# MARTEN HABITAT USE IN THE BEAR CREEK BURN ALASKA

A

THESIS

MASTER OF SCIENCE

By

Donald James Vernam, B.S.

Fairbanks, Alaska

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Presented to the Faculty of the University of Alaska

in Partial Fulfillment of the Requirements

for the Degree of

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The known is finite, the unknown infinite; intellectually we stand on an islet in the midst of an illimitable ocean of inexplicability. Our business in every generation is to reclaim a little more land.

-T. H. Huxley, 1887

ABSTRACT

Habitat use patterns of marten were examined in the Bear Creek Burn, interior Alaska from February through August, 1985. Study objectives were to delineate home ranges, describe habitat use, and sample microtine prey and berry crop abundance in burned and unburned areas.

Ten marten (5 male, 5 female) were live-trapped. Nine had radio transmitters surgically implanted within the peritoneal cavity.

Over 60% of the 200 $km^2$ study area burned in 1977. Marten home ranges occupied both burned and unburned habitats. Home ranges were selectively chosen along riparian zones where windthrown trees provided overhead cover. Squirrel middens in unburned inclusions were important as resting areas.

Small mammal traplines produced more red-backed voles in unburned habitat and more *Microtus* species in burned habitat. Greatest berry production was found in unburned black spruce and open conifer-wet meadow areas. The effects of the Bear Creek Burn on marten habitat are discussed.

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# INTRODUCTION

Pine marten (*Martes americana*) are ecologically and economically important furbearers. They are found throughout the forested regions of Alaska, Canada, and the western and northeastern portions of the United States (Hagmeier 1956). In Alaska, they are the primary target for most commercial and recreational trappers due to their relative value, abundance and ease of capture. For at least the past five years, the harvest of marten in Alaska has annually produced over one million dollars worth of fur (H. Melchior, pers. comm.).

Most historical perspectives and some more recent reviews of marten distribution and habitat use emphasize the importance of maintaining mature stands of coniferous or mixed coniferous-deciduous trees to satisfy food and cover requirements (Marshall 1951a, Lensink 1953, Edwards 1954, Allen 1984, Taylor and Abrey 1982). One of the main points of discussion of marten habitat relates to the homogeneity and age of the stand, and whether marten use meadows or openings in the forest. Some authors (Marshall 1951a, Lensink 1953, Allen 1984), have stressed that old growth coniferous stands should be maintained for optimal habitat whereas others (Koehler and Hornocker 1977, Bunnell 1980, Steventon and Major 1982, Spencer et al. 1983, Buskirk and MacDonald 1984) have suggested that heterogeneous stands (mature conifers interspersed with meadows or plants representing seral stages) provide both cover and a greater diversity of forage items (primarily microtines and berries).

Fires, whether natural or human-caused, play an integral part in determining the vegetative complex throughout much of boreal North America. In Alaska, fire is the principal factor creating forest openings and maintaining heterogeneous habitat types. It has been estimated that in Alaska from 1900 to 1940 (before active fire control and when human-caused fires were at a peak), an average of 1.5 to 2.5 million acres burned annually (Barney 1971). After 1940, when fire control was initiated coincident with increased access to remote lands, roughly one million acres have burned annually. Fires have variable effects on forested areas depending on site factors, burn intensity, and meterological conditions, but fires generally act to increase plant species diversity and produce stands representing early successional stages. It follows that if marten are closely tied to very old forest communities, fires would be largely detrimental to their habitat needs.

Although fire historically has been used for habitat manipulation by various Native peoples, land managers have only recently recognized fire as a useful wildlife management tool. During the early part of this century, Brabant (1922) cautioned that uncontrolled forest fires were decimating furbearer populations across Canada, and Edwards (1954) believed that a fire in Wells Gray Park in British Columbia had destroyed marten habitat for decades. In Alaska, Lensink (1953) advocated the control of forest fires as one management technique favoring marten populations and this idea has been included in current state marten management policies (AK Dept. of Fish and Game 1980). More recently, Bunnell (1980) reviewed the scant literature on fire effects on furbearers and concluded that small fires were most likely not detrimental to marten and may even help them by providing openings in the forest canopy where increased herbaceous ground cover allows for increased microtine prey abundance. Similarly, Koehler and Hornocker (1977) suggested that fires may help to support more marten over time by creating a favorable mosaic of forest types. The only study done in Alaska on the relationship between fire and marten is an extensive review of trapper´s opinions by Stephenson (1983). Although opinions varied on the timing and extent of use of burns by marten, most trappers believed that fires were generally beneficial, especially if the fire left many unburned inclusions.

As a response to a need for information on the effects of fire on marten habitat quality and use in Alaska, a joint federal (BLM)/ state (ADFG) project was initiated in 1984 in the Bear Creek Burn in interior Alaska (Magoun and Vernam 1986). The study reported here was a part of that larger project and was designed to evaluate the habitat use patterns of marten within this burn. Specific study objectives were to:

1. delineate home ranges of marten,
2. describe their habitat use, and
3. develop an index of microtine prey and berry crop abundance

in habitat types where marten lived within and adjacent to burned areas. The hypothesis tested was that burned areas did not provide adequate marten winter habitat. The sampling of small mammals and berry production was done to compare the primary foods of marten (Buskirk and MacDonald 1984) between burned and unburned habitat types.

## STUDY AREA

The Bear Creek Burn is approximately 480 km southwest of Fairbanks and about 65 km east of McGrath, Alaska on the northwest side of the Alaska Range (Fig.1). This fire burned approximately 142,000 ha in August 1977 (Waggoner and Hinkes 1983). Part of the southern portion of the burn (not included in this study area) previously burned in 1972. Vegetation in the area prior to the fire was typical of the forest communities of interior Alaska with extensive stands of white spruce (*Picea glauca*), mixedwood [white spruce, white birch (*Betula papyrifera*)], and cottonwood (*Populus balsamifera*) along major drainages, and aspen (*P. tremuloides*) on ridges and south-facing slopes. Extensive stands of black spruce (*Picea mariana*) occurred in the lowlands and were intermixed with tamarack (*Larix laricina*) and bog shrub species (Knapp 1982).

A 200 $km^2$ study area was selected at the northern edge of the burn near the confluence of the Salmon and Pitka Fork rivers. This area was selected because 1. the area supported marten within both burned and unburned areas based on track sign and conversations with local trappers, 2. there was a variety of habitat types available for sampling, and 3. the area was accessible in winter by snowmachine from the village of Nikolai and in summer by riverboat from McGrath.

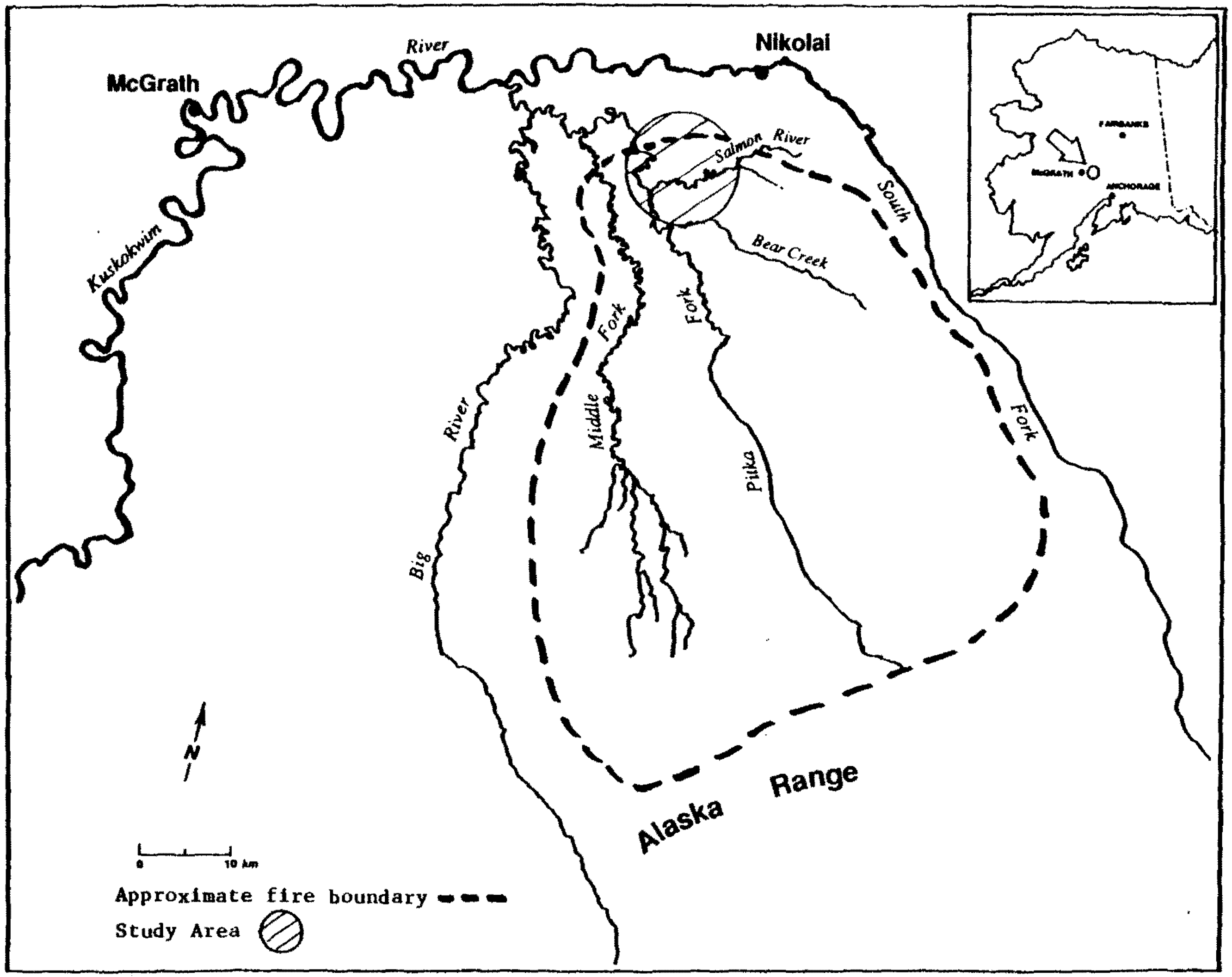


Figure 1. The Bear Creek Burn study area, interior Alaska.

