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MOVEMENTS AND HABITAT USE OF AMERICAN MARTEN IN GLACIER NATIONAL PARK, MONTANA

BY

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Movements of American marten (*Martes americana*) in Glacier National Park, Montana were studied from March 1979 to September 1980 by radio telemetry. Radio collars were fitted on 6 juveniles (4 male, 2 female) and 5 adults (3 male, 2 female). Collared marten were located 142 times, primarily by ground tracking. All collared adult marten were resident on the core study area, while 2 juvenile males established resident home ranges and 2 were non-resident. Collared juvenile females were non-resident. Home range ellipses of adult marten showed little intrasexual overlap, but extensive intersexual overlap. Adult males and adult females occupied average home ranges of 2.9 sq km and 0.7 sq km, respectively. Resident juvenile males had home ranges averaging 0.7 sq km. Non-resident marten occupied areas significantly larger than the average area residents occupied.

Marten moved an average of 0.6 km (range 0.1 to 2.8 km) between consecutive days. Non-residents traveled significantly farther (mean=4.1 km) than residents (mean=0.8 km) between initial collaring site and relocations.

Adult marten occupied a variety of cover types but locations where concentrated in mesic spruce types. *Abies lasiocarpa*/*Clintonia uniflora* and *Picea*/*Clintonia uniflora* habitat types were most heavily used. Juvenile marten also used a variety of cover types but locations were not concentrated in any one type. All marten showed a preference for canopy cover greater than 17%.

Daytime resting sites (N=36) were located significantly more often in trees than on the ground. Cover and habitat types were not significantly different between sheltered and unsheltered resting sites.

Management measures that will favor marten populations should emphasize the perpetuation of forest mosaics with old-growth components. This can be accomplished on reserved lands (e.g., national parks, wilderness areas) by accepting and reinstating the role of fire and other natural processes. On commercial lands the goal can be accomplished by careful planning of harvest areas and selection of silvicultural systems. The marten habitat quality of potential harvest sites can be determined based on guidelines provided.

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CHAPTER I

INTRODUCTION

"Many parks and wildlife preserves are destined to become habitat islands as we continue to intensify our use of the earth's land resources" (Soule and Wilcox 1980:119). Intensive management of the largest reserves in the world may be insufficient to preserve populations of many mammal species. The most sensitive mammalian species are those with the lowest population densities, such as predators (Soule et al. 1979). The American marten (Martes americana), one such predator, has already been eliminated from much of its former range as a result of habitat destruction and overexploitation (Seton 1929, Aldous and Mendal 1941, Yeager 1950, deVos 1952, Edwards 1954, Dodds and Martell 1971).

Immigration of marten from areas of well-stocked habitat aid restocking of adjacent, exploited range (Lensink 1953, Miller et al. 1955). In this way, as Lensink (1954) stated, dispersal may be a significant stabilizing influence to populations depleated by overtrapping that are adjacent to refuges. Glacier National Park (GNP), Montana represents one such reserve of occupied habitat adjacent to exploited areas.

An intensive study of marten conducted in GNP from 1953-1958 reported that 2 marten ear-tagged inside the Park had traveled across the North Fork of the Flathead River (NFFR) into the Flathead National Forest (FNF) where commercial trapping occurs (Hawley 1955, Weckwerth 1957, Jonkel 1959;Fig. 1). However, Thompson (1950) reported that during an intensive tracking study of marten in the Whitefish Mountain Range (WMR), only one instance was observed of a marten crossing into the WMR from GNP. He indicated that at the time of his study, GNP was of no value as a reservoir for marten, for miles of open burns (the result of extensive forest fires in the early 1900's) separated GNP and the WMR. He concluded that marten avoided openings devoid of canopy cover, confining their activity to densely forested areas. Other authors reported similar avoidance of open areas during winter months (Dice 1921, Grinnel et al. 1937, Marshall 1951b, Hagmeier 1956, Hawley and Newby 1957, Streeter and Braun 1968, Ingram 1973, Koehler 1975, Clark and Campbell 1977, Major 1979, Steventon 1979).

Many of the large burns in the NFFR drainage (which includes portions of GNP, and the FNF west of GNP) have since progressed to even-aged stands of lodgepole pine (Pinus contorta). Largely in response to the extensive stands of even-aged lodgepole pine (USDA 1979), the NFFR drainage has been subjected to an epidemic of the mountain pine beetle (Dendroctomus ponderose) since 1975 (Elliott et al. 1977). For many years fire has not been allowed to play its natural role in national parks and on other public lands. However, present GNP fire management policy recognizes lightning-caused forest fires ". . . as natural phenomena, which must be permitted to continue to influence the ecosystem if truly natural areas are to be

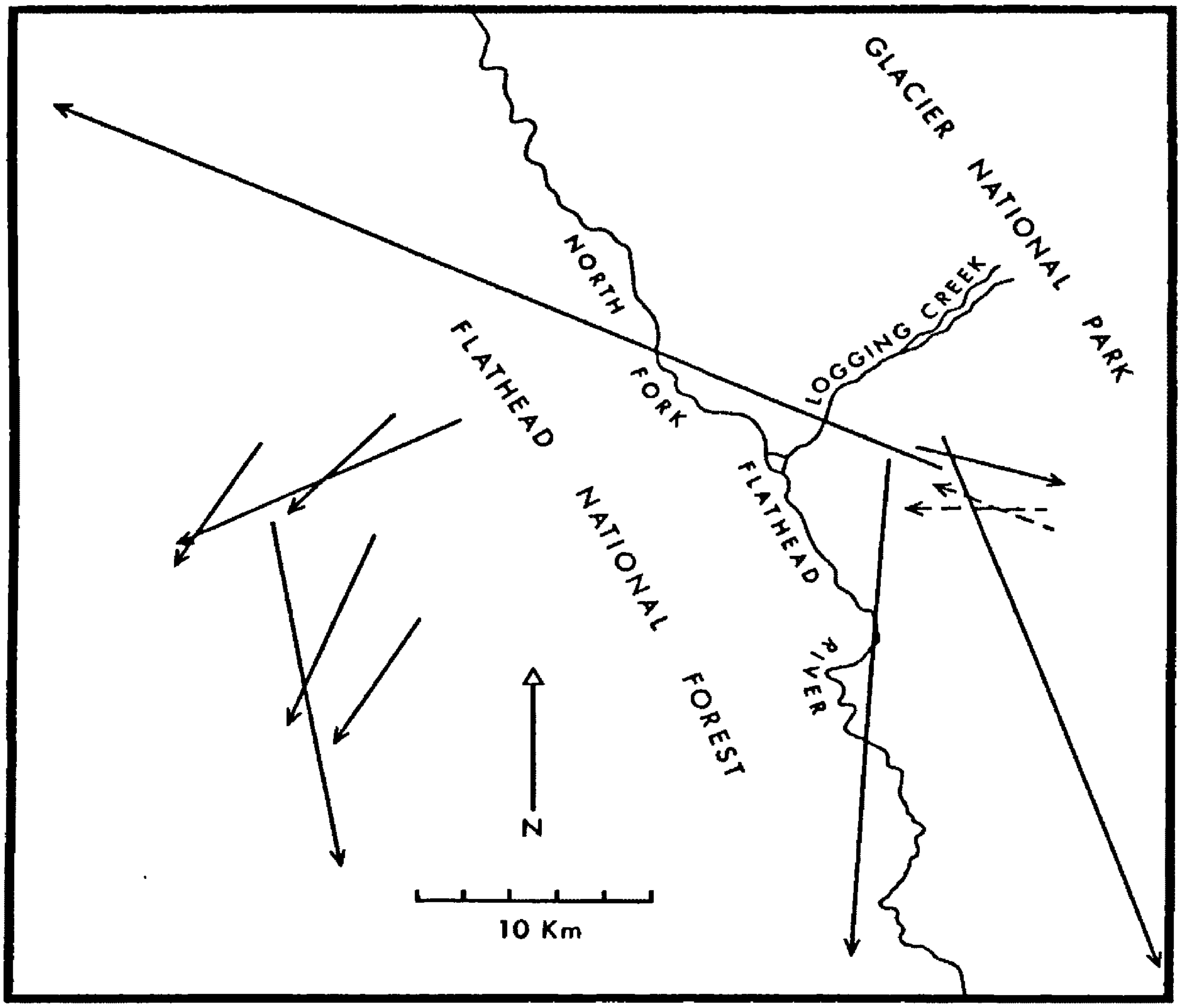

Fig. 1. Movements of marten from 1953-58, inclusive, in the North Fork of the Flathead River drainage.

perpetuated" (USNPS 1975).

