to each group, but had difficulty redefining subspecies boundaries because of small sample sizes (Giannico and Nagorsen 1989). Kenai marten were designated as the subspecies M. a. kenaiensis in the caurina phenotype based on a description in Elliot (1923).

Hagmeier (1961) stated that marten body size varies with location, and may provide some insight in differentiating between subspecies. Kenai marten were originally described as being smaller than interior Alaska marten, but having proportionally longer tails (Elliot 1923). Pelage was also generally darker and four of six specimens were reported to have no gular markings. All marten handled during this study had gular patches, and no marten captured on the KP during the 1988-1989 trapping season was reported to lack these markings. As elsewhere, pelage color was highly variable (de Vos 1951). Buskirk (1983) found M. a. actuosa in the upper Susitna Basin, Alaska to have tails over 30% longer and body weights 20% heavier than Kenai marten. Vernam (1987), also working with M. a. actuosa near McGrath, Alaska, found these same characteristics to be 8-12% greater, and both reported hind foot lengths 10-12% longer and tail lengths proportionally similar or slightly longer than Kenai marten. These measurements indicate that Kenai marten are indeed smaller than interior Alaska marten, but some of the features traditionally described to differentiate this subspecies may not be valid.

Giannico and Nagorsen (1989) reported that based on skull measurements, marten from the Alaskan panhandle and Alexander Archipelago were significantly different from marten occurring along the southern British Columbia coast, and shared characteristics with the americana phenotype. They suggested that the caurina and americana phenotypes may intergrade in this area. The relationship of Kenai marten to those from southeastern Alaska is unknown, but substantial differences in size from interior Alaska marten and similarities to body measurements reported for marten from California (Simon 1980, Zielinski 1981) suggest that they are more closely allied to the caurina phenotype and may be a distinct subspecies.

Electrophoresis comparisons between Kenai and interior Alaska marten showed little if any difference. Modern methods of mitochondrial DNA analysis or DNA sequencing give a finer degree of resolution and may provide more conclusive results on the subspecific status of Kenai marten (Becky Everett, pers. comm.).

Habitat

Overhead cover appears to be a critical element of marten habitat (Magoun and Vernam 1986). Koehler and Hornocker (1977) determined that during winter marten in Idaho preferred areas with evergreen cover greater than 30%, and Burnett (1981) believed marten to have a strong preference for areas with over 17% cover and an average of 35% cover. Spencer et al. (1983) found marten in California preferred areas with 40-60% cover at both resting and foraging sites, and avoided areas with less than 30% cover. Total evergreen cover values exceeded 40% at all four of our study areas as did live evergreen cover at all but SC. Canopy cover in Kenai marten habitat appeared to be similar to or more dense than marten habitats elsewhere.

The spruce bark beetle infestation at SC, and to a lesser extent at PL and CC, lead to substantial changes in canopy closure and composition. The beetles tend to attack older less vigorous white spruce trees (Holsten 1980), and at SC over half of mature white spruce were affected. The beetle kill resulted in a more open canopy and an increase in the number of new age snags and downed logs. At SC newly created forest openings were colonized by shrubs including alder and menzeisia, and canopy replacement appeared slow.

We believe the beetle kill will not negatively impact marten habitat. Unlike fire or clear cutting, which have been cited as potentially destructive to marten habitat (Yeager 1950, Edwards 1954, Dodds and Martell 1971, Steventon and Major 1982), the effects of beetle kill are more similar to selective cutting, which Sourtiere (1979) and Steventon and Major (1982) believed to have little impact on marten habitat quality. In addition, beetle kill results in the formation of many snags and downed logs. Overall canopy cover at SC may fall below the 30% recommended by Koehler and Hornocker (1977), but numerous unaffected hemlock and immature spruce stands will remain. These may function like unburned inclusions which Vernam (1987) described as being important to marten in a large burn. Alder invading new openings may also provide adequate cover for marten. Steventon and Major (1982) reported dense raspberry bushes provided adequate summer cover for marten in clearcuts, and marten inhabit Chisik Island in Cook Inlet, Alaska where there are no trees and alder provides the only cover. In terms of canopy cover, the spruce bark beetle kill in our study areas should not have a negative impact on the quality of marten habitat.

The beetle kill has created an abundance of snags and downed logs. Both have been cited as important components of marten habitat (Marshall 1951, Burnett 1981, Martin and Barrett 1983, Bateman 1986). Snags have been used as denning and resting sites (Martin and Barrett 1983, Spencer 1987), and 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). Buskirk (1984) believed that the number of rest sites available near foraging areas was an important factor in habitat quality, and Buskirk et al. (1987) and Spencer (1987) emphasized the importance of large diameter snags and woody debris as marten resting sites. The increased number of snags and downed logs in beetle kill areas may have actually improved marten habitat in terms of foraging areas, and denning and resting sites.

Forests on the KNWR have relatively dense uniform cover and very few openings in the canopy exist. Meadow and burn edges and other ecotones have been reported as important foraging areas for marten (Koehler and Hornocker 1977, Simon 1980, Buskirk 1983, Spencer et al. 1983). The closed canopy may not provide marten with the optimum number of foraging opportunities, and thus may be an indicator of marginal habitat.

Little information is available on numbers and types of snags in marten habitat, or number and amounts of ground cover provided by downed logs. Spencer et al. (1983) found that marten preferred microhabitats with snag basal area over 12m^2 per hectare and more than 300 downed logs per hectare, but did not quantify the distribution of these features throughout their study area. Martin and Barrett (1983), working in the same area, reported snag and downed log densities of 21.70-26.54 snags per hectare and 10.87- 32.62 downed logs per hectare. Our study did not determine log densities, but snag densities were four times greater at BI and over six times greater in beetle kill areas. Snags eventually become downed logs so it is reasonable to assume that in all refuge study areas these habitat components occurred in densities greater than those in good marten habitat in California.

Habitat components in the potential reintroduction site at BI and the other three areas supporting marten differed significantly in several ways. Cover values at BI were higher and snag and downed log densities were lower. Most of these differences can be attributed to the spruce bark beetle kill in areas supporting marten and to the locations of sampling units. Sampling units at SC and PL were located to coincide with known marten home ranges, but this was not possible at BI as no marten inhabited the area during the study. Therefore, since marten and mountain hemlock distribution on the KP appear linked, sampling plots were centered on hemlock dominated ridges. Hemlock usually occurs in pure stands with dense canopies, and the higher proportion of hemlock encountered in the BI sampling units resulted in significantly higher cover values there. This may not have been the case with larger or more evenly distributed sampling units. Higher snag and downed log densities in areas supporting marten were probably a direct result of the beetle kill. It is likely that prior to the infestation, both canopy cover and snag and downed log densities in all four areas sampled were more similar. All vegetative components of marten habitat in the four areas sampled compare favorably with the literature, and BI appears to have adequate cover to support a marten reintroduction.

Snowtracking

Difficult access and crusty snow conditions limited the amount of snowtracking data collected. Habitat data accumulated while snowtracking suggests marten may have selected for slightly more dense cover than was generally present in the SC study area. Marten use of microhabitats with denser cover than the general area is well documented (Spencer et al. 1983, Hargis and McCullough 1984, Vernam 1987).

Behaviors observed while snowtracking were similar to those reported elsewhere. Marten movements are not limited by deep soft snow (Raine 1981), and Kenai marten travelled mainly on the snow surface with some subnivean excursions, but arboreal travel was rare (Marshall 1951, Zielinski 1981). Kenai marten often concentrated activities around downed logs, which provide easy access to the subnivean environment, shelter prey species, and create insulated open pockets under the snow for rest sites (Simon 1980, Zielinski 1981, Steventon and Major 1982, Spencer et al. 1983, Hargis and McCullough 1984). In addition, Hargis and McCullough (1984) felt that although marten can dig down through snow, accessing the subnivean environment by tunnels under downed logs protruding from the snow was more energy efficient.

Simon (1980) and Zielinski (1981) reported that marten showed great interest in investigating holes and crevices. Kenai marten also exhibited this behavior when hunting. They were also observed to pause in their travels on hummocks or elevated downed logs. Spencer et al. (1983) noted this behavior and suggested marten may do this to enhance their view of the surrounding area, or as perches from which to pounce on small mammals. Our observations indicate the former to be the more likely reason for this behavior.

Rest Sites

Marten live in seasonally severe environments, and insulated winter rest sites have been cited as a critical component of marten habitat (Stordeur 1986, Buskirk et al. 1987, Buskirk et al. 1989). Rest sites have been reported to be almost exclusively subnivean when 100% snow cover is present (Steventon and Major 1982, Spencer 1987), and 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, and woody debris provides a dry surface. Buskirk et al. (1989) felt that if marten rested in contact with snow, body heat would cause snow to melt resulting in wet fur with decreased insulating value.