The study area is generally flat terrain at about 125 m above sea level. There are a few narrow ridges in the area which provided 16-31 m-high elevated sites for improved telemetry reception. The Salmon and Pitka Fork rivers are both slow-flowing and are approximately 50 m in width. Much of the area consists of extensive lowland bogs with many small ponds scattered throughout. A detailed description of the vegetation types can be found in the Vegetative Composition of Habitat Types section (p. 23).

Climate in the area is typical of interior Alaska with cool, moist summers and cold, dry winters. Average precipitation at McGrath is 38.9 cm (NOAA 1985). Temperatures at McGrath range from a low average monthly in January of -23.4 $^{o}$C to a high average of 14.6 $^{o}$C in July. Temperature extremes measured at the base camp were -46 $^{o}$C on 20 February 1985 to 31 $^{o}$C on 18 July 1985.

Vertebrate fauna observed or known to occur (R. Pegau, pers. comm.) in the study area include 28 mammal, 62 bird, and 1 amphibian species (Appendix 1). In addition to marten, five species of mustelids occur in the area: mink (<u>Mustela vison</u>), short-tailed weasel (<u>M.erminea</u>), least weasel (<u>M.nivalis</u>), river otter (<u>Lutra canadensis</u>), and wolverine (<u>Gulo gulo</u>).

Historical trapping pressure in the area appears to be light to moderate with most trappers operating out of Nikolai (J.Stokes, pers. comm.). Two Athabascan Indian fishing camps are located on the Salmon River and are used primarily in July during the king salmon

(*Oncorynchus tshawytscha*) migration. The historic Iditarod Trail passes through the area and is used for access from Nikolai in to the burn as well as for the annual sled dog race in March.

METHODS

## General

Preliminary field work was conducted in March, April, and August 1984. An insulated wall tent was used as a base camp approximately 0.4 km below the confluence of the Salmon and Pitka Fork rivers. Transportation in the area was by snowmachine, skis, snowshoes, and ski-equipped airplane in winter, and by flatbottom riverboat, motorized canoe, and foot in summer. Intensive field work occurred from February through August 1985, with a 1 month interruption during spring break-up in May.

## Marten Capture and Radio-tagging

Marten were trapped using single- and double-door wire mesh livetraps (18cm x 18cm x 61cm and 28cm x 28cm x 91cm) (Tomahawk Live Trap Co., Tomahawk, WI). Sardines were used as bait and drops of anise or wintergreen oil were placed on elevated branches as an additional attractant. Traps were checked twice daily and closed at temperatures below -29 $^{o}$C. Initially, traps were placed randomly in all habitats regardless of the presence of marten sign. To increase capture success, traps were later concentrated in areas with marten sign, most often within 500 m of the rivers.

Once a marten was captured, a blanket or foam pad was placed around the trap to minimize disturbance during transport to the base camp. There, the animal was placed in a wire holding cone where it was weighed and anesthetized intramuscularly with 0.4 ml Xylazine (Rompun, Cutter Laboratories, Shawnee, KA, 20 mg/ml), 0.5 ml Ketamine Hydrochloride (Vetalar, Parke-Davis and Co., Detroit, MI, 100 mg/ml), and 1.0 ml Atropine Sulfate (Northwest Veterinary Supply, Portland, OR, 0.5 mg/ml) through separate injections. This dosage maintained a state of heavy sedation for 45-60 min during which time a 26.5 g, 6.0 cm x 2.0 cm cylindrical transmitter (Telonics IMP/200/L, Mesa, AZ) was surgically implanted in the peritoneal cavity. Sterile surgery techniques were used to insert the transmitter through a 3 cm incision approximately 1 cm posterior to the last rib on either the right or left side of the animal. The surgical procedure required 20-45 min.

While the animals were still anesthetized, a premolar was removed for age determination, and eartags were inserted using standard plastic rototags (Nasco West, Modesto, CA). The eartags were trimmed to about half their original size to minimize interference to the animals. Sex, reproductive condition, development of sagittal crest (for relative aging, Marshall 1951b), and standard body measurements were noted (Appendix 2). Radio-tagged marten were released at their capture site once they had regained full mobility, usually 3-10 hr after surgery.

## Radio-telemetry and Habitat Use

Most observations of radioed marten were made from the ground. Two stationary 8 m-high towers equipped with dual 4-element null/peak Yagi antennae were placed on ridges at the highest points in the study area. Signals from several animals could be received from each tower. These towers were used simultaneously to triangulate bearings and fix animal locations on standard 1:63,360 scale topographic maps or on 1:15,000 scale NASA high altitude infrared photographs. The accuracy of position fixes was verified on several occasions by walking to resting animals and it was found to be within 100-200 m at distances up to 2.4-3.2 km. If radio signals were not detected from the stationary towers, attempts were made to locate the animals by searching the study area via snowmachine or boat using a hand-held Telonics "H" antenna.

Attempts were made to locate all animals daily. At 15-min intervals, two observers at known locations recorded the bearings of the animal(s) and whether the animal(s) was (were) active or resting. Activity was identified when varying signal strength occurred over an approximately 1-min listening period. An animal was considered resting if signal variation and location did not change for 1 hr or more. Monitoring periods lasted for 6 hr unless the animals moved out of reception range (2.4-3.2 km for fixed towers, 0.4-0.8 km for hand-held antenna).

Home ranges were described by connecting the outermost points of radio locations. Home ranges were drawn for animals with more than four locations, but I believed that at least 10 observations on separate days were required to describe home range boundaries accurately. Less than 10 locations could only provide general information on the area used by the animal immediately after being released.

The reason for locating radioed marten was to determine patterns of habitat use. For this objective, animals were located from the ground. If the animals were active, triangulated bearings were plotted on maps. If the animals were resting, the resting site was located. The resting animal's signal was continuously monitored to determine if the observer's approach caused the animal to move. In cases where the animal did not move, characteristics of the resting site [vegetation, location under or above ground, and presence or absence of red squirrel (<u>Tamiasciurus</u> <u>hudsonicus</u>) sign within a 50 m radius] were recorded. These locations, as well as locations plotted during continuous monitoring periods, were transferred to acetate overlays on the color infrared photographs and placed into one of ten habitat types.

From the color infrared photographs, habitat categories could be outlined based on color rendition and textured appearances of the vegetation. The scale of the maps (1:15,000) was such that groups of trees could be recognized easily. Ground truthing provided a check and key for the various habitat categories. Marten location points were placed into one of ten habitat types unless they were within 150-200 m of the edge of two habitats when they were classified as being within the edge. For purposes of analysis, those locations classified as edges (approx. 20% of total) were reclassified evenly into the two habitats involved. For example, if there were six locations in the edge of burned and unburned white spruce, three were placed into the burned white spruce category and three were placed into the unburned white spruce category. Often, exact habitat types were known from ground locations. The area included by each habitat type was measured on a digital plotter from the infrared photos. Spearman's Rho rank correlation was used to test the hypothesis that marten used habitat types in proportion to their occurrence within each home range. Additionally, the proportion of habitat types within each home range was compared with the proportions of types in the entire study area to determine if marten home ranges were selectively chosen based on habitat type.

## Vegetation and Berry Sampling

Sampling of vegetation and berry production was done with a two-stage design similar to that of Smith (1984). To compare burned (as a result of the 1977 fire) and unburned areas, I selected four similar habitat types in each of the two categories. The habitat types sampled included white spruce, mixedwood, open conifer-wet meadow, and black spruce. Additionally, unburned wet meadow was sampled because this type was common in the study area. It was not possible to determine if wet meadows had been burned due to the lack of fire-scarred woody vegetation. All plots were sampled between 30 July and 3 August 1985.

The locations of the major (stage 1) habitat types sampled were chosen based on observations during travel throughout the study area and from examination of aerial photographs. Extent of stand and ease of access were the main criteria for selection. Two areas of each habitat type were sampled with the exception of burned open conifer-wet meadow which was sampled in only one area.

Before I arrived at each site, 10 randomly chosen points were selected from a paper grid representing an area 30 m x 30 m containing 900 1-$m^2$ plots. Once at a site, the initial starting point was chosen randomly and the imaginary grid aligned with the left edge in a north/south direction. Each of the 10 1-$m^2$ plots was located with a compass and measuring tape.

A wooden frame 1 m x 1 m was placed at each (stage 2) sampling location. Within the frame, the composition and percent cover of overstory, shrub, and ground level species (except lichens) were recorded as were the amounts of windthrown trees and litter. Additionally, any berries on the plot were picked and counted to develop an index of abundance. Analysis of the vegetation composition was done by summing the 20 plots (10 plots in each of two similar habitats) to determine percent cover and composition.

## Small Mammal Trapping

Small mammal traplines were established in August, 1984 and 1985. In 1984, two habitat types (unburned white spruce and burned white spruce) were selected for sampling. Two, 250 m-long traplines were established in each habitat type. Trap stations were located at 25 m intervals with two small snaptraps and one Museum Special snaptrap placed at each station. Traps were set for three nights for a total of 450 trap-nights per habitat. Bait used was a mixture of peanut butter and oatmeal.