Management efforts outside of GNP have been directed towards harvesting infested trees before deterioration makes them unmerchantable or to prevent excessive fuel loading (USDA 1979). Extensive clearcutting has occured throughout the lower portions of several major tributaries of the NFFR (Border Grizzly Project 1978). Future sales in the NFFR drainage generally will be harvested by clearcutting (USDA 1979). During 1978, more than 90 million board feet (mbf) of timber were harvested in the Canadian portions of the upper NFFR drainage, and cutting on the United States side amounted to over 50 mbf, all ownerships combined. Much of this salvage cutting is taking place at lower elevations along major streams. Although large scale removal of lodgepole pine on the FNF should taper off by the mid-1980's, it will continue in British Columbia for the next several years (Ahner 1978). Much of this Canadian harvest is taking place, or will occur, adjacent to GNP and Waterton Lakes Park (north of GNP in Canada), increasing the isolation of these reserves.

Thompson (1950) reported that by 1938 heavy and indiscriminant trapping of marten in the NFFR drainage had nearly decimated the population. However, interest in trapping apparently dropped off, and the marten population began to increase in the 1940's. According to Montana Fish, Wildlife, and Parks Fur Inventory Reports from 1953-1980, the Whitefish Mountain Range (WMR) has yielded some of the largest harvests of marten in Montana. The northwest region of Montana (of which the WMR is a part) yielded over 51% of the state harvest on a yearly average. The average price paid for a marten pelt was fairly stable until the mid-1970's; it had more than doubled by the end of the decade. The number of marten harvested followed a similar increase, changing from an average of a few hundred pelts in the 1950's, 1960's and early 1970's, to over 2,000 during the 1976-77 and 1977-78 trapping seasons, and over 1,500 during the 1979-80 and 1980-81 seasons (Appendix A).

Loss of habitat and overexploitation in Montana may eliminate marten from many areas, just as marten were extirpated from many parts of eastern North America. Management guidelines are needed to maintain self-perpetuating marten populations.

This study was conducted in a national park but was designed to provide information useful for both reserved and commercial lands. The study objectives were to:

1) document movements of juvenile marten;
2) describe habitat use by non-resident and resident marten; and
3) propose management guidelines for marten and their habitat in spruce-fir habitat types in western forests.

CHAPTER II

STUDY AREA

The 15.5 sq km core study area is located in the West Lakes District of GNP, Montana, between Sullivan Meadow and Anaconda Creek (Fig. 2), within the NFFR drainage. This is the same study area used in previous marten studies 20-30 years ago (Newby and Hawley 1954, Hawley 1955, Hawley and Newby 1957, Weckwerth 1957, Jonkel 1959, Weckwerth and Hawley 1962). GNP is separated from the WMR on the west by the NFFR. The average temperature at Polebridge Ranger Station (PRS) is -6.2 degrees C (C) in January and 16.5 C in July; the average annual precipitation is 55 cm (Habeck 1970).

Temperatures at PRS were -3.1 C in February and -1.6 C in March. The precipitation at PRS from May 1979 through May 1980 totaled 42.8 cm (NOAA 1979,1980), 12.2 cm below the annual average. Temperatures at West Glacier, 16 km southwest of Logging Creek Ranger Station (LCRS), averaged -9.7 C in January, -2.8 C in February, and -0.8 C in March 1980. Precipitation at West Glacier totaled 59.0 cm from May 1979 through May 1980. Temperatures at LCRS averaged -12.5 C in January averaged -12.5 C in January, -3.1 C in February, and -1.9 C in March 1980 (Appendix B).

Snow began accumulating on the study area in late December 1979. Snow depths at LCRS averaged 51.1 cm during winter months, and

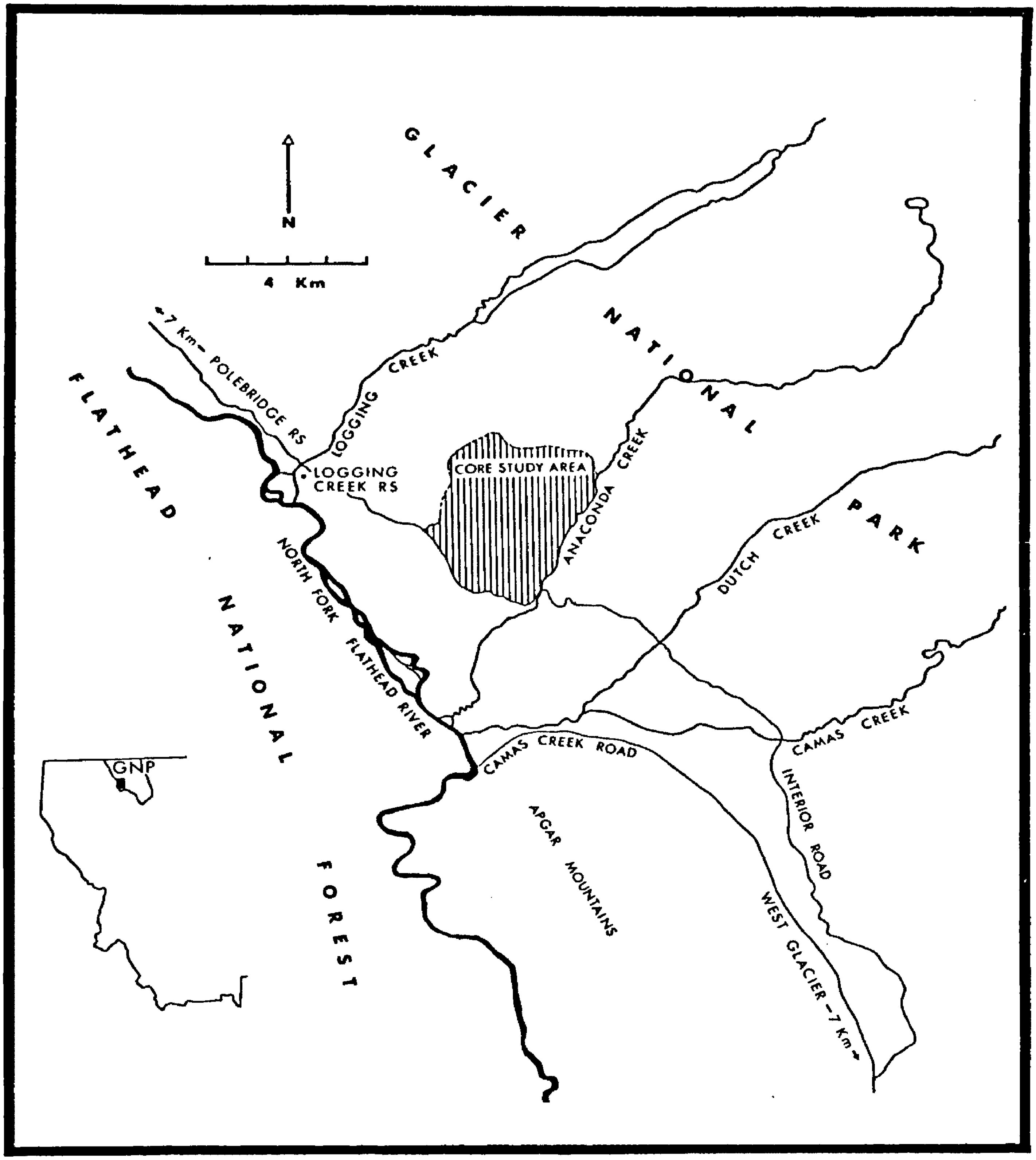

Fig. 2. Map of the study area.