Winter rest site selected by Kenai marten were similar those reported for marten in interior Alaska (Buskirk 1983), California (Spencer 1987), Montana (Burnett 1981), and Wyoming (Buskirk et al. 1989). Squirrel middens and subnivean sites associated with coarse woody debris were preferred. All but one winter rest site was under snow.

The woody component of winter rest sites do not appear limiting in KP marten habitat. All KNWR marten habitat is currently designated wilderness and has not been affected by logging or recent fires so ample coarse woody debris exists, especially in beetle kill areas. Midden density was not documented, but they appeared plentiful.

Snow may provide the majority of insulation at winter rest sites associated with coarse woody debris, so the suitability of these sites may depend on snowfall. Large old middens may provide sufficient insulation for marten without a layer of snow. Indeed, middens often occur under dense coniferous canopies and receive little snow cover regardless of accumulations in surrounding areas. Sufficient coarse woody debris for marten rest sites probably exists in mature forest on the Kenai lowlands, but snowfall may not always be adequate to provide the necessary insulation. Mature lowland forest has a much greater percentage of deciduous trees, and thus probably has fewer large middens than the more coniferous forests associated with the mountains. Buskirk (1984) felt that the dispersion of rest sites among foraging areas may be a factor in marten habitat quality and could limit the distribution and abundance of this species at some times of year. As prey densities on the lowlands appear double that of current marten habitat, and snow there provides less than half the insulation of adjacent upper elevations, it may be reasonable to assume that a lack of sufficiently insulated winter rest sites limits marten distribution on the Kenai lowlands.

Summer rest sites do not appear to perform a thermoregulatory function (Buskirk 1984), and marten have been reported to utilize hollow logs, tree limbs, and "witches brooms" for this purpose (Marshall 1951, Wynne and Sherburne 1984, Buskirk et al. 1987). Kenai marten were also found to use hollow logs and "witches brooms", but one juvenile male shed his collar in an active squirrel midden in late August 1986. Buskirk (1984) reported the use of middens during cold weather from late September to early May. We believe this was the first report of midden use in summer and may relate to cool wet summers on the KP where weather conditions may occasionally be unfavorable for marten to rest at thermoneutrality without some insulating cover. The availability of natal den and summer rest sites on the KP does not appear limiting.

Snow and Thermal Cover

Marten are small nonhiburnators with high metabolic demands (Buskirk et al. 1988) and live in a seasonally cold environment (Formozov 1946, Strickland et al. 1982). They are lean-bodied and incapable of storing fat (Buskirk and Harlow 1989), and have short fur which provides relatively little insulation (Scholander et al. 1950). In addition, 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). For these reasons marten have developed behavioral and physiological strategies discussed in Brown and Lasiewski (1972) and Buskirk et al. (1988) to minimize heat loss.

Snow is an omnipresent feature of marten habitat in winter. Winter rest sites are almost exclusively of a subnivean nature, but little work has been done to relate marten distribution and abundance to thermal cover provided by snow. In many areas prey availability and vegetative cover may limit marten range, but we believe that snowfall patterns on the KP may be the most important factor confining marten distribution.

Marchand (1982) developed a TI which to predict the insulating capability of snow as a function of depth and density. Insulating capacity varies directly with depth and inversely with density so shallow fluffy snow may provide as much insulation as deep dense snow. Marchand (1982) felt that a TI of 150-200 $cm*cm^3/g$ provided temperature stability in the subnivean environment. Although our data were not collected in as consistent a manner as Marchand (1982), they appeared to concur with his finding that accumulation beyond this point provided little additional temperature stability under the snowpack.

Raine (1981) reported that the temperature in an unoccupied fisher den under snow was 15^{0} C warmer than ambient air temperature, and Buskirk et al. (1989) found microenvironmental temperatures in unoccupied subnivean rest sites to vary between $-.5^{0}$ and $-2.5^{0}C$, while ambient air temperatures ranged from -28^{0} to $-9^{0}C$. The mean subnivean thermal advantage of $12.7^{0}C$ reported for this study was similar to these findings even though our subnivean readings were not associated with the coarse woody debris of an actual rest site. These data may suggest that a majority of insulation at winter rest sites is provided by snow, and that the function of woody debris is to act as a dry barrier between the marten and snow.

TI's recorded for low elevation E-W and high elevation N-S snow transects in GMU 15A revealed that insulating capacities were 75% greater on the high elevation transect. Snow depth data collected at SC demonstrated that significantly more snow fell 30m above 260m elevation than 30m below. These data suggest that marten inhabiting the drier western side of the Kenai Mountains may require access to suitable habitat near or above a certain elevation to have adequate thermal cover provided by snow each year. At SC the critical elevation appeared to be around 260m, but this may vary with the site. More snow falls at lower elevations in glaciated areas so marten can survive in valley bottoms in the eastern Kenai Mountains.

Recent records of two marten tracks in GMU 15A and an adjacent portion on GMU 7 north of the Kenai River were the first confirmed evidence of marten presence in these areas in 16 years, and may have been associated with two consecutive winters of deeper than average snow. It is unknown how long these marten had been in the area, or where they came from, but it is possible that they crossed the Kenai River, which froze in mid-January 1989, from areas marten are known to inhabit in GMU 15B and GMU 7. While deep snow may not have directly facilitated their dispersal, we believe that it made conditions in this unoccupied habitat favorable for dispersal by providing sufficiently insulated rest sites, especially at the low elevation site at Mystery Creek.

Currently Kenai marten appear to reproduce only in deep snow areas associated with glaciers and the coastal climate. Nearly all marten trapped during the 1988-89 season were taken in the eastern Kenai Mountains. No reproduction was ever recorded in the refuge study areas, although some may have taken place east of PL. These areas are all associated with consistently deep winter snow. Mean TI's calculated from 25 year average data for three site on the KP known to support marten were significantly higher than areas around the potential reintroduction site at BI, the Kenai lowlands, or in marten habitat in interior Alaska. Whether Kenai marten actually require higher TI's than interior Alaska marten, deep snow has restricted access for trapping and these areas serve as a refuge, or if higher TI's denote sites with other habitat or prey base characteristics preferred by marten is unknown. However, if Kenai marten are food stressed, they may require more insulated winter rest sites than marten elsewhere.

Areas which appear to be less favorable, yet adequate, habitat such as BI, had 25 year mean TI's similar to interior Alaska marten habitat. These data suggest that snowfall at BI will provide adequate thermal cover for a reintroduced marten population. Twenty five year mean snowfall in low elevation areas of the western KP did not provide the minimum $150cm*cm^3/g$ TI for subnivean temperature stability, and inadequate thermal cover appears to be the reason marten cannot survive on the western KP lowlands. Distribution of thermal cover provided by snow closely parallels the apparent relative quality of marten habitat on the KP (Figures 3 and 4).

The presence of mountain hemlock may be a year round indicator of KP marten habitat. This tree usually grows in dense pure stands with moss ground cover, and probably provides little other than overhead cover to marten. However, hemlock, requires moist sites and can survive at higher elevations where coastal climate snowfall is heavy. Spruce generally occurs at these high elevations on south facing slopes or in drier areas away from the coastal climate influence. Assuming marten require heavy snowfall, hemlock appears to serve as an indicator of potential KP marten habitat.

Weckworth and Hawley (1962) and Bennett and Samson (1984) stated that marten are food limited. Buskirk (1983) felt that they exist on the verge of starvation. The generally low small mammal numbers and high consumption of berries during winter in our study areas could explain why marten populations there appeared to be of a transient nature and no adult females or reproduction were ever recorded. However it does not explain why marten do not live on the lowlands where small mammal numbers are much higher. Consistently inadequate winter thermal cover provided by snow is the likely reason.

KP Marten Distribution

Historically, marten distribution on the KP was influenced by the availability of food, forest and snow cover, and geographic barriers. KP Natives apparently trapped marten, but it is unknown what impact they had on the population (Alaska Dep. Fish and Game, unpublished memo). Marten are easily trapped (Marshall 1951, Quick 1956, Dodds and Martell 1971), but it was not until white settlement that numerous furbearers including marten were negatively impacted (U.S. Fish and Wildlife Service, unpublished report).