In 1985, two additional habitat types were sampled (unburned and burned black spruce). In each of the four habitat types, one 500 m-long line was established with stations every 10 m. At each station, two small snaptraps, one Museum Special, and one cone pitfall trap were set for three nights for a total of 600 trap-nights per habitat.

# RESULTS

## Marten Capture and Radio-telemetry

Ten marten (5 males, 5 females) were captured in 1985 (Table 1). Five of these (F-07, F-09, M-06, F-11, F-15) were known residents of the study area and I believed all resident marten within the study area were captured. F-07 died before 31 May 1985, three months post-capture, and was probably killed by a mammalian predator. The transmitters in F-11 and F-09 failed one and five months, respectively, after implantation. The ultimate fate of F-09 was unknown while F-11 was caught by a trapper in January 1986. M-06's transmitter operated through October 1985. Although F-15's transmitter failed after the end of July 1985, she was located several times at a den and was presumed to have raised a litter of young.

Male M-03 was initially captured in April, 1984 (Magoun and Vernam 1986) and was recaptured on 3 March 1985. The old transmitter was replaced, but the animal was found dead six days following reimplantation. It is unknown if his death was caused by the second implantation, but it is probable that complications following surgery were at least partially responsible.

Table 1. Status of marten captured on the Bear Creek Burn study area, interior Alaska, 1985.

| Animal No. [1] | Date of Capture | Age | Status | Date of last Observation | Fate |
|---|---|---|---|---|---|
| M-03 [2] | 4/08/84<br>4/11/84<br>4/12/84<br>3/03/85 | N/A | Resident | 3/09/85 | Died |
| F-07 | 3/03/85<br>3/21/85 | N/A | Resident | 5/31/85 | Died |
| F-09 | 3/11/85 | N/A | Resident | 7/24/85 | Radio Failure |
| M-06 | 3/15/85<br>3/19/85<br>3/21/85<br>3/22/85<br>6/14/85 | 2 | Resident | 10/26/85 | Radio Failure |
| F-11 | 3/20/85 | N/A | Resident | 4/22/85 | Radio Failure, Caught by Trapper in January 1986 |
| M-08 | 3/21/85 | 2 | Probable Resident | 4/09/85 | Died |
| M-10 | 3/21/85 | N/A | Probable Resident | 4/12/85 | Died |
| F-13 [3] | 3/23/85 | 1 | Unknown | -- | -- |
| F-15 | 3/24/85 | 4 | Resident | 7/24/85 | Radio Failure |
| M-12 | 4/03/85 | N/A | Transient | 4/12/85 | Radio Failure or Dispersal, Caught by Trapper in January 1986 |

1 M refers to males, F refers to females
2 Marten M-03 first implanted 4/03/84 (Magoun and Vernam), recaptured in 1985.
3 Female F-13 received eartags only.

Of the four additional animals captured in 1985, two (M-08 and M-10) were found dead 19 and 22 days, respectively, after implantation. F-13 received eartags only and was never recaptured. M-12 was probably a transient as I located him only three times subsequent to implantation and he was caught by a trapper in December 1985 approximately 60 km from his initial capture site.

## Home Range Size and Configuration

Most marten home ranges were centered on the Pitka Fork and Salmon rivers (Fig. 2). These rivers presented no barriers to movement even in summer as radio locations indicated that animals freely crossed them, sometimes more than once in a 24-hr period. One marten was observed swimming the Pitka Fork, even diving under water for a short distance before emerging on the bank.

Most of the home ranges are based only on locations from the ground, but the home ranges of females F-09 and F-15 include locations made during aerial tracking (Magoun and Vernam 1986) (Table 2). Observations from aerial tracking of M-06 are not included in these calculations as they disclosed what I consider to be an exploratory foray in May when he travelled 11 km from his normal area of activity. Including this foray would have increased his home range size from 7.5 $km^2$ to 23.0 $km^2$; deleting it does not alter the shape and size of

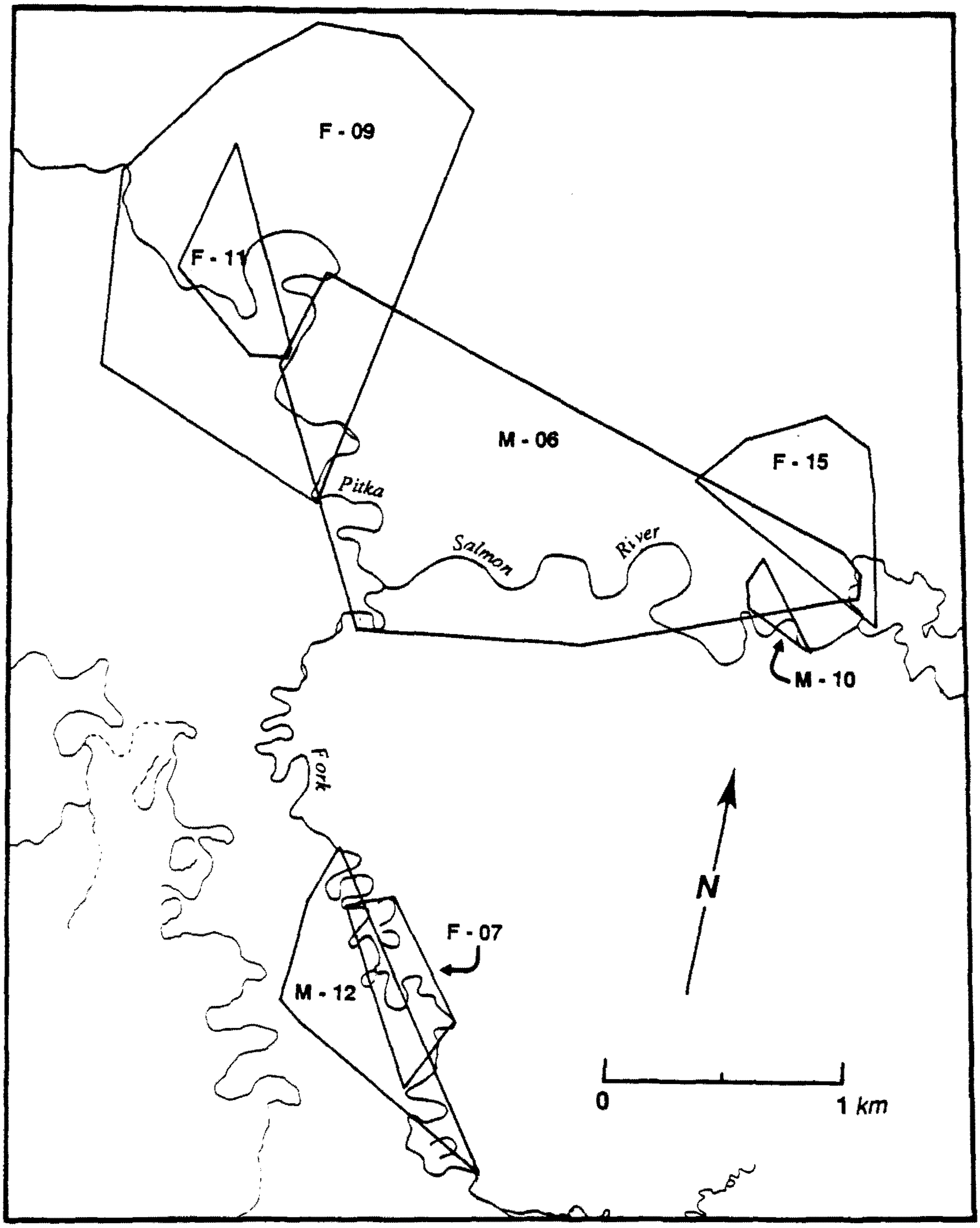


Figure 2. Home ranges of resident marten captured on the Bear Creek Burn study area, interior Alaska, 1985.

Table 2. Minimum home range size, number of locations, and tracking period for radio-tagged marten on the Bear Creek Burn study area, interior Alaska, 1985.

| Marten | Home Range ($km^2$) | No. Locations | Tracking Period |
|---|---|---|---|
| M-06 | 7.50 | 35 | Mar. - July |
| M-10 | 0.13 | 5 | Late Mar. - Early Apr. |
| M-12 | 1.38 | 6 | Apr. |
| F-07 | 0.63 | 17 | Mar. - May |
| F-09[1] | 7.10 | 46 | Mar. - July |
| F-11 | 0.74 | 14 | Mar. - Apr. |
| F-15[1] | 0.72 | 21 | Mar. - July |

[1] Includes aerial observations of Magoun and Vernam (1986).

his "area of most use".

It is difficult to compare the size of male and female home ranges as the number of locations recorded for two of three males was small. There was a positive correlation (r = 0.888) between the number of locations and the size of home ranges for all marten but this was a result of inclusion of the large home ranges of M-06 and F-09. Their home ranges were substantially larger than the other three females. F-07, F-11, and F-15 each had smaller and similarly sized home ranges with variable numbers of location points.

Although the monitoring period for most marten covered only the late winter and spring, there was an apparent shift and expansion of the home range of M-06. For about one month following his initial capture, M-06 occupied a range of about 2 $km^2$. During the first week of April 1985, he increased his range to include the ranges of F-09 and F-11. M-06 continued to occupy this larger area, periodically returning to his initial capture area, until radio contact was lost in July. Although F-09's range was substantially larger than those of the other females, and she was also followed into July, there was not much seasonal change in her area of occupation.

Home range boundaries and location points showed some overlap between and within sexes. For instance, F-09 completely overlapped F-11. Of particular interest is the overlap by M-06 of M-10's range. Males M-06 and M-10 were captured within 1 week of each other approximately 0.5 km apart. Another male (M-08, home range not determined due to only two locations) was also captured within the ranges of M-06 and M-10. Both M-08 and M-10 were found dead about 3 weeks following initial capture, while M-06 continued to occupy his home range through at least July 1985 when radio reception became intermittent.