35.4 cm at the southern end of the core study area (Appendix C).

The topography of the core study area consists of glaciated foothills on the west slope of the Continental Divide. Elevations range from 1067 m on the southern end to 1372 m on the northern end of the area. Climax vegetation is Englemann spruce (*Picea englemannii*), white spruce (*Picea glauca*), or spruce hybrids (*P. englemannii* X *P. glauca*) at the lower elevations blending to subalpine fir (*Abies lasiocarpa*) at higher sites. Due to recurrent forest fires and the variety of exposures, the present cover includes an interspersion of seral stages of lodgepole pine and western larch (*Larix occidentalis*). Climax tree species occuring in mixtures with these seral species, or in nearly pure stands, are spruce, Douglas-fir (*Pseudotsuga menzeisii*), ponderosa pine (*Pinus ponderosa*), and subalpine fir. The complex drainage pattern results in extensive riparian areas throughout the study area.

CHAPTER III

METHODS

Trapping

Methods for live-trapping, handling, and measuring of captured animals were initially developed by Newby (1955). Hawley (1955) modified and expanded these procedures. Weckwerth (1957) and Jonkel (1959) used the same procedures during their field work, adding to them whenever necessary. Similar methods were used in this study, setting traps as close as possible to original trap sites.

Small Mammals

The original 7 small mammal plots (Hawley 1955), representing different vegetation types, were reestablished and censused for small mammals. Live-trapping was attempted on the first 2 plots but deemed impractical because of the time involved and the logistics of moving 240 non-collapsible live-traps to remote sites. Small mammals were trapped on the remaining plots using standard snap trap procedures (Calhoun 1948).

Marten Live-trapping

Marten were captured using collapsible 15X15X67 cm wire mesh live-traps placed in a trench dug into a slope or next to a tree trunk.

This formed the bottom, sides, and back of a sheltered location. Pressed, tempered masonite trap covers were placed over each trap for top and side shelter, and to keep marten from reaching into the trap and removing bait. The trap and cover were covered with dirt and moss for added insulation. Kippered herring was used to bait each trap. To attract marten to each trap site, a scent of rotten fish and an aromatic oil (e.g. anis, wintergreen, peppermint) was dropped in front of each trap and on elevated vegetation nearby.

Trapped marten were handled using a cone-shaped chute that was fitted to the front of the traps. Marten were encouraged to enter this chute by hooking the distal end of the chute on a branch while I stood behind the trap, holding the trap lower than the chute.

Marten were fed and watered immediately upon arriving at the trap. Once a marten was in the handling chute, it was ear-tagged (tags were cleaned with alcohol and smeared with an antibiotic before application); sex, weight, and age were determined (Brassard and Bernard 1939, Marshall 1951a, Hawley 1955),and general condition, behavior, and breeding condition were recorded. When a marten was recaptured within about 2 months from its previous capture, its tagged ears often were infected, requiring cleaning with alcohol, and then applying antibiotics. However, when marten were recaptured after several months I found no evidence of infection.

Habitat Analysis

The Montana Forest Habitat Typing System (Pfister et al. 1977) was 1 of 2 methods used to classify the study area vegetation. At each trap site, and at 10 additional points between, the percent cover class of indicator species was recorded (Appendix E). For cover typing purposes, additional information was gathered at each site by ocular estimate (Table 1), similar to the method used by Pfister et al. (1977) in determining the cover of indicator species for habitat typing. One person with prior experience made estimates to minimize bias. Percent cover classes of all tree species (in 3 size classes), dead standing timber, grasses, forbs, dominant shrubs, and downed logs were estimated. Cover classes were 0 - no cover, t - trace to 1%, 1 - 1 to 5%, 2 - 5 to 25%, 3 - 25 to 50%, 4 - 50 to 75%, 5 - 75 to 95%, 6 - 95 to 100% cover.

Cover types were determined on the basis of dominant tree species cover. Each percent cover class was assigned its mid-point (e.g. Cover class 4 - 50 to 75% cover - was assigned a value of 62.5). For each tree species present at a site, these mid-point values for each size class encountered were added, producing a species cover value. The sum of these species cover values represented total cover. If one species comprised 75% of the total cover it was listed as the cover type. If no one species represented more than 75% of the cover, the cover type was listed as a combination of the dominant and subdominant tree species present.

Unless otherwise noted, cover type (ct) refers to my own classification system, and habitat type (ht) conforms to the system

Table 1. Habitat and location variables measured at marten locations and trap sites. Variables WE1 to REST6 were only recorded at marten locations.

Variable	Description
WE1	Weather at location
WE2	Weather at location
LAT	Latitude of location
LONG	Longitude of location
MOVE	Movement at time of location
DOR	Duration of rest
BEH1	Behavior at location
BEH2	Behavior at location
BEH3	Behavior at location
REST1	Marten height at resting site
REST2	Tree species of resting site
REST3	Tree height at resting site
REST4	Live or dead resting tree
REST5	Dbh of resting tree
REST6	Location at resting site
HHT1	Habitat series
HHT2	Habitat type
HHT3	Habitat type phase
PICEA1	Percent cover of _Picea_ spp. in <10 cm dbh class
PICEA2	Percent cover of _Picea_ spp. in 10-30 cm dbh class
PICEA3	Percent cover of _Picea_ spp. in >30 cm dbh class
ABLA1	Percent cover of _Abies lasiocarpa_ in <10 cm dbh class
ABLA2	Percent cover of _Abies lasiocarpa_ in 10-30 cm dbh class
ABLA3	Percent cover of _Abies lasiocarpa_ in >30 cm dbh class
PICO1	Percent cover of _Pinus contorta_ in <10 cm dbh class
PICO2	Percent cover of _Pinus contorta_ in 10-30 cm dbh class
PICO3	Percent cover of _Pinus contorta_ in >30 cm dbh class
PSME1	Percent cover of _Pseudotsuga menziesii_ in <10 cm dbh class
PSME2	Percent cover of _Pseudotsuga menziesii_ in 10-30 cm dbh class
PSME3	Percent cover of _Pseudotsuga menziesii_ in >30 cm dbh class
LAOC1	Percent cover of _Larix occidentalis_ in <10 cm dbh class
LAOC2	Percent cover of _Larix occidentalis_ in 10-30 cm dbh class
LAOC3	Percent cover of _Larix occidentalis_ in >30 cm dbh class
PIPO1	Percent cover of _Pinus ponderosa_ in <10 cm dbh class
PIPO2	Percent cover of _Pinus ponderosa_ in 10-30 cm dbh class
PIPO3	Percent cover of _Pinus ponderosa_ in >30 cm dbh class
POPU	Percent cover of _Populus_ spp.
BETU	Percent cover of _Betula_ spp.
DLL10	Percent cover of downlogs <10 cm in diameter

Table 1 (cont't).