As discussed previously, KP marten distribution can be closely linked to thermal cover provided by snow. Apparently the best quality habitat and highest marten densities occur in the eastern Kenai Mountains near glaciated areas where snowfall is heaviest, and less favorable habitat currently supporting few or no marten in mountains away from deep snow associated with the coastal climate. Marten have a low biotic potential (Marshall 1942) and are susceptible to overharvesting and extirpation (de Vos et. al 1959, Strickland et al. 1982). In addition, most KP marten habitat is confined to narrow forested valley bottoms connected to adjacent habitat by thin corridors. Marten in these relatively confined and isolated populations could be easily trapped out. These factors combined with relative ease of access probably lead to marten being extirpated from the nonglaciated northwestern Kenai Mountains. Winter access to marten habitat adjacent to glaciated areas is much more difficult.

Apparently marten have never inhabited the western KP south and west of the CC study area or the eastern KP coast south of Seward. Unfavorable habitat including rocky cliffs and alpine tundra, and several large glaciers which terminate at the coast may be insurmountable barriers south of Seward, but the reasons marten on the west side of the Kenai Mountains have not dispersed from CC south into the Skilak-Tustumena benchlands and GMU 15C are less clear. Upper elevation benchland habitat is spruce dominated and receives considerably more snow than the lowlands, but nothing is known of potential prey populations or the availability and suitability of rest sites in this area.

Current and historical trapping records indicate that marten numbers in the Kenai Mountains north of the Sterling Highway and west of the Seward Highway have always been relatively low. Trapping pressure in this area has generally decreased over the last half of this century, yet marten have failed to increase their numbers or repopulate vacant habitat (U.S. Fish and Wildlife Service, unpublished report). Little is known of current marten dispersal patterns on the KP away from the SC and PL study areas. Burnett (1981) believed that marten populations in Montana could expand their range by 2-3km per year once populations in the source area had reached the saturation point. Due to trapping and natural mortality current KP marten populations may rarely reach the density where dispersal becomes necessary for juvenile females to locate unoccupied territories, and when this point is reached, discontinuous habitat and substantial geographic barriers exist which make dispersal difficult. For these reasons a reintroduction is the only realistic method to re-establish marten populations in the northwestern Kenai Mountains.

Summary

Kenai marten appear similar to marten elsewhere in terms of vegetative cover requirements, rest site selection, and home range size. Food habits were generally similar to other reports in the literature, but the high use of mountain ash berries in winter may indicate seasonal nutritional stress in marten at SC. Relatively low small mammal numbers except during summer 1988 may have contributed to this food stress.

Marten on the KP appear most numerous and reproductively successful in habitats associated with the glaciated mountains and coastal climate of the eastern peninsula. Marten numbers and apparent reproductive success decrease from east to west across the Kenai Mountains as climate becomes more continental, and the lowlands appear to be unsuitable habitat even though small mammal densities are higher. This distribution closely parallels the snowfall gradient across the peninsula and suggests an important relationship between Kenai marten and thermal cover provided by snow and squirrel middens.

Suitable unoccupied habitat with a history of supporting marten exists on the KNWR in the Big Indian Creek area and on the adjacent CNF north of the Sterling Highway and west of the Seward Highway. Current trapping pressure and geographical barriers make it unlikely that marten will recolonize this area on their own in the foreseeable future. A reintroduction would be the best method for re-establishing marten on the refuge in GMU 15A and 7.

Research Needs

Additional research recommended to better manage marten on the KP includes: 1) map current distribution and relative densities of marten and relate to thermal cover provided by snow, middens, and woody debris,

2) determine genetic variation between KP and mainland Alaska marten, 3) initiate carcass collection program on KP to obtain information on sex, age, and productivity of animals in the harvest, 4) document dispersal patterns in good quality habitat on the CNF, and 5) determine small mammal population composition and trends in marten habitat on the CNF.

Literature Cited

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Archibald, W.R. and R.H. Jessup. 1984. Population dynamics of the pine marten (Martes americana) in the Yukon Territory. pp.81-97 In: R. Olson (ed.). Northern ecology and resource management. Univ. of Alberta Press. 438pp.

Banfield, A.W.F. 1974. Mammals of Canada. Univ. of Toronto Press, Toronto, Ontario, 438pp.

Bangs, E.E. 1979. The effects of tree crushing on small mammal populations in southcentral Alaska. M.S. Thesis. University of Nevada, Reno, Nevada. 80pp.

Bateman, M.C. 1986. Winter habitat use, food habits, and home range size of marten, (Martes americana), in western Newfoundland. Can. Field-Nat. 100:58-62.

Bennett, L.A. and F.B. Samson. 1984. Marten ecology and habitat management in the central Rocky Mountains. Colorado Cooperative Wildlife Research Unit. Colorado State Univ., Fort Collins. 60pp.

Brower, J.E., and J.H. Zar. 1977. Field and laboratory methods for general ecology. Wm. C. Brown Company Publishers, Dubuque, Ia. 194pp.

Brown J.H., and R.C. Lasiewski. 1972. Metabolism of weasels: The cost of being long and thin. Ecology. 53:939-943.

Burnett, G.W. 1981. Movements and habitat use of American marten in Glacier National Park, Montana. M.S. Thesis, Univ. of Montana, Missoula. 130pp.

Buskirk, S.W. 1983. The ecology of marten in Southcentral Alaska. Ph. D. dissertation, Univ. of Alaska, Fairbanks. 131pp.

__________. 1984. Seasonal use of resting sites by marten in south-central Alaska. J. Wildl. Manage. 48:950-953.

__________, S.C. Forrest, M.G. Raphael, and H.J. Harlow. 1989. Winter rest site ecology of marten in the central Rocky Mountains. J. Wildl. Manage. 53:191-196.

__________, and H.J. Harlow. 1989. Body-fat dynamics of the American marten (Martes americana) in winter. J. Mam. 70:191-193.

__________, __________, and S.C. Forrest. 1987. Studies on the resting site ecology of marten in the central Rocky Mountains. pp.150-153 in: Management of subalpine forests: building on 50 years of research: The proceedings of the technical conference. U.S. Dep. Agric. For. Serv. Gen. Tech. Rep. RM-149. 253pp.

____________, ____________, and ____________. 1988. Temperature regulation in American marten (Martes americana) in winter. Natl. Geogr. Res. 4:208-218.

____________, and S.O. MacDonald. 1984. Seasonal food habits of marten in south-central Alaska. Can. J. Zool. 62:944-950.

Culver, W.G. 1923. Report of moose on Kenai Peninsula. Unpubl. Rep., Kenai National Wildlife Refuge, Soldotna, Alaska. 18pp.

de Vos, A. 1951. Overflow and dispersal of marten and fisher from wildlife refuges. J. Wildl. Manage 15:164-175.

____________, A.T. Cringan, J.K. Reynolds, and H.G. Lumsden. 1959. Biological investigations of traplines in northern Ontario. Ont. Dep. Lands For. Tech. Bull. 62pp.

Dodds, D.G. and A.M. Martell. 1971. The recent status of the marten (Martes americana) in Nova Scotia. Can. Field-Nat. 85:61-62

Douglass, R.J., L.G. Fisher, and M. Mair. 1983. Habitat selection and food habits of marten (Martes americana) in the Northwest Territories. Can. Field-Nat. 97:71-74.

Edwards, R.Y. 1954. Fire and the decline of a mountain caribou heard. J. Wildl. Manage. 18:521-526.

Elliot, D.G. 1903. Description of an apparently new subspecies of marten from the Kenai Peninsula, Alaska. Field Columb. Mus., Publ. 72 Zool. Serv. 3:151-152.

Formozov, A.N. 1946. Snow cover as an integral factor of the environment and its importance in the ecology of mammals and birds. Moscow society of Naturalists, Materials for Fauna and Flora U.S.S.R. Zoology Section, new series 5:1-152. ½Translation 1983 by W. Prychodko and W.O. Pruitt, Jr. Occ. Pap. No. 1, Boreal Institute, Univ. Alberta.¾

Garrott, R.A., G.C. White, R.M. Bartmann, and D.L. Weybright. 1986. Reflected signal bias in biotelemetry triangulation systems. J. Wildl. Manage. 50:747-752.

Giannico, G.R. and D.W. Nagorsen. 1989. Geographic and sexual variation in the skull of Pacific coast marten (Martes americana). Can. J. Zool. 67:1386-1393.

Hagmeier, E.M. 1958. Inapplicability of the subspecies concept to North American marten. Syst. Zool. 7:1-7.

____________. 1961. Variation and relationships in North American marten. Can. Field-Nat. 75:122-138.

Hall, E.R. 1981. The mammals of North America. Vol. 2. 2nd ed. John Wiley and Sons, Toronto, Canada. 1181pp.

____________, and K.R. Kelson. 1959. The mammals of North America. Vol. 2. 1st ed. The Ronald Press Co., New York, N.Y. 1083pp.