## Vegetative Composition of Habitat Types

### Unburned Habitat

The five unburned habitat types sampled in the study area included white spruce, mixedwood, open conifer-wet meadow, black spruce, and wet meadow. In each stand, the mean percent cover of plant species in the overstory, shrub, and ground layers within plots was measured (Table 3). Berry producing plants are not included in this section; for a more complete description of these species, see the section on Berry Sampling.

A mixedwood stand is one in which neither coniferous nor deciduous tree species are considered dominant, but both contribute 25 to 75 percent of the total canopy cover (Viereck and Dyrness 1980). This type occurred most frequently on well-drained sites adjacent to

Table 3. Vegetative composition of habitat types within the Bear Creek Burn study area, interior Alaska, 1985 ($\bar{x}$ percent cover and number of occurrences on plots).

| | UNBURNED | | | | |
|---|---|---|---|---|---|
| | Mixedwood | White Spruce | Black Spruce | Open Conifer-Wet Meadow | Wet Meadow |
| OVERSTORY | | | | | |
| *Picea glauca* | 25.2, 11 | 48 | | | |
| *P. mariana* | | | 16.5, 10 | 2.0, 2 | |
| *Betula papyrifera* | 20.5, 8 | | | | |
| *Larix laricina* | | | 2.8, 3 | 10.4, 6 | |
| SHRUB | | | | | |
| *Ledum palustre* | | | 17.0, 19 | 1.4, 3 | |
| *Betula* spp. | | | 7.0, 11 | 9.8, 16 | |
| *Alnus* spp. | 40.8, 16 | 22 | | 9.6, 4 | |
| *Salix* spp. | 1.0, 2 | 3 | 2.5, 6 | 5.9, 9 | |
| *Spirea* spp. | | | | | |
| *Myrica gale* | | | 1.4, 4 | 4.8, 5 | |
| *Betula* sapling | | 6 | | | |
| *Picea* sapling | 1.4, 4 | | | | |
| *Populus* sapling | | | | | |
| GROUND | | | | | |
| Moss-Liverworts | 33.6, 19 | | 67.4, 19 | 4.2, 6 | 1.6, 5 |
| *Epilobium* spp. | | | | | |
| Litter | 60.4, 20 | | 6.0, 9 | 48.5, 20 | 50.8, 20 |
| Deadwood | 7.2, 5 | | 1.2, 4 | | |
| *Eqiusetum* spp. | 19.0, 18 | 16 | | | |
| Grass-sedge | | 1 | 3.8, 4 | 35.0, 17 | 57.2, 20 |
| Bare Ground | | | | | |
| *Picea* seedling | | | | | |
| Water | | | | | 5.8, 10 |
| *Potentilla* spp. | | | | 1.4, 7 | |
| Livewood | 1.2, 2 | | 4.2, 4 | | |
| *Cornus canadensis* | 12.4, 20 | 3 | | | |
| *Linneae borealis* | 3.5, 12 | 5 | | | |

Table 3. continued.

| | BURNED | | | |
|---|---|---|---|---|
| | Mixedwood | White Spruce | Black Spruce | Open Conifer-Wet Meadow[2] |
| **OVERSTORY** | | | | |
| *Picea glauca* | | | | |
| *P. mariana* | | | | |
| *Betula papyrifera* | | | | |
| *Larix laricina* | | | | |
| **SHRUB** | | | | |
| *Ledum palustre* | | | 13.3, 14 | 1.5, 7 |
| *Betula* spp. | | | 3.8, 10 | |
| *Alnus* spp. | | | 1.3, 2 | |
| *Salix* spp. | 5.2, 8 | | | |
| *Spirea* spp. | | | 2.2, 4 | |
| *Myrica gale* | | | | |
| *Betula sapling* | 22.0, 16 | 1.6, 4 | 5.8, 12 | |
| *Picea* sapling | | | | 3.0, 2 |
| *Populus* sapling | | | | |
| **GROUND** | | | | |
| Moss-Liverworts | 4.4, 12 | 21.4, 14 | 21.2, 17 | 32.0, 9 |
| *Epilobium* spp. | 12.3, 14 | 51.8, 20 | 1.1, 10 | |
| Litter | 32.8, 20 | 60.5, 20 | 40.2, 20 | 26.8, 10 |
| Deadwood | 15.5, 16 | 30.2, 19 | 7.2, 16 | 8.2, 9 |
| *Equisetum* spp. | 18.0, 14 | 14.0, 16 | 7.2, 9 | 13.5, 7 |
| Grass-sedge | 18.9, 12 | | 15.1, 17 | 23.0, 9 |
| Bare Ground | 1.0, 3 | | | 5.0, 2 |
| *Picea* seedling | | | 1.4, 17 | 5.3, 8 |
| Water | | | | |
| *Potentilla* spp. | | | | |
| Livewood | | | | |
| *Cornus canadensis* | | | | |
| *Linneae borealis* | | | | |

[1]Berry producing plants excluded.
[2]Only 10 plots sampled, all other plots n = 20.

the rivers. The mixedwood stands contained white spruce and birch, with a canopy cover of 25.2% and 20.5%, respectively. The shrub layer contained mostly alder (*Alnus* spp.) (40.8% canopy cover) with a small percentage of tree saplings and willow (*Salix* spp.). Ground cover was dominated by mosses and liverworts (33.6%). *Equisetum* spp. and dogwood (*Cornus canadensis*) were also present (19.0% and 12.4%, respectively). Litter covered approximately 60% of the ground in mixedwood stands.

Open conifer-wet meadow stands are those with widely spaced conifer species (primarily black spruce and tamarack) interspersed with wet meadow (grass-sedge) in poorly drained lowland areas. Tamarack was the most common tree species with 10.4% cover. The shrub layer consisted mainly of dwarf birch (*Betula* spp.), alder, willow, and *Myrica gale*. The ground layer had a 35.0% canopy cover for grass-sedge species, litter, and mosses and liverworts combined.

Black spruce stands were drier than the open conifer-wet meadow areas yet were also found in poorly drained sites and on north-facing low ridges. Black spruce was dominant over tamarack with a canopy cover of 16.5%. Labrador tea (*Ledum palustre*) and dwarf birch were most abundant in the shrub layer while mosses and liverworts dominated the ground cover with 67.4% cover.

The white spruce stands had a canopy cover of 48% for live trees. The shrub layer, consisting primarily of alder and wild rose (*Rosa acicularis*), had a canopy cover of 54%. Primary ground cover was litter (76% cover), mosses (62%), and twigs less than 5 cm in diameter (31%).

Tall shrub habitat was not sampled as it only occurred in short, narrow strips along the banks of the Salmon River. These were nearly homogeneous stands of willow with some alder.

Wet meadows were primarily grass-sedge communities without overstory or shrub species present. These areas were found mostly along old sloughs and ponds in the study area.

### Burned Habitat

Although many of the burned areas contained unburned inclusions, the sampled plots were located in totally burned sites. This was done to provide a clearer picture of the vegetative composition of burned habitats. Plots were sampled in mixedwood, open conifer-wet meadow, black spruce, and white spruce.

None of the burned habitat types contained live overstory species. The shrub layers were also not well developed. In the black spruce habitat type, Labrador tea, paper birch saplings, and dwarf birch had an approximate combined canopy cover of 23%. In mixedwood sites, paper birch occupied about 22% of the canopy. Most of these saplings were between 1.5 and 1.8 m tall.

Generally, the burned plots had a greater density and variety of ground cover than unburned sites. Deadwood occurred in all sites and ranged from 7.2% cover in black spruce to 30.2% cover in white spruce. There were also other differences in ground cover composition in the burned sites. In burned mixedwood stands, mosses and liverworts and litter cover were less than in the unburned mixedwood. Fireweed (Epilobium spp.) was not observed in the unburned mixedwood, but occupied 12.8% of the understory canopy in burned sites.

The burned open conifer-wet meadow stands had more mosses and liverworts as well as Equisetum and spruce seedlings than unburned stands. They were also generally drier than unburned sites. Grass-sedge species and the amount of litter on the ground was lower in the burned open conifer-wet meadow. In the burned black spruce sites, all ground species except mosses and liverworts and livewood had a greater canopy cover. Burned white spruce stands had over 50% cover of fireweed and the highest percent cover of deadwood of any burned stand. Equisetum and mosses and liverworts covered 14.0% and 21.4%, respectively, of the ground layer in burned white spruce. Burned wet meadow areas were not sampled; detection of the influence of fire in these communities was difficult because of the lack of fire-scarred vegetation. In addition, high moisture content would have limited burning frequency and intensity.

## Marten Habitat Use

All marten home ranges occupied both burned and unburned habitat types. Three of the females (F-09, F-11, and F-15) however, had home ranges of more than 60% unburned habitat. F-07 was the only female whose home range was primarily burned (94.7%) with the major habitat type being burned white spruce. Although F-07's range contained only 3.0% unburned white spruce, 25.0% of her locations occurred in this type, most in an approximate 25 x 70 m unburned inclusion.

The proportions of habitat types within all marten home ranges were independent of the distribution of habitat types outside the home range boundaries (Spearman's Rho, $p < 0.05$) (Table 4). In other words, home ranges were chosen in a nonrandom fashion based on habitat type. Most notably, marten home ranges contained proportionally more unburned and burned white spruce, unburned open conifer-wet meadow, unburned wet meadow, and less unburned and burned black spruce than areas outside home range boundaries.