Variable	Description
DLG10	Percent cover of downlogs >10 cm in diameter
SH1	Percent cover of shrubs <1 m in height
SH2	Percent cover of shrubs 1-2 m in height
SH3	Percent cover of shrubs >2 m in height
FB	Percent cover of forb spp.
GR	Percent cover of grass spp.
LSR	Percent cover of litter, soil, and rocks
CANHT	Canopy height at location
ASP	Aspect at location
SLP	Slope at location
ELEV	Elevation at location

developed by Pfister et al. (1977) for Montana forests.

The cover types determined at 134 marten locations were used in an attempt to classify cover types groups. A stepwise (METHOD = WILKS) discriminant analysis (SPSS program DISCRIMINANT) was used to produce an ordination for statistically distinguishing groups of sites, representing cover types. Sites most similar in vegetation occupied similar discriminant space. Sites not easily grouped were given a probable cover type designation during the classification phase of the analysis. Shrub cover was used as a variable in the habitat ordination but not in the original determination of cover types. Ground cover other than shrubs was not used in either as it was unmeasurable when covered with snow.

Sites dominated by lodgepole pine proved difficult to separate. On these, I ran a cluster analysis (BMDP program P4M) to identify groups of similar sites. These were regrouped according to the classification results of discriminant analysis.

Initially, 27 cover types were identified. To obtain interpretable functions, these cover types were regrouped with cover types occupying similar discriminant function "space", producing 7 cover types.

For an indepth discussion of discriminant analysis and the mathematical assumptions for this technique the reader is refered to Green (1974), Nie et al. (1975), or Smith (1977). The following is a brief explanation of the parameters produced by the discriminant analysis.

Group centroid values are the mean discriminant scores each cover type "scored" on the respective functions. These centroids summarize the group locations in the reduced space defined by the discriminant functions. Eigenvalues represent the variation in cover type variables accounted for by each function. The sum of these eigenvalues is a measure of the total variation accounted for by the discriminant analysis. The functions are derived and arranged in order of decreasing importance, so a given numeric difference between group discriminant scores on the last function is not as important as the same difference on the first. The group discriminant score is computed by multiplying the value of each discriminating variable (e.g. % cover of PICO >10 cm dbh) by its corresponding coefficient, and adding these products together. Each coefficient represents the relative contribution of its associated variable to that function. The sign merely denotes whether the variable is driving the score positively or negatively. Coefficients are used to name the functions by identifying the dominant characteristics they measure (Nie et al. 1975).

Telemetry

Marten were equipped with radio collars manufactured by Wildlife Materials, Inc., Carbondale, Illinois. Collars had tuned loop antennae to obtain maximum range with small, light-weight batteries. Frequencies were in the 164 MHz band, and each collar was equipped with an activity switch. The mounted weight of each collar was 40 grams (4-8% of marten winter weight); the pulse rate was 50-60 pulses per minute, and the predicated life was 6.5 months.

Trapping for adult marten to instrument was concentrated in the southwest corner of the core study area; juveniles were collared wherever they were captured. Marten were anesthetized using ketamine hydrochloride (Ketaset, Bristol Laboratories: 100 mg/cc) injected intramuscularly in a thigh (approximately 10 mg ketamine hydrochloride/kg marten weight). Instrumented marten were placed back in the trap until they had recovered.

Tracking of marten was primarily conducted from the ground; "lost" marten were located from aerial flights. Flights were made on average twice a month, or whenever needed. The majority of telemetry information was gathered by ground tracking, either by walking in on the marten or by triangulation readings. "Walking in" was more desirable because additional on-site information could be gathered.

Triangulation readings were made from various locations on the study area. An effort was made to minimize time between sightings. Activity was noted at the time of each reading. Bearings were taken by the "loudest-signal method" and the "null-signal method" (Springer 1979). Checks between these 2 methods resulted in very similar bearings. However, the "null-average method" was used when the loudest-signal was received over a broad arc.

Triangulation readings were used to plot locations of marten. However, the error polygons (Springer 1979) calculated represented such a large percentage of resident marten home ranges that the accuracy of locations was questionable. Thus, triangulation readings were not used for residents; however, they were very useful in estimating locations within 0.20 km for transients that typically moved several km between successive locations.

Aerial locations were estimated to be accurate within 0.10 km. They were used for non-residents in all cases, but for residents only if they did not represent movements of more than 0.10 km (the estimated accuracy of aerial locations) out of the convex polygon represented by their other locations.

When I located a collared marten from the ground, the habitat and cover typing variables and the marten's behavior were recorded (Table 1). In addition, the weather conditions, aspect, slope, and elevation were recorded. After data were recorded, I searched for another signal and attempted to locate that animal. Animals not found that day were given priority the next day of tracking, although locating juveniles was given priority over locating adults to gather more information on dispersal.

An effort was made in the spring of 1980, after all collars had ceased transmitting, to recapture collared marten; this yielded 4 collars. No damage to the martens' necks was evident when the collars were removed.

Activity

Activity over 8-hour periods, selected from 0000 to 2400 hours, was monitored in January and February. Because slight head movement by resting marten could be confused with true activity, criteria were established for separating activity and inactivity by observing marten while listening to the transmitted signal. If the pulse rate changed more than 3 times per minute while listening to the signal, it was assumed that the animal was active. Although marten often rested temporarily while listening for prey, this problem was partially eliminated by checking each marten's signal for as long as practically possible, usually 2-3 minutes.

Movements

The movements of marten were analysed using 3 distance estimates: 1) Consecutive distance (CD) - the distance between consecutive days using first daily location; 2) Successive distance (SD) - the distance between successive locations; and 3) Collar-relocation distance (CRD) - the distance between initial collaring site and subsequent relocations. The CD estimate indicated the daily movements of marten. The SD estimate, the traditional method employed, represented movement between successive locations. However, it had the inherent bias of equally weighing movements of only a few hours and those of a few days or weeks. This bias was eliminated by using the CRD estimate (Fig. 3). Any location point could have been chosen for the initial location, but the location of first capture was used because dispersal was of primary interest. This could only have been estimated by using the site of initial location.

Nonetheless, graphic plots of successive distances best represented the spatio-temporal movements of the marten.