Hargis, C.D. and D.R. McCullough. 1984. Winter diet and habitat selection of marten in Yosemite National Park. J. Wildl. Manage. 48:140-146.

Hays, R.L., C. Summers, and W. Seitz. 1981. Estimating wildlife habitat variables. U.S. Dep. Int. Fish and Wildl. Serv. FWS/OBS-81/47. 111pp.

Holsten, E.H., R.A. Werner, and T.H. Laurent. 1980. Insects and diseases of Alaskan forests. U.S. Dep. Agric. For. Serv. Alaska Reg. Rep. No. 75. 187pp.

Iverson, J.A. 1972. Basal energy metabolism of mustelids. J. Comp. Physiol. 81:341-344.

Kesterson, M.B. 1988. Lynx home range and spacial organization in relation to population density and prey abundance. M.S. Thesis, Univ. of Alaska, Fairbanks. 64pp.

Koehler, G.M. and M.G. Hornocker. 1977. Fire effects on marten habitat in the Selway-Bitterroot wilderness. J. Wildl. Manage. 41:500-505.

Lensink, C.A., R.O. Skoog, and J.L. Buckley. 1955. Food habits of marten in interior Alaska and their significance. J. Wildl. Manage. 19:364-368.

Magoun, A.J. and D.J. Vernam. 1986. An evaluation of the Bear Creek Burn as marten (Martes americana) habitat in interior Alaska. Special Project. Alaska Dep. of Fish and Game and U.S. Bur. Land Manage. Fairbanks, Alaska. 58pp.

Marchand, P.J. 1982. An index for evaluating the temperature stability of a subnivean environment. J. Wildl. Manage. 46:518-520.

Marshall, W.H. 1942. The biology and management of the pine marten in Idaho. Ph.D. Thesis, Univ. of Michigan. Ann Arbor. 107pp.

____________. 1951. Pine marten as a forest product. J. For. 49:899-905.

Martin A.M. and W.D. Barkley. 1961. Seed identification manual. Univ. of California Press. Berkley and Los Angeles. 221pp.

Martin S.K. and R.H. Barrett. 1983. The importance of snags to pine marten habitat in the northern Siera Nevada. pp.114-116 In: Snag habitat management: The proceedings of the symposium. U.S. Dep. Agric. For. Serv. Gen. Tech. Bull. R.M.-99. 226pp.

Maser, C., R.G. Anderson, K. Cromack, Jr., J.T. Williams, and R.E. Martin. 1979. Dead and down woody material. pp. 78-95 In: J.W. Thomas, ed. Wildlife habitats in managed forests. U.S. Dep. Agric. For. Serv. Agric. Handbook No. 553. 510pp.

Mohr, C.O. 1947. Table of equivalent populations of North American small mammals. Am. Midl. Nat. 37:223-249.

Moore, T.D., L.E. Spence, and C.E. Dugnolle. 1974. Identification of the dorsal guard hairs of some mammals of Wyoming. Wyoming Game and Fish Dep. Bull. 14. 177pp.

Newby, F.E. 1951. Ecology of the marten in the Twin Lakes area, Ohelan County, Washington. M.S. Thesis, State College of Washington, Pullman. 39pp.

Ott, L. 1984. An introduction to statistical methods and data analysis. 2nd ed. Duxbury Press. Boston, Ma. 775pp.

Quick, H.F. 1955. Food habits of marten in northern British Columbia. Can. Field-Nat. 69:144-147.

____________. 1956. Effects of exploitation on a marten population. J. Wildl. Manage. 20:267-274.

Raine, R.M. 1981. Winter food habits, responses to snow cover and movements of fisher (Martes pennanti) and marten (Martes americana) in southeastern Manitoba. M.S. Thesis, Univ. of Manitoba, Winnepeg. 145pp.

Scholander, P.F., V. Walters, R. Hock, and L. Irving. 1950. Body insulation of some arctic and tropical mammals and birds. Biol. Bull. 99:225-236.

Simon, T.L. 1980. An ecological study of the marten in the Tahoe National Forest, California. M.S. Thesis, California State Univ., Sacramento. 187pp.

Sokal, R.R. and F.J. Rohlf. 1973. Introduction to biostatistics. 2nd ed. W.H. Freeman and Company. San Francisco, Ca. 368pp.

Soutiere, E.C. 1979. Effects of timber harvesting on marten in Maine. J. Wildl. Manage. 43:850-860.

Spencer, W.D. 1987. Seasonal rest-site preferences of pine martens in the northern Sierra Nevada. J. Wildl. Manage. 51:616-621.

Spencer, W.D., R.H. Barrett, and W.J. Zielinski. 1983. Marten habitat preferences in the northern Sierra Nevada. J. Wildl. Manage. 47:1181-1186.

Springer, J.T. 1979. Some sources of bias and sampling error in radio triangulation. J. Wildl. Manage. 1979. 43:926-935.

Steventon, J.D. and J.T. Major. 1982. Marten use of habitat in a commercially clear-cut forest. J. Wildl. Manage. 46:175-182.

Stordeur, L.A. 1986. Marten in British Columbia with implications for forest management. Research Branch, B.C. Ministry. of Forests and Lands. WHR-25. Victoria, B.C. 57pp.

Strickland, M.A., C.W. Douglas, M. Novak, and N.P. Hundzinger. 1982. pp.599-612 In: J.A. Chapman and G.A. Feidhamer, eds. Wild mammals of North America. Johns Hopkins Univ. Press, Baltimore, Md. 1184pp.

Thompson, I.D. and P.W. Coglan. 1987. Numerical responses of martens to a food shortage in northcentral Ontario. J. Wildl. Manage. 51:824-835.

U.S. Fish and Wildlife Service. 1985. Kenai National Wildlife Refuge, Final Comprehensive Conservation Plan. Soldotna, Ak. 195pp.

Vernam, D.J. 1987. Marten habitat use in the Bear Creek Burn, Alaska. M.S. Thesis, Univ. of Alaska, Fairbanks. 72pp.

Viereck, L.A. and E.L. Little, Jr. 1972. Alaska trees and shrubs. U.S. Dep. Agric. For. Serv. Agric. Handbook No. 410. 265pp.

Weckworth. R.P. and V.D. Hawley. 1962. Marten food habits and population fluctuations in Montana. J. Wildl. Manage. 26:55-74.

Wynne, K.M. and J.A. Sherburne. 1984. Summer home range use by adult marten in northwestern Maine. Can. J. Zool. 62:941-943.

Yeager, L.H. 1950. Implications of some harvest and habitat factors on pine marten management. Wildl. Con. 15:319-334.

Zielinski, W.J. 1981. Food habits, activity patterns, and ectoparosites of the pine marten at Sagehen Creek, California. M.S. Thesis, Univ. of California, Berkeley. 121pp.

Table 1. Summary of marten captured on the Kenai National Wildlife Refuge, June 1986 - August 1988.

Marten Number	Study Area	Sex	Age at First Capture	Measurements at First Capture: Weight(g)	Body Length(cm)	Tail Length(cm)	Hind Foot Length(cm)	Date of First Capture	Number Times Captured	Number Radio Locations	Total Home Range Size(km^2)	Date of Last Radio Contact	Fate
M401	SC	M	Ad.	907	438	178	102	06/25/86	10	30	6.61	02/25/87	Live Trap Mortality
M451	PL	M	Ad.	1134	470	188	81	07/29/86	3	25	9.24	02/05/88	Collar Shed
M403	PL	M	Juv.	907	400	155	83	07/31/86	4	17	3.63	01/30/87	Collar Shed
M426	PL	M	Juv.	907	460	170	90	08/26/86	1	2	--	08/27/86	Collar Shed
M476	SC	M	Juv.	907	460	180	90	10/31/86	12	46	3.46	06/19/87	Dispersed from Study Area
M472	SC	M	Juv.	907	470	180	90	11/15/86	1	2	--	12/10/86	Collar Shed
M407	PL	M	Juv.	795	410	180	85	09/17/87	1	14	a	04/27/88	Lost Radio Contact
M498	SC	M	Ad.	907	445	165	90	11/05/87	5	35	3.69	07/27/88	Lost Radio Contact
M876	UR	F	Juv.	680	413	163	--	09/11/86	1	6	0.82	10/31/86	Collar Shed
M470	SC	F	Juv.	850	415	155	75	01/23/87	17	64	5.46	06/16/88	Lost Radio Contact
M405	PL	F	Juv.	680	400	95	70	09/16/87	1	4	0.46	09/28/87	Collar Shed

a. This marten did not appear to establish a home range during radio contact

Table 2. Maximum distance marten radiocollard on the Kenai National Wildlife Refuge moved east and west of their original capture site, 1986-1988.