Within home ranges, marten generally used habitat types in proportion to their occurrence (Table 5). For purposes of analysis, the ranks of use and availability were averaged for all females and it was determined that their use of habitats was dependent on the

Table 4. The proportions of habitat types within and outside marten home ranges on the Bear Creek Burn study area, interior Alaska, 1985.

| | Proportion Within Home Ranges | Proportion Outside Home Ranges |
|---|---|---|
| UNBURNED | | |
| Mixedwood | .032 | .006 |
| White Spruce | .060 | .007 |
| Black Spruce | .106 | .200 |
| Open Conifer-Wet Meadow | .160 | .083 |
| Wet Meadow | .121 | .039 |
| Shrub | .006 | .007 |
| BURNED | | |
| Mixedwood | .069 | .025 |
| White Spruce | .125 | .032 |
| Black Spruce | .027 | .270 |
| Open Conifer-Wet Meadow | .294 | .331 |
| | 1.000 | 1.000 |
| Total $km^2$ | 18.53 | 177.08 |

Table 5. Marten habitat use and available habitats within each home range on the Bear Creek Burn study area, interior Alaska, 1985.

| HABITAT | M-06 USE | M-06 AVAIL | M-10[1] USE | M-10[1] AVIAL | M-12[1] USE | M-12[1] AVAIL | F-07 USE | F-07 AVAIL | F-09 USE | F-09 AVAIL | F-11 USE | F-11 AVAIL | F-15 USE | F-15 AVAIL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **UNBURNED** | | | | | | | | | | | | | | |
| Mixedwood | .125 | .012 | .500 | .629 | 0 | .005 | 0 | 0 | .167 | .036 | .250 | .216 | .019 | .008 |
| White Spruce | .161 | .031 | 0 | 0 | .056 | .016 | .250 | .030 | .400 | .084 | .545 | .360 | 0 | 0 |
| Black Spruce | .152 | .137 | 0 | 0 | 0 | 0 | 0 | 0 | .017 | .010 | 0 | 0 | .596 | .687 |
| Open Conifer-Wet Meadow | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .167 | .400 | .182 | .208 | 0 | 0 |
| Wet Meadow | .018 | .149 | 0 | 0 | .222 | .100 | 0 | .024 | .008 | .118 | 0 | .140 | 0 | .048 |
| Shrub | .018 | .015 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **BURNED** | | | | | | | | | | | | | | |
| Mixedwood | .125 | .082 | 0 | 0 | 0 | .097 | .143 | .110 | .108 | .065 | 0 | .037 | 0 | 0 |
| White Spruce | .027 | .097 | 0 | 0 | .389 | .346 | .518 | .785 | .100 | .086 | .023 | .039 | 0 | 0 |
| Black Spruce | .027 | .068 | .200 | .015 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Open Conifer-Wet Meadow | .348 | .410 | .300 | .356 | .333 | .435 | .089 | .052 | .033 | .202 | 0 | 0 | .385 | .257 |
| **TOTAL** | 1.001 | 1.001 | 1.000 | 1.000 | 1.000 | 0.999 | 1.000 | 1.001 | 1.000 | 1.001 | 1.000 | 1.000 | 1.000 | 1.000 |
| **No. Of Obs.** | 56 | | 5 | | 9 | | 28 | | 60 | | 22 | | 26 | |

[1] Sample sizes too small for statistical analyses.

availability of those habitats (Spearman's Rho, $p > 0.05$). Due to small sample sizes for M-10 and M-12, they were excluded from the analysis. M-06 was found to use some habitats selectively in his home range (Spearman's Rho, $p < 0.05$), most notably preferring unburned mixedwood and white spruce and avoiding wet meadows.

Although sample sizes for males were small, there were some apparent differences in the habitat types used by male and female marten for resting sites (Table 6). Males tended to select burned open conifer-wet meadow and white spruce areas for resting whereas females were observed more often resting in unburned white spruce, black spruce, and mixedwood stands as well as burned white spruce. The observations of males resting in burned open conifer-wet meadow occurred in the summer. Of 27 confirmed locations of female resting sites (Table 7), 11 were under the snow with access gained at the base of a live or dead standing tree, and 11 were in active squirrel middens.

F-15 was located several times at a den site by triangulation (confirmed once), and although no young were observed, I believe she raised a litter because she remained at the den site for several months. This den was located underground with three access holes within a radius of 1 m. The holes were in a small mound in an extensive stand of unburned black spruce. The area resembled those used by yellow-cheeked voles (<u>Microtus</u> <u>xanthognathus</u>) and it was possible that F-15 simply enlarged existing vole burrows.

Table 6. Habitat types used by marten for resting sites on the Bear Creek Burn study area, interior Alaska, 1985 (proportions of observations).

| HABITAT | MALES | FEMALES |
|---|---|---|
| UNBURNED | | |
| Mixedwood | .045 | .118 |
| White Spruce | .045 | .368 |
| Black Spruce | .045 | .145 |
| Open Conifer-Wet Meadow | 0 | .053 |
| Wet Meadow | .091 | 0 |
| BURNED | | |
| Mixedwood | .045 | .105 |
| White Spruce | .136 | .132 |
| Black Spruce | 0 | 0 |
| Open Conifer-Wet Meadow | .500 | .079 |
| HUMAN-MADE | | |
| Log Cache | .091 | 0 |
| TOTAL | 0.998 | 1.000 |
| No. Of Obs. | 11 | 38 |

Table 7. Marten resting site characteristics for locations observed on the Bear Creek Burn study area, interior Alaska, 1985.

| | MALES | FEMALES |
|---|---|---|
| Under Snow at Base of Tree | 0 | 11 |
| Base of Blowdown Root Mound | 1 | 1 |
| Active Squirrel Midden | 1 | 11 |
| Holes in Ground | 0 | 1 |
| Log Cache | 2 | 0 |
| In Live Tree (Active at Approach) | 1 | 3 |
| TOTAL | 5 | 27 |

## Berry Sampling

Eight habitat types (four each in unburned and burned) were sampled for berry abundance and production (Table 8). Within the unburned habitats, seven species of berry-producing plants were observed, whereas in the burned habitats there were five species. The unburned areas generally had more cover and greater numbers of berries per plot. Blueberry (Vaccinium uliginosum), wild rose, and lowbush cranberry (V. vitis-idaea) were the most common berry plants in unburned habitat types while cloudberry (Rubus chamaemorus), blueberry, and lowbush cranberry dominated the burned sites.

Differences in berry species composition existed between burned and unburned areas. For example, blueberries in the unburned open conifer-wet meadow habitat had a mean percent cover per plot of 27.5; the value in burned open conifer-wet meadow was only 3.3. Lower percent cover values in burned habitat types was also the case for blueberry in black spruce and for lowbush cranberry and rose in mixedwood. Only cloudberry had a higher percent cover value in burned habitats (open conifer-wet meadow and black spruce) over unburned sites.

Berry production appeared to be low throughout the study area in 1985. Most (85.2%) of the 1-$m^2$ plots with berry species present had less than 10 berries per plot. The vegetation type with the greatest production was unburned open conifer-wet meadow with an average of 84.9 blueberries per plot. Blueberries were also

Table 8. Percent cover and berries per plot for habitat types within the Bear Creek Burn study area, interior Alaska, 1985 ($\bar{x}$, no. of occurrences on plots).

| | *Vaccinium uliginosum* | *Vaccinium vitis-idaea* | *Rosa acicularis* | *Rubus chamaemorus* | *Arctostaphylos uva-ursi* | *Viburnum edule* | *Ribes hudsonicus* |
|---|---|---|---|---|---|---|---|
| **UNBURNED** | | | | | | | |
| Mixedwood | | | | | | | |
| % cover | 0.3, 2 | 9.4, 17 | 27.0, 16 | | | 0.2, 1 | 0.2, 1 |
| berries/plot | 0 | 0.4, 2 | 1.8, 9 | | | 0 | 0.7, 1 |
| Open Conifer-Wet Meadow | | | | | | | |
| % cover | 27.5, 18 | | 0.2, 2 | | | | |
| berries/plot | 84.5, 18 | | 0 | | | | |
| Black Spruce | | | | | | | |
| %cover | 12.7, 17 | 14.4, 18 | 0.1, 1 | 0.6, 7 | 0.1, 2 | | |
| berries/plot | 17.2, 13 | 20.4, 15 | 0 | 0 | 0 | | |
| **BURNED** | | | | | | | |
| Mixedwood | | | | | | | |
| % cover | 0.2, 1 | 0.2, 1 | 0.1, 1 | | 0.8, 2 | | |
| berries/plot | 0 | 0 | 0 | | 0 | | |
| Open Conifer-Wet Meadow [1] | | | | | | | |
| % cover | 3.3, 6 | 0.5, 2 | | 4.0, 8 | | | |
| berries/plot | 1.9, 3 | 0 | | 0 | | | |
| Black Spruce | | | | | | | |
| % cover | 3.0, 13 | 8.6, 17 | 0.8, 5 | 12.1, 18 | | | |
| berries/plot | 6.6, 9 | 13.0, 9 | 0.1, 2 | 1.4, 3 | | | |
| White Spruce | | | | | | | |
| % cover | | | 1.0, 1 | | | | |
| berries/plot | | | 0.6, 1 | | | | |

[1] Only 10 plots sampled, all others had 20 plots.

relatively abundant on unburned black spruce (17.2 berries per plot). None of the burned plots contained substantial quantities of blueberries; lowbush cranberries were the most abundant species on burned plots with 13.0 berries per plot in black spruce. These values for berries per plot may be less valuable as trend indicators due to the high year-to-year variation in production, but they do provide a relative index for 1985.

## Small Mammal Abundance

Red-backed voles (*Clethrionomys rutilus*) and yellow-cheeked voles were the most common rodents caught in the study area in 1984 and 1985, respectively (Table 9). Differences in small mammal abundance and composition were significant both among habitat types and between years (Chi-square, $p < 0.001$). In 1984, about three times the number of red-backed voles were captured in the unburned white spruce as in burned white spruce. This pattern continued in 1985 for both white and black spruce, although the relative numbers of red-backed voles declined in all habitat types in the second year. Some of these differences may be attributable to the selection of different trapping areas in 1985.