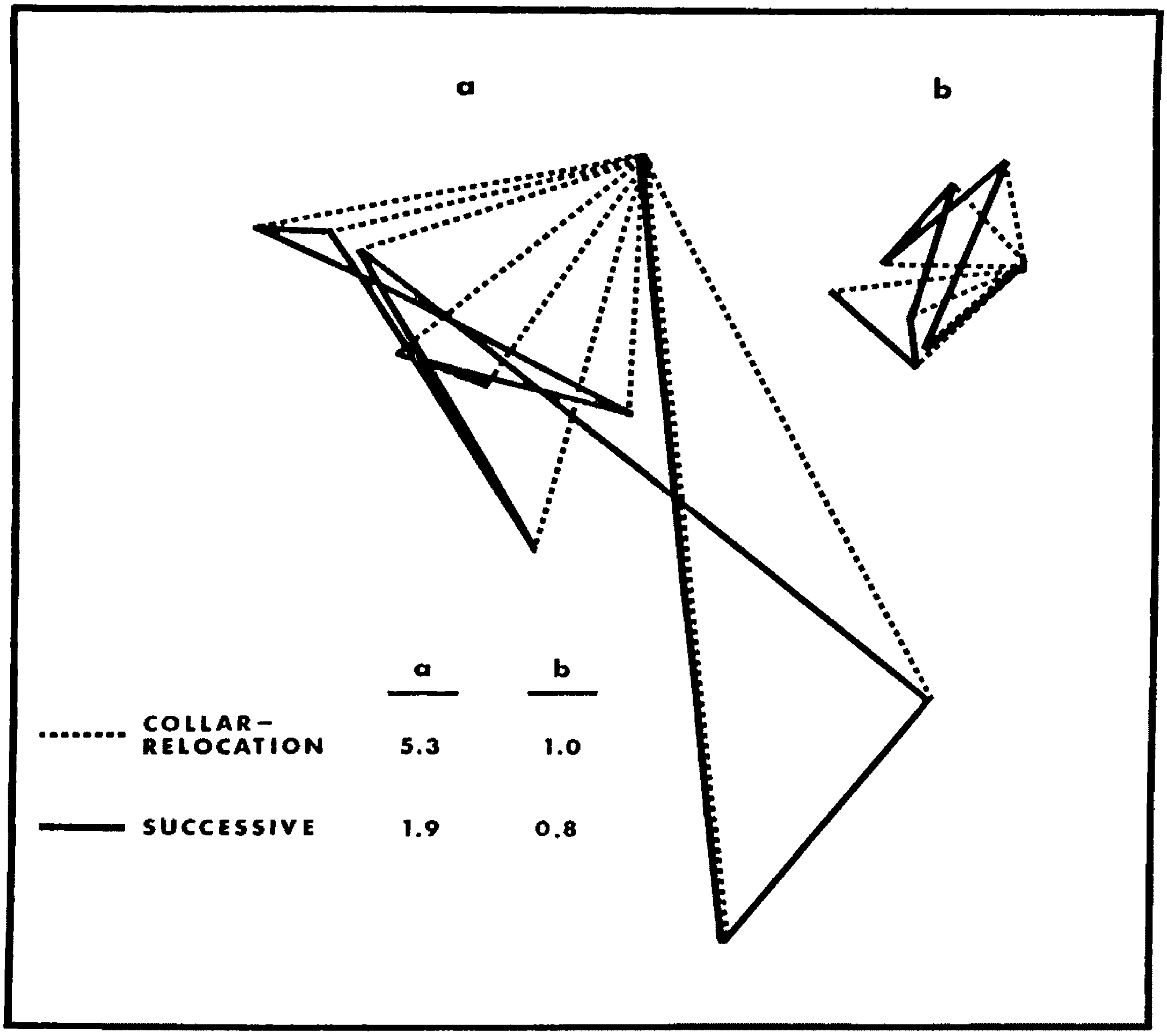

Fig. 3. Representation of the successive and collar-relocation distance estimates. Figures represent (a) non-resident movements, and (b) resident movements. Respective distances (km) are shown in the legend.

Home Range

The minimum area method (MAM)(Southwood 1966) and the infinity index method (IIM)(Metzgar and Sheldon 1974) were both used to calculate home range size. The MAM represents the traditional boundary enclosed by the outer most points of an animal's range. The IIM is thought to more accurately represent the geometric area used by an animal, rather than the geographic area (represented by the MAM) which includes range between areas of use (i.e. travel routes). Like other polygon estimates (Stickel 1954), the MAM determines an area that increases with the sample size. Jennrich and Turner (1969) suggested the use of correction factors to compensate for differential sample size. These factors were employed, and the resulting home range values (JTM) derived for statistical comparisons. However, due to the prominence of the MAM estimate in other marten studies calculating home range, the MAM estimates are listed.

The IIM and JTM home range estimates make no assumptions regarding home range shape. They also use all available information and are not dependent on the number of locations obtained. As such, they are not biased for sample size, which is highly variable among marten in this study (mean=15.1, s=7.9).

Dispersion

Confidence ellipses (95%) were used to view the dispersion of collared marten. Confidence ellipses characterize the distribution of the scattered locations, much as a line characterizes the scattered points along a trend. However, single confidence limits (1-dimensional) are not adequate for locations, as they vary in the 2-dimensional space defined by the axes of the 4 cardinal points. As such, confidence ellipses are confidence regions around the center of an animal's locations and the locations themselves.

Confidence ellipses are developed from a bivariate normal distribution. This assumes that the observed locations are taken from a normal distribution, which is probably not true for all wildlife species. However, for viewing the dispersion pattern of marten home ranges, I chose to use this model as it is less biased than the MAM.

The normal distribution is used to calculate the expected frequency distribution of locations. Analogously, confocal ellipses are calculated from the areas under the bell-shaped surface of the bivariate normal distribution. In effect, the confocal ellipses are the contour lines of a 3-dimensional, bell-shaped mound. In other words, a concentration of locations is expected near the center of an animal's home range, with a graduating decrease in the expected number of locations as one travels out from the center. Therefore, for locations that are not concentrated near the center a home range, 95% confidence ellipses depict an area much larger than the actual area used. Confidence ellipses (95%) then exaggerate the home range overlap of those animals that do not have a "center of activity". As such, 95% confidence ellipses that show little or no overlap are essentially non-overlapping. If ellipses represent overlap of animal locations, one must keep in mind the model used to develop ellipses when judging the extent of overlap.

A computer program (SPLOT, CORRL, University of Montana Computer Center) was used to plot ellipses. For a complete discussion of confidence ellipses see Sokal and Rohlf (1981).

Resting Sites

When locating a marten I noted whether it was moving prior to approach. At resting sites, the marten's resting height, location, and behavior were recorded. I also noted the species of resting tree, the tree's height and dbh, and the standard habitat and cover typing variables.

Resting site locations were placed into 2 groups depending on whether they were judged to be sheltered or unsheltered locations. Sheltered locations were 1) holes in logs, trees, or the ground; 2) dwarf mistletoe (Arceuthobium spp.) bundles; 3) squirrel nests; and 4) sheltered ground sites under downfall (i.e. snow covered). Unsheltered locations were 1) on a limb, or 2) exposed ground sites.

Statistical Analysis

In addition to the analyses mentioned, several others were employed (Table 2). Use of tests is indicated by appropriate abbreviations preceding significance levels. Computer programs used in this thesis are explained in SPSS (Nie et al. 1975) and BMDP (Dixon and Brown 1979).

Table 2. Statistical tests used to analyse data. For a complete discussion of each test see the appropriately referenced source. [ ] indicates the abbreviation used in the text to identify the test used.

Test used	Data organization	Data scale	Purpose
Chi-square [X] (SPSS CROSSTABS)* (SPSS NPAR TESTS)**	2 independent samples	Nominal	Test of independence
T-test [T-TEST] (SPSS T-TEST)*	Paired samples	Interval; ordinal	Differences of means
Mann-Whitney [M-W] (SPSS NPAR TESTS)**	2 independent samples	Ordinal	Test differences in central tendency
Kruskal-Wallis [K-W] (SPSS NPAR TESTS)**	k independent samples	Ordinal	Tests differences in central tendency
Dunn's [D] (Daniel 1978:211)	mean ranks from Kruskal-Wallis	Ordinal	Multiple comparisons
Kendall's W [W] (Daniel 1978:326)	k independent samples	Ordinal	Association of m rankings
L statistic [L] (Schucany and Frawley 1973) (Li and Schucany 1975)	k independent samples	Ordinal	Concordance of 2 groups of rankings
Cluster analysis (BMDP P2M)***	k cases	Ordinal	Grouping of cases
Discriminant analysis (SPSS DISCRIMINANT)*	k variables	Interval	Classification

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* Nie et al. 1975
** Hull and Nie 1979
*** Dixon and Brown 1979

Terms

The following terms are used throughout this thesis and need clear definition.