Marten I.D. Number	Age	Sex	West	East
M401	Ad	M		6.50
M451	Ad	M	0.81	2.42
M403	Juv.	M	0.56	2.74
M426	Juv.	M		
M476	Juv.	M	1.10	4.03
M472	Juv.	M		0.89
M407	Juv.	M		10.00
M498	Ad.	M	1.45	1.10
M876	Juv.	F	1.13	
M470	Juv.	F	1.21	1.05
M405	Juv.	F		0.73
Mean			0.57	2.68

10 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 10

Distance (km)

Table 3. Seasonal food habits derived from analysis of 143 marten scats collected on the Kenai National Wildlife Refuge, 1986-1988.

Species	Spring %FO	Spring %Vol	Summer %FO	Summer %Vol	Autumn %FO	Autumn %Vol	Winter %FO	Winter %Vol	Total %FO	Total %Vol
Red-backed Vole	27.8	34.9	21.0	27.7	16.7	19.4	18.2	26.2	20.7	26.9
Tundra Vole	7.7	10.8	17.7	21.8	2.6	3.2	0	0	6.6	8.9
Unid. Microtus	0	0	3.2	3.7	1.3	0.5	0	0	1.1	1.0
N. Bog Lemming	3.1	4.3	14.5	13.8	2.6	3.8	3.0	3.7	5.5	5.4
Masked Shrew	3.1	0.6	0	0	0	0	1.5	0.3	1.1	0.2
Unid. Small Mammal	1.5	0.3	11.3	14.9	5.1	4.7	3.0	4.2	5.2	6.0
Red Squirrel	13.8	21.2	0	0	0	0	3.0	5.0	4.1	6.4
Snowshoe Hare	4.6	8.0	0	0	0	0	13.6	17.2	4.4	6.1
Unid Mammal	1.5	2.7	1.6	1.0	1.3	0.3	5.1	2.8	2.6	1.7
Total Mammal	63.1	82.8	69.3	82.9	29.6	31.9	48.4	59.4	51.3	63.6
Bird	16.9	8.7	9.7	6.8	9.0	2.5	9.1	5.3	11.1	5.8
Mountain Ash	1.5	2.7	0	0	33.3	52.8	16.7	22.2	14.0	20.0
Crowberry	6.2	0.6	6.5	5.5	9.0	8.9	0	0	5.5	3.8
Low Bush Cranberry	0	0	1.6	0.3	1.3	0.3	1.5	0.3	1.1	0.2
Bait Remains	9.2	4.7	0	0	7.7	1.7	16.7	10.3	8.5	4.2
Pacific Red Elder	1.5	0.3	0	0	2.6	0.5	0	0	1.1	0.2
Western Serviceberry	0	0	0	0	0	0	4.5	0.8	1.1	0.2
Vaccinium sp.	0	0	0	0	0	0	1.5	0.3	0.4	0.1
Rubus sp.	0	0	0	0	5.1	1.0	0	0	1.5	0.3
Blueberry	0	0	1.6	0.6	1.3	0.3	0	0	0.7	0.2
Trailing Black Current	0	0	1.6	2.6	0	0	0	0	0.4	0.6
Devil's Club	0	0	0	0	1.3	0.3	0	0	0.4	0.1
Lichen	1.5	0.3	0	0	0	0	1.5	1.5	0.7	0.5
Total Fruit	19.9	8.6	11.3	9.0	61.6	65.8	42.4	35.4	35.4	30.4
Insect	0	0	9.7	1.3	0	0	0	0	2.2	0.3
Total	99.9	100.1	100.0	100.0	100.2	100.2	99.9	100.1	100.0	100.1

Table 4. Summary of habitat features measured in the Kenai National Wildlife Refuge marten study areas.

Habitat Feature	Areas Supporting Marten: Surprise Creek	Pothole Lake	Cottonwood Creek	Subtotal	Reintroduction Site: Big Indian Creek Area	Grand Mean
Stand Age	129(yrs)	138	113	128	135	131
Canopy Cover:						
Live Evergreen	26.4(%)	46.7	43.1	35.0	55.3	42.1
Beetle-killed 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 No./Transect	9.3(snags)	7.2	7.0	8.3	4.3	6.9
Mean Height	15.6(m)	11.7	8.8	13.6	7.8	12.4
Mean DBH	25.6(cm)	21.0	17.4	23.3	19.7	22.5
Mean Basal Area	9.6(m^2/ha)	5.0	3.3	7.1	2.6	5.5
Mean Decay Class	3.6	3.9	4.2	3.8	4.8	4.0
Downed Logs:						
Mean No./Transects	11.9 (logs)	7.2	7.1	9.7	6.6	8.6
Mean Mp Diameter	7.4 (cm)	6.3	6.0	7.0	6.8	6.9
Mean Ground Coverage per transect	430.2(cm)	141.1	92.5	288.2	91.8	218.1
Mean Decay Class	2.0	1.6	1.4	1.8	1.9	1.8
Mean Forest Opening per transect	2.8(m)	2.9	1.6	2.6	3.2	2.8

Table 5. Results of small mammal trapping conducted in marten habitat on the Kenai National Wildlife Refuge, 1986-1988.

Year	Red-backed Vole	Tundra Vole	Bog Lemming	Masked Shrew	Total	TN	Captures Per 100TN
1986	4	0	0	8	12	720	1.67
1987	21	0	0	7	28	485	5.77
1988	20	2	1	3	26	120	21.67
TOTAL	45	2	1	18	66	1325	4.98

Table 6. Percent use of habitat features over 12.2 km of marten snowtracking on the Kenai National Wildlife Refuge.

Habitat Feature	Meters of Tracks	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 7. Percent occurrence of behaviors over 12.2km of marten snowtracking on the Kenai National Wildlife Refuge.

Behavior	Number Occurrences	Percent Occurrence
Travelling	149	44.3
Travelling/Hunting	82	24.4
Hunting	12	3.6
Resting	1	0.3
Prey Capture	0	0
Investigate Hole	67	19.9
Interaction	1	0.3
Urination/Defecation	24	7.1
Total	336	99.9

Table 8. Snow measurements and thermal indexes for three areas of the Kenai Peninsula and interior Alaska derived from U.S. Soil Conservation Service 25-year average data (1961-1985).

Sample Sites	Elevation(m)	February Snow Depth(cm)	Snow Density(g/cm^3)	Thermal Index(cm*cm^3/g)
Kenai Peninsula				
Low Elevation:				
Kenai Moose Pens	91	23	0.24	96
Jean Lake	189	33	0.21	157
Snug Harbor Road	152	26	0.23	113
Mean	144	27.3	0.23	122
Conditions Similar To Reintroduction Site:				
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 Habitat:				
Upper Russian Lake	213	95	0.30	317
Cooper Lake	366	95	0.30	317
Ski 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
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