Table 9. Results of small mammal trapping on the Bear Creek Burn study area, interior Alaska, 1984 and 1985.

| SPECIES | NUMBERS TRAPPED AND PROPORTION BY HABITAT TYPE[1] | | | |
|---|---|---|---|---|
| 1984 | Burn. Wh. Spr. | Unburn. Wh. Spr. | Burn. Black Spr. | Unb. Black Spr. |
| *Clethrionomys rutilus* | 19 (0.54) | 60 (0.76) | | |
| *Microtus xanthognathus* | 1 (0.03) | 9 (0.11) | | |
| other *Microtus* species[2] | 5 (0.14) | 0 | | |
| Shrews | 10 (0.29) | 10 (0.13) | | |
| TOTAL | 35 (1.00) | 79 (1.00) | | |
| 1985 | | | | |
| *C. rutilus* | 8 (0.24) | 13 (0.54) | 0 | 16 (0.67) |
| *M. xanthognathus* | 22 (0.67) | 0 | 5 (0.26) | 1 (0.04) |
| *M. pennsylvanicus* | 0 | 1 (0.04) | 2 (0.11) | 0 |
| *M. oeconomus* | 0 | 1 (0.04) | 1 (0.05) | 0 |
| *Synaptomys borealis* | 0 | 0 | 8 (0.42) | 2 (0.08) |
| Shrews | 3 (0.09) | 9 (0.38) | 3 (0.16) | 5 (0.21) |
| TOTAL | 33 (1.00) | 24 (1.00) | 19 (1.00) | 24 (1.00) |

[1] Based on 450 and 600 trap/nights per habitat type in 1984 and 1985, respectively.
[2] Five individual specimens lost before identification could be made. None were *C. rutilus* or *M. xanthognathus*.

Yellow-cheeked voles, although not common in 1984, were found primarily in unburned white spruce. In 1985 however, they were most common in the burned white and black spruce. This suggests that either trap stations may have coincided randomly with localized vole colonies, or that yellow-cheeked voles select burned habitat types and may have undergone a population increase in 1985. In general, the results suggest that red-backed voles prefer unburned habitat types and *Microtus* species prefer burned habitat types.

## DISCUSSION

Historical viewpoints on the effects of fire on marten habitat are gradually being improved by a better understanding of the specific habitat needs of marten. The opinion that marten exclusively require old-growth forests (Lensink 1953) is now giving way to acceptance that marten can utilize forest openings, especially those created by fire (Koehler and Hornocker 1977, Simon 1980, Stephenson 1983). This study showed that marten home ranges in the study area occupied both burned and unburned habitats. Thus, my original hypothesis that marten winter habitat requirements are not met in burned areas must be rejected. However, the selection of home ranges in a linear arrangement along the major waterways by those animals occupying primarily burned habitat suggests that certain characteristics must be present in burned areas to provide food and cover requirements, with some form of overhead cover probably most important.

Most Alaskan trappers interviewed by Stephenson (1983) believed that fires were beneficial to marten, with extensive use of burns occurring as early as one to three years following fire, but in some cases not until 10 or 15 years following fire. Differing opinions on the timing of use probably result from variability in site, burn, and regeneration characteristics, as well as other problems associated with the collection of oral history data. Most trappers thought that marten use of a burn was dependent on animals being in or adjacent to the area prior to burning. My conversations with trappers from Nikolai indicated that marten traditionally occurred within the study area before the Bear Creek fire in 1977, and that marten densities were similar both pre- and post-burn.

With a few exceptions, most trappers in Stephenson's (1983) study also thought that burned edges and unburned inclusions were the areas most frequently used by marten. Potential bias exists here in that unburned areas provide the easiest access for humans; in the Bear Creek area, travel in the interior of the burn in winter is difficult unless snow depths cover windthrown trees. Also, most observations by trappers occur in the winter months; summer habitat preferences may be different (Koehler and Hornocker 1977, Steventon and Major 1982).

Koehler and Hornocker (1977) believed that fires maintained a necessary habitat diversity over time for marten but that winter cover requirements were not met in burned areas in their Montana study area. Wildfires in that general area occurred on an average of every 17.8 years, but the last fire in their immediate study area was in 1910. Since most of the observations of habitat use in the present study occurred during late winter and spring, winter cover requirements were apparently being met. The marten home ranges studied contained 8.0% to 94.7% burned habitat. Live overhead canopy cover was not present in burned areas, but marten were able to use the cover of windthrown trees as a substitute. Highest amounts of dead and down wood occurred in burned white spruce areas, primarily along the riparian zone of the Salmon and Pitka Fork rivers. Vertical layering of log debris provided numerous snow-free tunnels and passageways that marten used frequently. Judging from tracks, marten often entered the subnivean zone and did not re-emerge until many meters away. Marten were observed resting under windthrown trees, and from track observations, they presumably hunted there. Hargis and McCullough (1984) have pointed out the importance of trees as access points to the subnivean zone to decrease the energetic costs involved in digging directly through deep snow which may be crusted and contain ice layers.

Although no studies have found marten occupying home ranges totally devoid of live canopy cover, many researchers have documented the importance of snags and downed logs as denning and resting areas (Marshall 1951a, Francis and Stephenson 1972, Simon 1980, Hargis 1981). Steventon and Major (1982) found that marten rested in stump cavities in regenerating clearcuts in Maine, with certain sites being favored and used up to 10 times throughout the winter. Although Marshall (1951a) stated that resting sites were not regularly re-used, I found that certain sites were used frequently, especially the squirrel middens used by F-07, F-09, and F-15.

Extensive use of squirrel middens has also been documented by Marshall (1951a), Spencer et al. (1983), and Buskirk (1984). Buskirk (1984) believed that continued use of middens by squirrels made active nests more suitable than inactive ones. Also, the underground nests give a thermoregulatory advantage to marten when outside air temperatures fall well below freezing. From track observations, decreases in above-snow activity by marten in the study area occurred when ambient temperatures fell below about -20 $^{o}$C.

Buskirk (1984) also stated that the presence of suitable resting sites adjacent to foraging areas may be important in determining marten habitat suitability (c.f. Patton and Escano 1983, Allen 1984). Besides containing extensive areas of windthrown trees, each marten home range with burned habitat in this study contained at least one active squirrel midden within an unburned inclusion. F-07 (whose home range was entirely within the burn) made frequent use of an active midden in a small unburned inclusion of white spruce in her home range. The next nearest stand of live white spruce was several hundred meters away, although burned white spruce stands with high densities of windthrown trees for cover were close. I had the impression from track observations of F-07 and F-09 that these squirrel middens were used as resting sites between foraging bouts in the nearby burned white spruce.

Although many researchers (deJounge n.d., Masters 1980, Steventon and Major 1982, Buskirk 1983, Spencer and Zielinski 1983, Wynne and Sherburne 1984) have found marten resting or perching on limbs or in live tree canopies, especially in summer, I believe that animals found resting in trees in winter are more likely exhibiting predator avoidance behavior. On four occasions when I observed marten in trees, they were initially active but went into the tree as I approached. Manville (1961) and Raine (1982) also reported marten climbing trees when approached closely. This seems to be an efficient avoidance pattern for ground predators if trees are available. Marten could possibly become trapped by a ground predator when hiding in stumps or squirrel middens. Also, because of their relatively low fat reserves (Buskirk 1983), marten in winter must select resting sites providing the greatest thermoregulatory advantage. Underground or under snow sites would be better in this respect than arboreal ones.

If trees are important as escape terrain, then burned sites could make marten more vulnerable to ground predators. No studies to my knowledge have been done in entirely burned areas and none have documented predation on marten. Potential ground predators of marten in the study area include red fox (Vulpes vulpes), coyote (Canis latrans), wolf (C. lupis), and wolverine, and in summer, black bear (Ursus americana), and grizzly bear (U. arctos).

Murie (1940 as cited in Hargis 1981) found the skull of a young marten in the scat of a coyote, but it was unknown if the coyote actually killed the animal or if it was found dead. Golden Eagles (Aquila chrysaetos) are known to kill European marten (M. martes) in Finland (Pulliainen 1981) and along with Great Horned Owls (Bubo virginianus) were thought by California trappers in the 1930's to be the principal predators of marten (Grinnell et al. 1937 as cited in

Hargis 1981). Herman and Fuller (1974) and Hargis (1981) believed that the threat of avian predators caused marten to avoid open areas in winter, but diet studies showing use by marten of berries and small mammals typically found in openings (Marshall 1951a, Lensink 1954, Koehler and Hornocker 1977, Buskirk and MacDonald 1984) suggest that summer habitat use may be less restrictive. Dense herbaceous growth probably provides sufficient cover in meadows and other forest openings in summer. Although Great Horned Owls, Great Grey Owls (*Strix nebulosa*) and Red-tailed Hawks (*Buteo jamaicensis*) were common in the Bear Creek burn, no attempts at predation on marten were observed.

Although direct evidence of predation on marten is lacking, indirect evidence suggests it does occur on the study area. The carcass of M-08 was found after having been consumed by a red fox - all that remained was the backbone, transmitter, and a few tufts of hair. On 5 April 1985 (one week prior to the finding of his remains), M-08 was visually observed at close range and was in apparent good health. On the following night, his signal was detected at 2345 hr and indicated an unusual movement out of his normal area of activity. M-06 was also showing similar movements, but returned to his home range shortly after. M-08's signal was followed until 0215, at which time it went out of reception range. The signal was not located again until six days later when the carcass was found about 8 km from his capture site.