Residential status - resident or non-resident.

Resident - marten located on the core study area over a period longer than 3 months.

Non-resident - grouping of transient and temporary resident marten.

Transient - marten located on the core study area over a period not longer than 1 week.

Temporary resident - marten located on the core study area longer than 1 week but less than 3 months.

Adult - marten 1 year of age or older.

Juvenile - marten less than 1 year of age and not sexually mature.

Social class - subgrouping of collared marten, classed according to spatio-temporal movement patterns:

1) non-resident juveniles,
2) resident juveniles,
3) resident adult males, and
4) resident adult females.

Notation

The following notation is used throughout this thesis.

m - indicates juvenile male marten
f - indicates juvenile female marten
M - indicates adult male marten
F - indicates adult female marten

These letters are associated with numbers in 2 ways to produce alphanumeric symbols. When used parathetically they indicate the ratio of m:f:M:F, for example, (1m:2f:2M:1F). When used with a double digit number they indicate the age, sex, and number of a marten (e.g. adult male 64 is written as M64).

CHAPTER IV

RESULTS

Small Mammal Trapping

The results of small mammal trapping during the fall of 1979 (October–December) and the early summer of 1980 (June–July) are summarized in Table 3. The cover and habitat types at each plot, and the dates of trapping are summarized in Table 4. Plots 5 and 7 were not trapped on in 1979 due to time limitations. Live-trapping rather than snap trapping was conducted on plots 1 and 6 in 1979, possibly indicating lower numbers than actually existed. Wiener and Smith (1972) and Duran (1968) reported higher catches of certain small mammal species when using snap traps compared to live traps. However, Key (1979) studied small mammals on the NFFR floodplain and concluded that, while some species such as shrews (*Sorex* spp.) probably are trapped less efficiently by live traps than snap traps, deer mice (*Peromyscus maniculatus*) and red-backed voles (*Clethrionomys gapperi*) responded similarly to both types of traps.

The total catch between plots in 1979 was significantly different (X $p<.001$); plot 4 (PICEA-PSME ct, ABLA/CLUN ht) yielded the most small mammals (N=49) and plot 3 (PICO ct, ABLA/VACA ht) the least (N=10). The other plots had similar catches to each other.

In 1980, the difference between plots was not as great as in

Table 3. Small mammal trapping results for late fall 1979 and summer 1980. Plots 5 and 7 were not trapped in 1979.

Fall 1979

	Plot						
Species	1	2	3	4	5	6	7
Clethrionomys gapperi	21	26	9	37	-	26	-
Microtus pennsylvanicus	7	4	1	10	-	3	-
Microtus longicaudus	1	0	0	0	-	0	-
Sorex vagrans	0	5	0	2	-	0	-
Sorex cinereus	1	0	0	0	-	1	-
Total	30	35	10	49	-	30	-

Spring 1980

	Plot						
Species	1	2	3	4	5	6	7
Clethrionomys gapperi	3	13	6	11	15	3	3
Microtus pennsylvanicus	15	0	0	0	0	9	7
Peromyscus maniculatus	0	1	0	1	0	0	0
Sorex vagrans	0	0	0	1	0	0	0
Sorex cinereus	0	0	1	0	0	0	0
Zapus princeps	7	1	0	0	0	1	3
Total	25	15	7	13	15	13	13
2 year total	55	50	17	62	-	43	-

Table 4. Cover and habitat types, and dates of trapping, at each small mammal plot.

			Dates trapped	
Plot	Cover type	Habitat type	1979	1980
1	PICO	PICEA/VACA	11-8 to 11-10	7-2 to 7-4
2	PICEA	PICEA/CLUN	12-3 to 12-5	6-28 to 2-30
3	PICO	ABLA/VACA	12-3 to 12-5	6-24 to 6-26
4	PICEA-PSME	ABLA/CLUN	12-3 to 12-5	6-24 to 6-26
5	PICO-PIPO	PICEA/VACA	-	7-8 to 7-10
6	PICO	PICEA/VACA	10-27 to 10-29	7-2 to 7-4
7	LAOC*	PICEA/VACA	-	7-8 to 7-10

* this plot bordered the western edge of a large burn.

1979 (X p=.061), and plot 1 (PICO ct, PICEA/VACA ht) yielded the highest catch of rodents (N=25). Plot 3 again produced the lowest number of small mammals (N=7), and the other plots had similar catches to each other. For both years the most common species trapped were red-backed voles and meadow voles (Microtus pennsylvanicus). Red-backed voles clearly dominated the catch in 1979, but meadow voles were caught in similar numbers to red-backed voles during the 1980 summer trapping. It is possible that meadow voles were under represented in the 1979 catch because 2 plots were live-trapped.

Live-trapping

Marten were live-trapped from 5 June to 15 October 1979 and 17 May to 5 July 1980 (Table 5). A total of 1025 trap nights (1 trap night is 1 trap set overnight) resulted in 70 (6.8% success) captures of 29 individual marten. No marten died as a result of live-trapping.

Bears (Ursus americana) disturbed 37 (3.6%) traps; 35 (3.4%) pine squirrels (Tamiasiurus hudsonicus), 9 (0.9%) columbian ground squirrels (Spermophilus columbianus), and 2 (0.2%) yellow pine chipmunks (Eutamias amoenus) were captured. Traps were found tripped by unknown causes at 102 (9.9%) sites.

Of the 29 individual marten captured, 9 (31.0%) were resident on the core study area (2m:0f:4M:3F;Table 6). Of these, 1 did not meet the 90 day requirement for residency. F37 was radio collared on her

Table 5. Live-trapping results from 5 June to 15 October 1979 and 17 May to 5 July 1980.

Species	N	Other	N
Martes americana	70	Trap failure	17
Tamiasciurus hudsonicus	35	Traps torn out	
Spermophilus columbianus	9	Bear	37*
Eutamias amoeous	2	Marten	2
		Unknown	4
		Unknown trip	98

* one of these contained an adult male marten (M26). He was unharmed.

Table 6. Live-trap captures (70) of 29 marten from 20 June to 15 October 1979 and 18 May to 2 July 1980. N: indicates the number of live-trap captures; *: radio collared marten.

Residents

Males	N	Period captured	Females	N	Period captured
Juveniles					
m51*	3	7-21-79 to 9-9-79			
m69*	6	8-26-79 to 6-27-80			
Adults					
M13*	2	8-19-79 to 10-14-79	F14	5	6-30-79 to 7-2-80
M56*	2	8-27-79 to 8-29-79	F37*	4	6-21-79 to 8-27-79
M64*	3	8-22-79 to 5-25-80	F66*	6	6-20-79 to 6-27-80
M77	3	6-21-79 to 6-25-80			

Temporary residents

Males	N	Period captured	Females	N	Period captured
Juveniles					
m61*	3	7-2-79 to 9-7-79	f10*	1	8-2-79
			f32	2	7-27-79 to 8-18-79
Adults					
M11	2	7-23-79 to 8-29-79	F23	2	7-12-79 to 7-28-79
M72	2	6-24-79 to 7-12-79	F27	3	7-14-79 to 8-3-79
M75	3	6-21-79 to 8-18-79	F28	2	5-25-80 to 6-26-80

Transients

Males	N	Period captured	Females	N	Period captured
Juveniles					
m26	3	7-11-79 to 7-14-79	f16	1	7-2-79
m25	1	7-13-79	f35	1	7-28-79
m29	1	9-9-80	f59*	2	9-6-79 to 9-7-79
m63*	2	8-3-79 to 6-26-80			
Adults					
M30	1	5-18-80	F31	2	5-19-80 to 5-25-80
M34	1	8-16-79			
M38	1	7-2-80			
Total	39			31	

third capture; 10 days later the collar failed while tracking her. She had been located over a 67 day period and was judged a resident female, although she was not in breeding condition on her third and fourth capture.