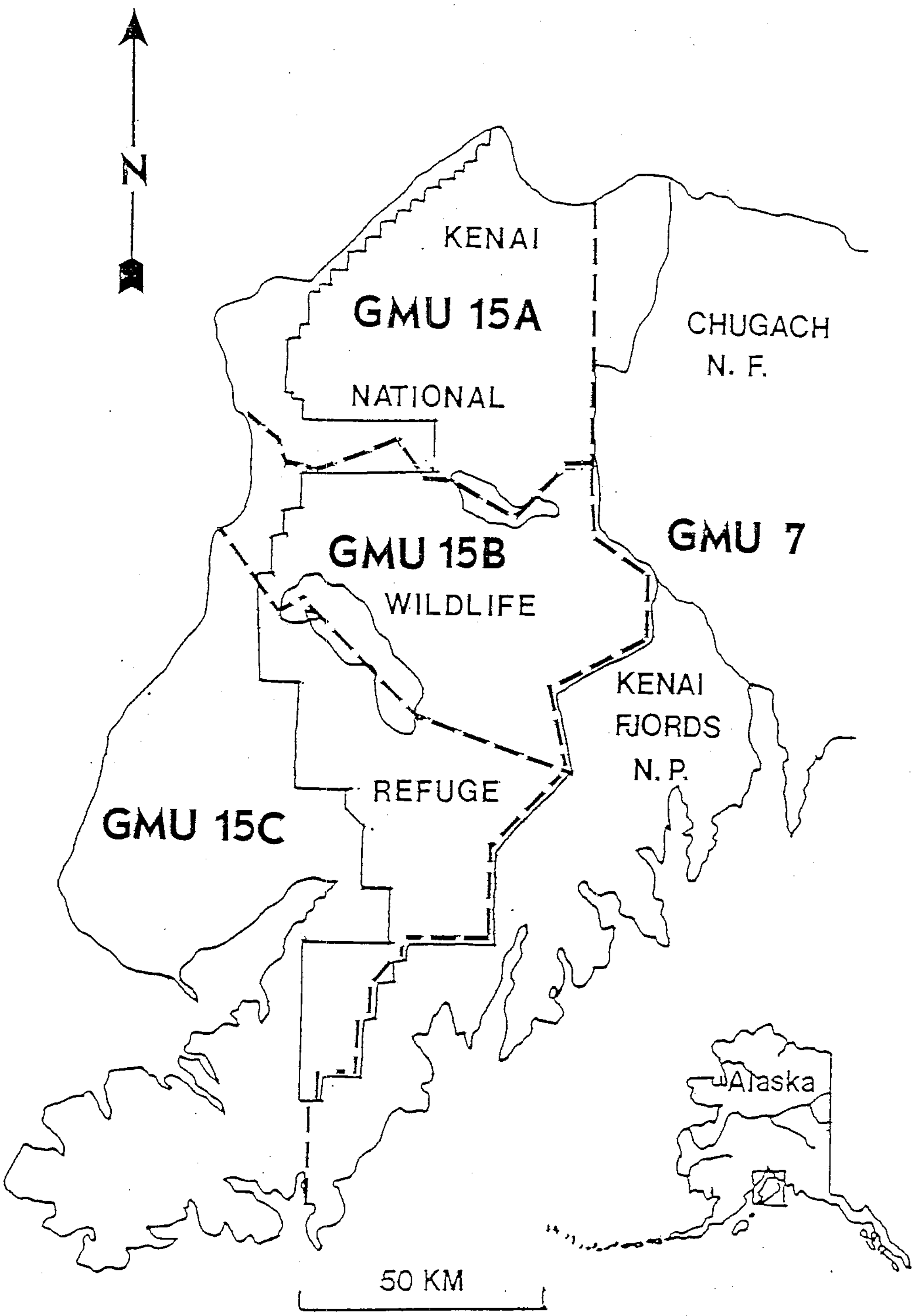

Figure 1. Kenai Peninsula and location of Kenai National Wildlife Refuge in relation to Alaska Department of Fish and Game game management units.

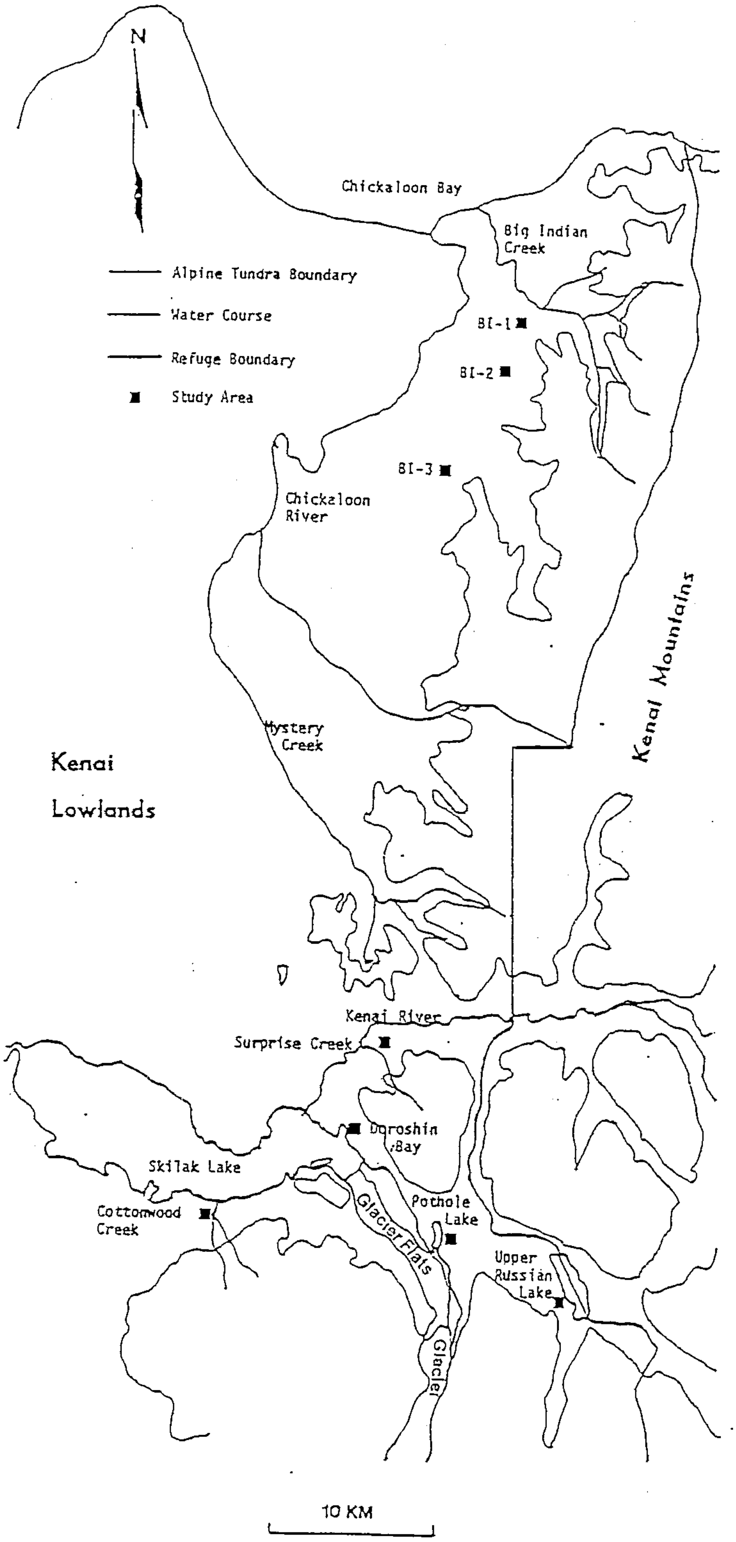

Figure 2. Locations of marten study areas in relation to geographic features on the Kenai National Wildlife Refuge.