Of particular interest were the deaths of M-03 and M-10. Both carcasses were found outside of their normal home ranges and in similar conditions; only half of the carcass remained in both cases. The anterior portions as well as the tail had been cleanly removed, as were the heart and lungs. No other marks were found on the bodies. Unfortunately in both cases, fresh snow prevented any identification of tracks around the area. I have mentioned these findings to several trappers and all thought that another marten could have produced these results as marten in traps have been found in this condition with fresh marten tracks around the capture site (J. Stokes, pers. comm.). Hargis (1981) found marten remains in the marten scats she examined from Yosemite National Park but gave no explanation as to their origin. Also, Remington (1952, p. 69) documented a captive female marten killing a male sibling and states that "the head and two front legs were torn from the carcass, but only the heart and lungs were missing." Dulkeit (1929 as cited in Marshall 1951a) believed that the killing of young European marten by adult males may be an important factor in marten population regulation.

In view of the above reports of others, it is possible that territorial rivalry was a factor in the deaths of M-08 and M-10. Males M-06 and M-08 were known to be 2 years old based on tooth cementum annuli and M-10 was believed to be of similar age based on sagittal crest development (Marshall 1951b). Both M-08 and M-10 were captured within the home range of M-06. It is possible that M-08 was being chased by M-06 when he was captured by a fox. M-06 and M-10 could have also entered a territorial battle with M-06 emerging victorious. It was also at this time that M-06 began increasing his home range to include the ranges of F-09, F-11, and possibly F-13. Since F-13 had no radio transmitter, I did not know her home range boundaries, but M-06 did occupy the area where she was trapped. After the deaths of the other three males, M-06 was the only known male to have a home range within the study area. It must also be noted that since M-08 and M-10 died within three weeks of implantation, weakness from surgery may have played a part in their deaths.

The cause of death of M-03 is not as readily explained in similar terms. He was initially captured in his home range in 1984, with a second capture and implantation in 1985. This indicates that he successfully maintained a territory for at least a year. His home range was not close to any other males although M-12 (a transient) was captured there 1 month following M-03's death. I did however, find tracks of what I believed to be an untagged marten within M-03's range a few days after his death. It is possible that he did have an encounter with another marten and in his weakened state following surgery was unable to defend his territory successfully. From these speculations, it can be hypothesized that territorial rivalry is an important density-dependent regulatory factor with important implications for marten management.

There is considerable variability in the sizes of marten home ranges reported in the literature. Males generally have larger home ranges than females, averaging 2-4 $km^2$ (Hawley and Newby 1957, Francis and Stephenson 1972, Simon 1980), but up to 19.9 $km^2$ (Mech and Rogers 1977). Male M-06 in this study had a range of 7.50 $km^2$, similar to the average male home range size in spring of 7.77 $km^2$ in southcentral Alaska (Buskirk 1983). Three of the four females that I followed had similar home range sizes of about 0.7 $km^2$, which is much smaller than the average of 6.70 $km^2$ in Montana (Hawley and Newby 1957) and 3.08 $km^2$ in California (Simon 1980). Simon (1980) found significantly smaller home ranges of marten in her study area relative to other published data. She suggested that marten home range size may be a function of habitat quality, especially food supply. I suggest that the relatively small home ranges of females in this study were also due in part to a lack of quality habitat adjacent to the established ranges. These marten were simply not able to expand their ranges without entering suboptimal habitat, but they probably did not need to since winter food and cover requirements were obviously being met in the areas they occupied. Thus, the quality of the habitat types occupied by marten was sufficient to allow maximum late winter density with correspondingly small home range size. Further study comparing death rates of marten from various populations may refute this statement if marten in burns are found to suffer higher losses due to predation or as a result of intrasexual aggression.

Intersexual home range overlap for marten is well documented (Lensink 1954, Hawley and Newby 1957, Francis and Stephenson 1972, Simon 1980, Buskirk 1983, Archibald and Jessup 1984); intrasexual avoidance, especially in adult males, is also the rule (Francis and Stephenson 1972, Mech and Rogers 1977, Taylor and Abrey 1982, Buskirk 1983, Archibald and Jessup 1984). When home range overlap by males does occur, the overlap appears to be a function of general territory breakdown during the winter months (Clark and Campbell 1976, Simon 1980) or tolerance of juveniles by adults (Hawley and Newby 1957, Buskirk 1983). Marten home ranges do shift seasonally (Mech and Rogers 1977, Simon 1980, Taylor and Abrey 1982, Buskirk 1983) and although territorial maintenance through scent marking has been documented for European marten (Pulliainen 1982), actual territorial battles have only been alluded to (Hawley and Newby 1957).

Unfortunately, the data for the home range overlap of M-06, M-08, and M-10 are incomplete since M-08 and M-10 died shortly after radio implantation. It is probable that this overlap was simply a result of normal winter territory breakdown, but it is possible that increased aggression as the early summer breeding season approached (Danilov and Tuminov 1975) resulted in the need for M-08 and M-10 to search for a new home range and available females. The time of year when these deaths occurred also corresponds with overwinter dispersal noted by Archibald and Jessup (1984).

An alternative hypothesis that should also be considered is that home range overlap is at least partially a function of the availability of quality habitat. If a marten is forced to disperse through suboptimal and unfamiliar areas, these movements could be hazardous. Marten home ranges in this study were concentrated along the rivers, with little use of the large stands of burned habitat types away from the riparian zone. This was most likely due to the unsuitability of the relatively open meadows and burned black spruce stands found in these areas, either because of low food availability or lack of protective cover. The boundaries of home ranges in these areas coincided with the change from riparian to nonriparian habitats.

Some habitat types provide both food and cover, while others provide chiefly one or the other. Habitat types that provide food must have cover close by for them to be suitable for marten (Patton and Escano 1983). I suggest that although burned areas away from the rivers in the study area appear to be good foraging habitat, the open meadows and burned black spruce sites do not provide sufficient cover to be considered suitable marten winter habitat.

Although primarily carnivorous, marten diets include a wide variety of forage items including microtine and sciurid rodents, birds, hares (*Lepus* spp.), rabbits (*Sylvilgus* spp.), invertebrates, and berries (Hargis 1981, Buskirk and MacDonald 1984). Voles make up the greatest part of the diet, especially in winter (Cowan and MacKay 1950, Murie 1961, Weckwerth and Hawley 1962, Francis and Stephenson

1972, Zielinski et al. 1983). Mammals continue to dominate the summer diet, but the occurrence of invertebrates, red squirrels, and berries increases as they become available (Cowan and MacKay 1950, Lensink et al. 1955, Weckwerth and Hawley 1962, Francis and Stephenson 1972, Koehler and Hornocker 1977, Zielinski et al. 1983). This shift in diet is also accompanied by increased use of meadows and openings by marten in summer (Marshall 1951a, Koehler and Hornocker 1977, Soutiere 1979).

In Alaska, the primary mammalian prey include the red-backed vole and *Microtus* species (tundra vole and meadow vole). Yellow-cheeked voles are also consumed by marten where they occur in the northern boreal forest (Douglass et al. 1983). Although red-backed voles form a staple portion of the diet throughout the year, the *Microtus* species seem to be preferred when available (Weckwerth and Hawley 1962, Douglass et al. 1983, Buskirk and MacDonald 1984). These researchers have found higher proportions of *Microtus* species in marten diets than would be expected based on their abundance.

Red-backed voles are found in forested and shrubby habitats whereas *Microtus* are more restricted to moister meadows and grasslands (Cameron 1965, Douglass and Douglass 1977, Buskirk and MacDonald 1984). Thus, to obtain *Microtus*, marten must hunt for them in open areas. In the study area, I found red-backed voles primarily in the unburned spruce habitats and *Microtus* in the burned sites. This is consistent with the results found by Wein (1975 as cited in Fox 1983) and McDonald (1978). Similarly, Soutiere (1979) found meadow voles dominating clear-cuts and red-backed voles in uncut forests in Maine. Krefting and Ahlgren (1974) and West (1982) however, showed that red-backed voles could successfully colonize the early successional stages of a burn with correspondingly low and erratic numbers of *Microtus*. These differences are probably related to microhabitat variables, especially moisture, which *Microtus* prefer (West 1982).

Marten habitat use in the study area appeared to coincide closely with the types providing both food and winter cover. It is difficult to assign specific activities of marten to certain habitat types because some activities (e.g., exploration and dispersal) may be independent of habitat type (Buskirk 1983). Also, habitat use patterns may be local in nature; comparisons from geographically separate areas may produce conflicting results. Regardless of localized variables in vegetation types, marten habitat is dependent on the availability of food and cover. Koehler and Hornocker (1977) and Spencer et al. (1983) found that marten in Montana and the California Sierra Nevadas, respectively, preferred areas with greater than 30% overhead cover. Hargis and McCullough (1984) observed that marten preferred cover which was less than 3 m above the snow. Many authors (Simon 1980, Buskirk 1983, Spencer et al. 1983, Hargis and McCullough 1984) have shown that edges of habitats, especially meadows adjacent to cover, were used extensively by marten in winter. Summer use of meadows and other forest openings appears to increase as food (especially insects and berries) becomes available and herbaceous growth provides increased cover (Koehler and Hornocker 1977, Soutiere 1979, Steventon and Major 1982, Simon 1980).

Most marten locations in the study area were in unburned white spruce, a habitat that I believe has greater value for cover than for food; the staple food item, red-backed voles, were most abundant in this type, but the preferred Microtus was most common in burned habitats. Small patches of burned open conifer-wet meadow areas were also used frequently, probably due to the presence of microtine prey. These areas did not have great amounts of cover however, and the large stands away from the rivers were not used by marten in winter. There were two other burned habitat types in the study area that I believed afforded excellent cover from extensive amounts of windthrown trees, primarily burned mixedwood and burned white spruce. These stands were used for resting and presumably hunting, based on track observations. There appeared to be a greater heterogeneity in habitat types within the home ranges compared with the rest of the study area. Areas away from the rivers within the fire boundaries were characterized by extensive open meadows and stands of black spruce. Marten may expand into these areas in summer to forage for berries as the greatest berry production was found in open conifer-wet meadow and black spruce habitat types.