The 9 (1m:2f:3M:3F) temporary residents comprised 31.0% of the captured population. Some were probably residents, but this remained unknown due to the short period animals were trapped. Transient marten represented the largest segment (38%) of the population, 11 individuals (4m:3f:3M:1F). Individual characteristics and behaviors of captured marten are tabulated in Appendix F.

Habitat Analysis

Based on the 7 cover types produced by the classification phase of discriminant analysis, 3 functions were derived discriminating 96.0% of the sites (Table 7). The ordination produced by this analysis is represented by group centroids in Fig. 4. Canonical discriminant functions evaluated for group centroids appear in Table 8. The discriminant function parameters for each cover type are listed in Table 9. The variables selected by the analysis and their standardized (mean 0, variance 1) canonical discriminant function coefficients are tabulated in Table 10.

Cover Type Descriptions

The first function serves primarily to separate cover types with high ponderosa pine cover, largely PP2 and PP3, as the high

Table 7. Results of the discriminant analysis classification process for cover types.

		Predicted group membership						
Cover type	N	PICEA	PICEA -LAOC	PICEA -PSME	LAOC	PIPO	PICO	PICO -PIPO
PICEA	20	18 90.0%	0 0.0%	1 0.05%	0 0.0%	0 0.0%	1 0.05%	0 0.0%
PICEA -LAOC	5	0 0.0%	5 100.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
PICEA -PSME	7	0 0.0%	0 0.0%	7 100.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
LAOC	12	0 0.0%	0 0.0%	0 0.0%	12 100.0%	0 0.0%	0 0.0%	0 0.0%
PIPO	6	0 0.0%	0 0.0%	0 0.0%	0 0.0%	6 100.0%	0 0.0%	0 0.0%
PICO	73	1 1.4%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	72 98.6%	0 0.0%
PICO -PIPO	11	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 9.1%	10 90.9%

Cases grouped into their previously classified cover types: 97.0 %

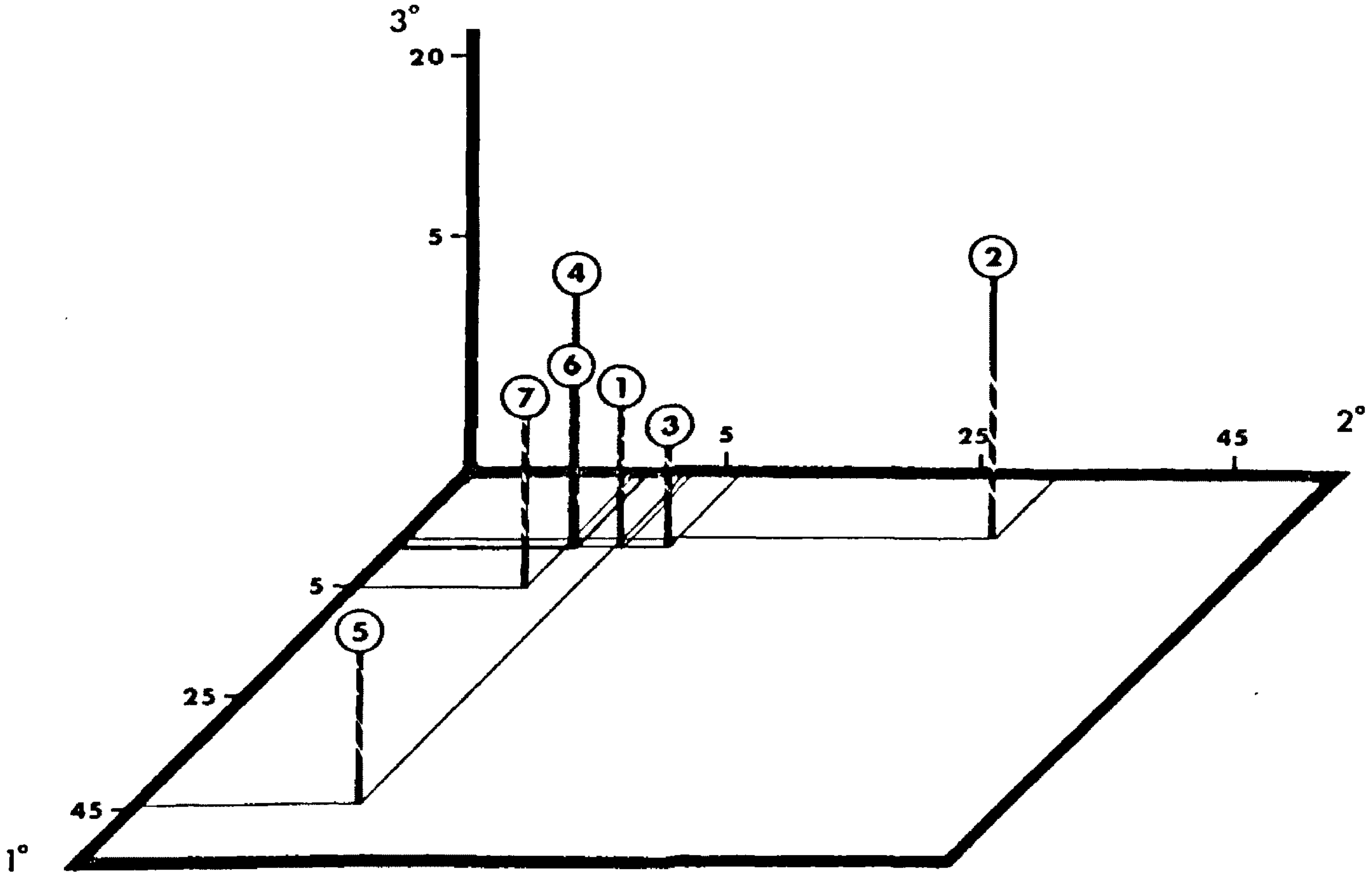


Fig. 4. Discriminant plot of cover type centroids. Group centroids represent 1) PICEA, 2) PICEA-LAOC, 3) PICEA-PSME, 4) LAOC, 5) PIPO, 6) PICO, and 7) PICO-PIPO.

Table 8. Exact group centroids of cover types.

Cover type	Functions 1	Functions 2	Function 3
PICEA	-2.23536	2.32927	-3.19418
PICEA-LAOC	-3.48027	30.05543	5.85657
PICEA-PSME	-2.41146	5.43432	-5.58849
LAOC	-2.30387	-1.37786	7.13015
PIPO	44.41443	1.74789	-0.53073
PICO	-2.17141	-1.64306	0.33371
PICO-PIPO	5.93996	-1.77939	0.95700

Table 9. Canonical discriminant function parameters for the cover types. The eigenvalues represent the variation accounted for by each function. The sum of these values is a measure of the total variation accounted for by the discriminant analysis. The relative percent indicates the contribution each function made to the overall separation. Canonical correlation values represent the association each function has with the types; the higher the value the stronger the association.