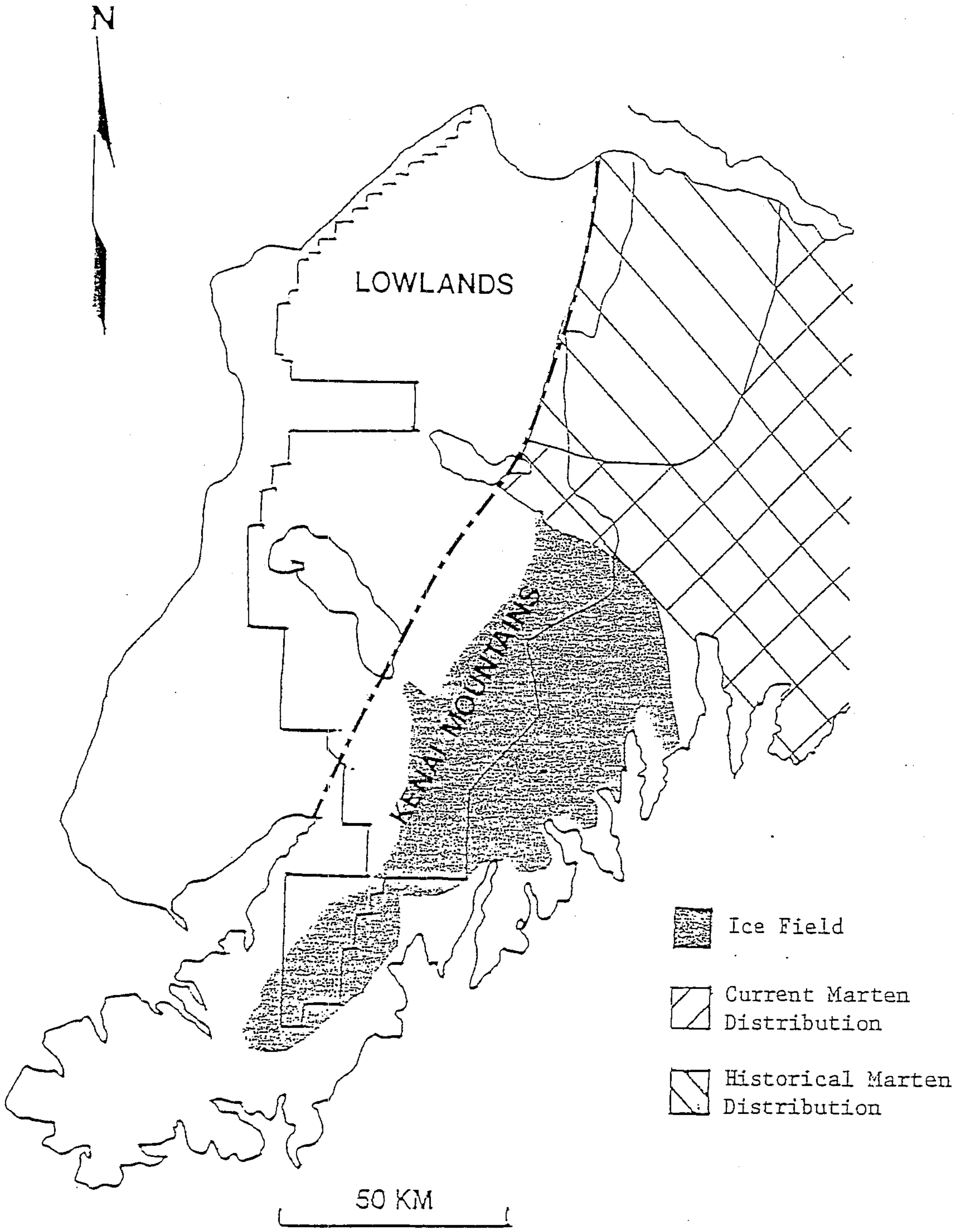

Figure 3. Current and historical marten distribution on the Kenai Peninsula.

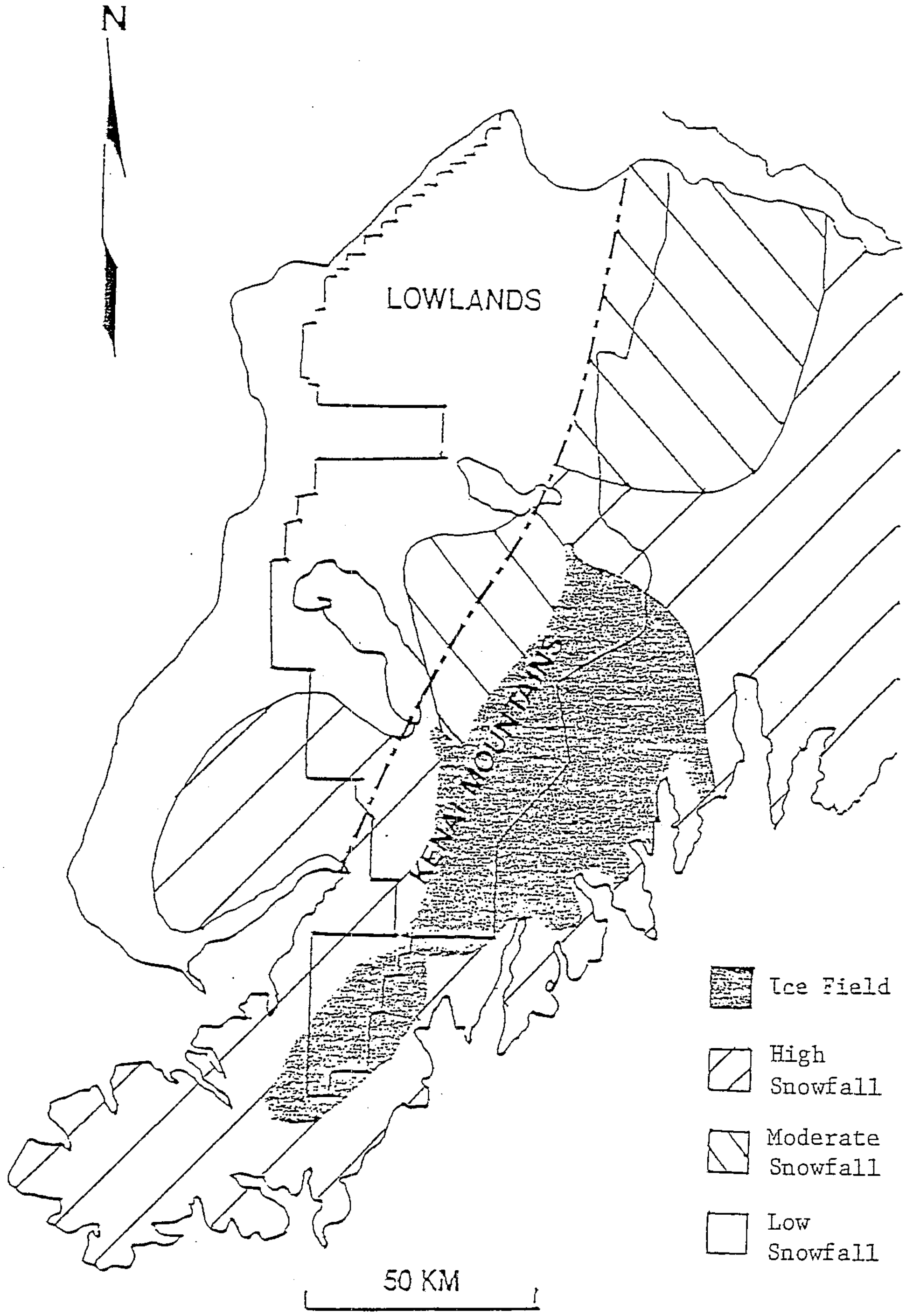

Figure 4. Approximate distribution of relative snowfall patterns on the Kenai Peninsula.

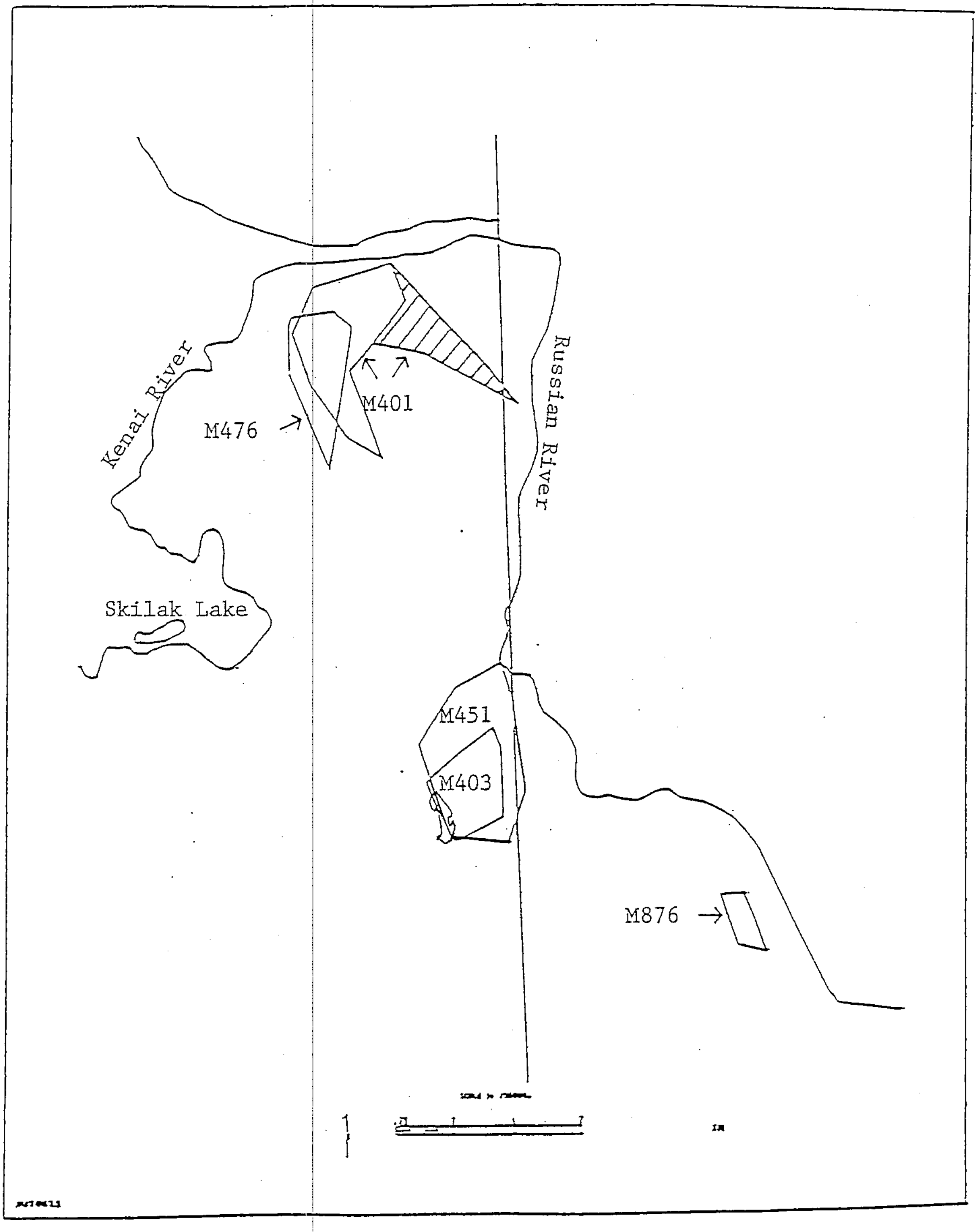

Figure 5. Radiocollared marten home ranges on the Kenai National Wildlife Refuge, June - December 1986. Shaded area indicates exploratory movement.