The suitability of habitat types after fire is largely dependent on the amount of overhead cover remaining. Overhead cover does not necessarily imply standing trees or canopies, but need only provide protection from predators and access to subnivean space. White spruce stands that burn and are not subsequently cut can provide sufficient cover in the form of windthrown trees. Burned white spruce stands, after 100 years or more without fire, generally return to mature white spruce forests (Viereck and Schandelmeier 1980). Younger successional stands may include dense herbaceous and shrub-sapling stages which would add significantly to the overhead cover component.

It was apparent in the Bear Creek Burn study area that riparian habitat types, especially white spruce stands, were best suited to use by marten after fire. Older, unburned white spruce stands along floodplains may eventually be replaced by black spruce as moss and permafrost levels increase (Viereck and Schandelmeier 1980). Dense black spruce stands in the study area were used by marten and in fact, the only breeding den located was in this type. But when black spruce stands burn, the remaining snags provide little in the way of overhead cover. Therefore, fire may be beneficial to marten in the long run by preventing an eventual development of a climax black spruce community that is highly susceptible to burning (Viereck and Schandelmeier 1980).

The post-fire revegetation pattern in black spruce forests is largely dependent on fire severity and depth of burn of the forest floor (Dyrness and Norum 1983). For the most part, burned black spruce trees in the study area remained standing with poor development of ground and shrub layers. The primary invaders, mosses and liverworts, were characteristic of severely burned black spruce forests (Dyrness and Norum 1983).

Although patterns of forest succession following fire are complex and variable, black spruce is fire-adapted and usually able to maintain its dominance over time. White spruce, on the other hand, may be replaced by deciduous aspen or birch given certain conditions. Although no living deciduous stands were present in the study area, they are considered poor marten habitat (Lensink 1953). Burned deciduous stands in the study area were used by marten, and the amount of overhead cover from windthrown trees in these areas was similar to the burned white spruce stands.

## CONCLUSIONS

It is difficult to state whether fires are generally beneficial or harmful to marten. The results presented here have shown that marten can successfully exploit some burned habitat types but these results are time- and site-specific. Soutiere (1979), Steventon and Major (1982), and Simon (1980) have shown that marten can make use of logged areas providing residual slash and uncut stands remain for cover. Soutiere (1979) found that marten avoided clearcuts up to 15 years in age.

I believe that the Bear Creek burn neither created nor destroyed marten habitat, but this may not be true in areas where fires greatly reduce potential cover (e.g., black spruce forests). Trappers from Nikolai who were familiar with the study area suggested that marten densities were similar before and after the Bear Creek fire. With the exception of dense black spruce forests, the large open meadows and open black spruce stands away from the rivers were probably never good marten habitat, but those areas used by marten adjacent to the rivers were most likely used before the fire. Most Alaskan trappers interviewed by Stephenson (1983) believed that marten use of burns was dependent on the animals being present in or adjacent to the area prior to burning.

Fires can be beneficial by creating favorable habitats for the preferred *Microtus*. I did notice that burned black spruce in the study area tended to be drier than unburned which may limit *Microtus* abundance. In general though, I believe (as does Koehler et al. 1975) that fires are useful in maintaining habitat heterogeneity over time, a characteristic of great value in maintaining long-term marten populations.

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## PERSONAL COMMUNICATIONS

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Jeff Stokes, Alaska Dept. of Fish and Game, Nikolai.

# APPENDICES

Bald Eagle, Haliaeetus leuocephalus

Northern Harrier, Circus cyaneus

Red-tailed Hawk, Buteo jamaicensis

Rough-legged Hawk, B. lagopus

Order Galliformes

Spruce Grouse, Dendragapus canadensis

Ruffed Grouse, Bonasa umbellus

Sharp-tailed Grouse, Tympanuchus phasianellus

Order Gruiformes

Sandhill Crane, Grus canadensis

Order Charadriiformes

Greater Yellowlegs, Tringa melanoleuca

Lesser Yellowlegs, T. flavipes

Solitary Sandpiper, T. solitaria

Upland Sandpiper, Bartramia longicauda

Least Sandpiper, Calidris minutilla

Common Snipe, Gallinago gallinago

Bonaparte's Gull, Larus philadelphia

Mew Gull, L. canus

Herring Gull, L. argentatus

Arctic Tern, Sterna paradisaea

Order Strigiformes

Great Horned Owl, _Bubo virginianus_

Northern Hawk Owl, _Surnia ulula_

Great Grey Owl, _Strix nebulosa_

Order Coraciiformes

Belted Kingfisher, _Ceryle alcyon_

Order Piciformes

Three-toed Woodpecker, _Picoides tridactylus_

Black-backed Woodpecker, _P. arcticus_

Northern Flicker, _Colaptes auratus_

Order Passeriformes

Olive-sided Flycatcher, _Contopus borealis_

Western Wood Pewee, _C. sordidulus_

Alder Flycatcher, _Empidonax alnorum_

Tree Swallow, _Tachycineta bicolor_

Bank Swallow, _Riparia riparia_

Cliff Swallow, _Hirundo pyrrhonota_

Gray Jay, _Perisoreus canadensis_

Common Raven, _Corvus corax_

Black-capped Chickadee, _Parus atricapillus_

Boreal Chickadee, _P. hudsonicus_

Swainson's Thrush, _Catharus ustulatus_

Hermit Thrush, _C_. _guttatus_

Bohemian Waxwing, _Bombycilla_ _garrulus_

Orange-crowned Warbler, _Vermivora_ _celata_

Yellow Warbler, _Dendroica_ _petechia_

Yellow-rumped Warbler, _D_. _coronata_

Northern Waterthrush, _Seiurus_ _novaboracensis_

American Tree Sparrow, _Spizella_ _arborea_

Savannah Sparrow, _Passerculus_ _sandwichensis_

Fox Sparrow, _P_. _iliaca_

White-crowned Sparrow, _Zonotrichia_ _leucophrys_

Dark-eyed Junco, _Junco_ _hyemalis_

Rusty Blackbird, _Euphagus_ _carolinus_

White-winged Crossbill, _Loxia_ _leucoptera_

Common Redpoll, _Carduelis_ _flammea_

MAMMALS

Order Insectivora

Masked Shrew, _Sorex_ _cinereus_

Arctic Shrew, _S_. _arcticus_

Pygmy Shrew, _S_. _hoyi_

Order Chiroptera

Little Brown Myotis, *Myotis lucifugus*

Order Carnivora

Black Bear, *Ursus americanus*

Grizzly Bear, *U. horribilis*

Marten, *Martes americana*

Shorttail Weasel, *Mustela erminea*

Least Weasel, *M. rixosa*

Mink, *M. vison*

River Otter, *Lutra canadensis*

Wolverine, *Gulo gulo*

Coyote, *Canis latrans*

Wolf, *C. lupus*

Red Fox, *Vulpes vulpes*

Order Rodentia

Red Squirrel, *Tamiastriatus hudsonicus*

Beaver, *Castor canadensis*

Northern Bog Lemming, *Synaptomys borealis*

Brown Lemming, *Lemmus sibiricus*

Red-backed Vole, *Clethrionomys rutilus*

Meadow Vole, *Microtus pennsylvanicus*

Tundra Vole, *M. oeconomus*

Yellow-cheeked Vole, *M. xanthognathus*

Muskrat, _Zondatra zibethicus_

Meadow Jumping Mouse, _Zapus hudsonicus_

Snowshoe Hare, _Lepus americanus_

Order Artiodactyla

Moose, _Alces alces_

Caribou, _Rangifer tarandus_

Bird and mammal nomenclature from, respectively:

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Appendix 2. Measurements (cm), weights (kg), and ages (from dental cementum annuli) of marten captured on the Bear Creek Burn study area, interior Alaska, 1985.

| | M-03 | F-07 | F-09 | M-06 | F-11 | M-08 | M-10 | F-13 | F-15 | M-12 |
|---|---|---|---|---|---|---|---|---|---|---|
| Date Captured | 3/03 | 3/03 | 3/11 | 3/15 | 3/20 | 3/21 | 3/21 | 3/23 | 3/24 | 4/03 |
| Total Length | 71.0 | 61.0 | 59.0 | 65.0 | 56.5 | 69.8 | 66.2 | 59.5 | 62.5 | 70.7 |
| Tail Length | 19.5 | 16.0 | 16.5 | 17.5 | 17.4 | 20.5 | 19.0 | 17.5 | 15.7 | 18.0 |
| Right Hind Foot | 10.8 | 9.4 | 8.7 | 9.7 | 8.5 | 9.8 | 9.0 | 8.7 | 8.6 | 9.5 |
| Girth | 18.0 | 15.0 | 15.0 | 17.5 | 15.5 | 17.5 | 18.5 | 14.5 | 15.5 | 17.5 |
| Head Length | 15.2 | 11.5 | 12.0 | 14.0 | 13.0 | 12.5 | 14.5 | 12.7 | 10.3 | 15.0 |
| Right Ear Length | 4.4 | 4.7 | 4.0 | 4.6 | 4.4 | 4.8 | 4.8 | 4.4 | 4.1 | 4.5 |
| Weight | 1.19 | 0.75 | 0.90 | 0.85 | 0.78 | 1.20 | 1.15 | 0.80 | 0.92 | 1.25 |
| Age | N/A | N/A | N/A | 2 | N/A | 2 | N/A | 1 | 4 | N/A |