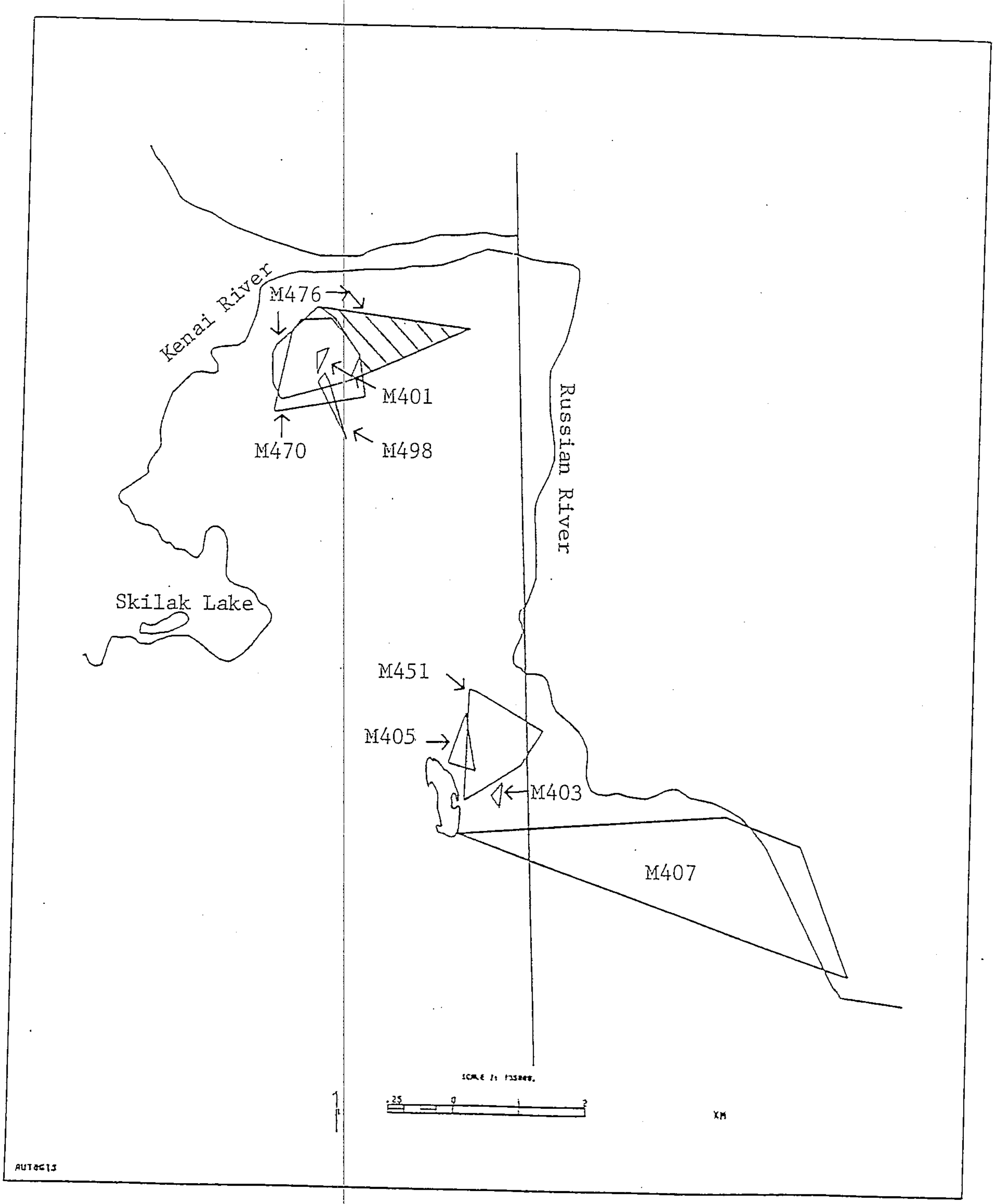

Figure 6. Radiocollared marten home ranges on the Kenai National Wildlife Refuge, January - December 1987. Shaded area indicates exploratory movement.

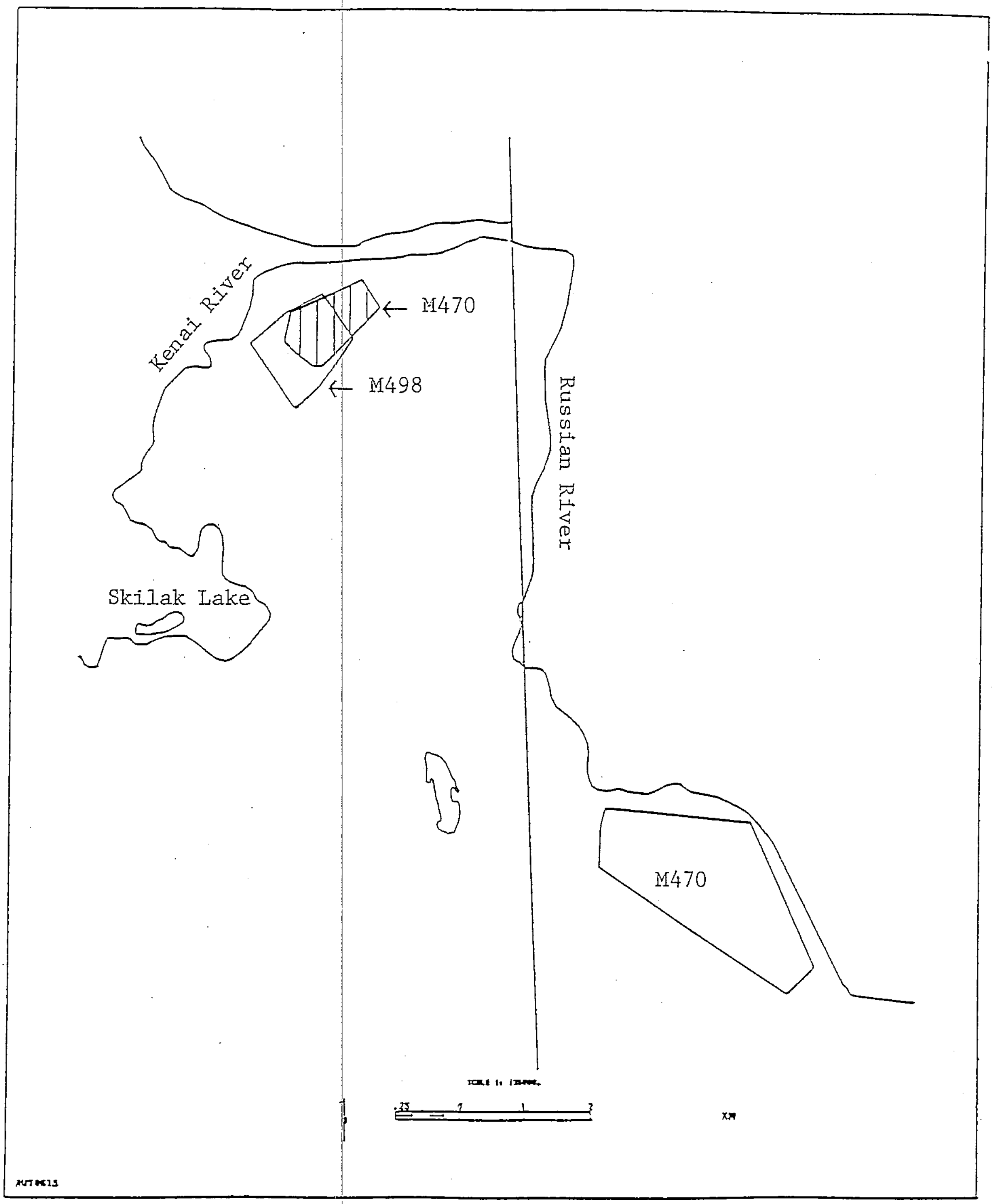

Figure 7. Radiocollared marten home ranges on the Kenai National Wildlife Refuge, January - July 1988. Shaded area indicates home range of M470.