Discriminant Function	Eigenvalue	Relative Percentage	Canonical Correlation
1	70.3398	65.49	0.9930
2	23.2832	21.68	0.9792
3	6.6550	6.20	0.9324

Table 10. Standardized canonical discriminant function coefficients for the cover groups.

Variable	Function 1	Function2	Function3
PI1	-0.0626	0.8880	-0.1689
PI3	-0.0692	0.9036	0.4648
PC1	-0.2168	0.3181	1.1295
PC2	-0.1285	0.4538	1.0167
PC3	-0.0006	-0.2304	0.6196
PS1	0.0218	0.5569	-0.4484
PS2	0.0042	-0.0231	-0.2473
L1	-0.0335	0.0805	0.8164
L2	0.1566	-0.3628	0.2329
L3	-0.0759	1.2564	0.4479
PP1	0.8942	0.1512	0.0324
PP2	3.6167	0.3359	0.0136
PP3	3.5251	0.5043	0.1012
SH1	0.0257	-0.0826	0.2922
SH3	0.0532	0.6662	-0.3385
DLG10	0.0532	-0.8724	-1.3035

coefficients for the variables indicates. This shows the dominance of ponderosa pine cover on PIPO ct sites, and the relatively high occurrence of this tree species in PICO-PIPO ct stands. The negative end of the primary function's axis represents, although to a lesser degree, lodgepole pine and spruce covered sites.

The PICEA-LAOC ct differentiates from the other cover types on the second function, a result of that ct's high spruce and western larch cover. This is reflected by the high positive coefficient for L3 and the corresponding high positive value for the PICEA-LAOC ct centroid. PI1, PI2, and DLG10 also load highly on the positive end of the second function's axis. This contributes to the positive cover type centroids for the spruce cts. The negative LAOC ct represents high L2 but low L3, indicative of their early to mid successional stage. This function separates spruce cts from cover types with minimal spruce cover.

The third function represents lodgepole pine on the positive end, and to a lesser degree, PS1 and PS2 on the negative end. The PICEA and PICEA-PSME cts have negative centroids paralleling the negative PS1 and PS2 coefficients, and inversely the positive PC coefficients. The PICEA-LAOC and LAOC cts are both positive, a function primarily of dense growth of western larch in these stands, as well as lodgepole pine.

The mature to old-growth spruce types, PICEA and PICEA-PSME, have more DLG10, whereas the LAOC and PICEA-LAOC cts represent mid-successional sites with few large trees and little opportunity for this type of ground cover.

Although the LAOC and PICO ct centroids overlaped completely on the first and second function, the differences on the third function are accounted for such that cover types are completely separated. The second and third function have a continuum of meaningful coefficients, and hence are somewhat difficult to interpret. However, the separation of 130 out of 134 sites into their respective groups is very good, indicating these cts represent reasonable ecological types.

Relationship of Cover Types to Habitat Types

When comparing the cover and habitat types determined at each location (Table 11), an interesting relationship emerged (X p<.001). PICEA and LAOC cover typed sites were identified as PICEA/CLUN ht at 26 (81.3%) out of 32 locations; 5 (15.6%) were keyed as ABLA/CLUN ht. Also identified as ABLA/CLUN ht were 9 (75.0%) of the 12 PICEA-LAOC and PICEA-PSME cover typed sites; 2 (16.8%) of the 12 sites were keyed as PICEA/CLUN ht. The PIPO, PICO and PICO-PIPO cts were keyed as PICEA/VACA ht at 72 (80%) sites out of 90; 12 (13.3%) were classed as PICEA/CLUN ht. As such, a natural grouping of cover types was evident based on the association of certain cover types with habitat types. The spruce and LAOC cts associated with the mesic CLUN hts, whereas the lodgepole and PIPO cts associated with the xeric VACA hts.

Telemetry

Radio collars were fitted on 11 marten (4m:2f:3M:2F;Table 12). Marten responded well to the anesthetic, ketamine hydrochloride

Table 11. Relationship between cover and habitat types found at each marten location.

Cover	PICEA /VACA	PICEA /CLUN	PICEA /EQAR	ABLA /VACA	ABLA /CLUN	Total
PICEA	0	16	1	0	3	20
PICEA -LAOC	1	0	0	0	4	5
PICEA -PSME	0	2	0	0	5	7
LAOC	0	10	0	0	2	12
PIPO	5	1	0	0	0	6
PICO	57	10	1	2	3	73
PICO -PIPO	10	1	0	0	0	11
	73	40	2	2	17	134

Table 12. Marten fitted with radio transmitters.

				Locations	
Marten Number	Residential Status	Period Monitored*	Days	Radio	Trap
Juveniles					
Males					
m51	R	8-26-79 to 1-11-80	174	13	3
m61	N	8-28-79 to 12-18-79	169	15	2
m63	N	3-8-79 to 4-4-80	328	28	2
m69	R	8-28-79 to 5-3-80	306	16	6
Females					
f10	N	8-2-79 to 8-12-79	10	2	1
f59	N	9-7-79 to 4-4-80	211	26	2
Adults					
Males					
M13	R	10-14-79 to 2-17-80	182	3	2
M56	R	8-27-79 to 4-4-80	221	23	2
M64	R	10-14-79 to 4-4-80	178	7	3
Females					
F37	R	8-27-79 to 9-5-79	76	3	4
F66	R	10-12-79 to 3-17-80	373	6	6

* see Table 6 for first and last live-capture dates.

(Appendix G). The first marten was collared on 2 August 1979, and the last was collared on 15 October 1979.

Juvenile female f10 was collared during her only capture; 22 days later her collar (still functioning) was found in a hollow log. Aerial signals and triangulation fixes from her collar had been received from that area for several days, but tracking her was not possible due to the remoteness of the area and the need to continue the trapping schedule. Only 3 locations of f10 were made, so her locations were not compared with other radio-collared marten.

Temporary resident m61 occupied a temporary home range adjoining the core study area from 28 August (his second capture) to 17 October, after which he traveled to continually new areas. While traveling off the core study area m63 and f59 also occupied temporary home ranges. As such, juveniles m61, m63, and f59 possessed a combination of transient and temporary resident characteristics, and were grouped in a non-resident class for telemetry calculations.

Adult female F14 was captured 5 times over a 368 day period. Her range was analysed with radio-collared marten because the period during which she was trapped satisfied the required definition for residency, and she was trapped 5 times (the minimum number of locations for a collared marten).

Radio locations (N=142) averaged 12.9 (s=9.11) locations per individual. The average period between first and last location was 202.5 days (s=105.8). Of these locations, 122 (86.6%) were visual observations of the marten from the ground, 14 (9.9%) were aerial fixes, and 8 (3.5%) were triangulations from the ground. Locations were made between 0800 and 2000 hours (s=0200).

Activity

Activity readings totaled 914, averaging 38.1 readings per hour. To increase the sample size, hourly readings were grouped into 12, 2-hour periods. Combinations starting at 0100 (1-2,3-4,5-6,...) and at 0200 (2-3,4-5,6-7,...) were calculated and graphed (Fig. 5). Both combinations showed a significant difference (X p<.001) between percent of active readings at each hour, suggesting marten activity peaked just before dark. Activity patterns of individual marten were plotted in Appendix H. Statistical procedures were inappropriate because of the small sample size, but the variation between individuals is interesting to note.

Movements

The distances estimates are summarized in Table 13.

Consecutive. No significant differences in consecutive distances were found between non-residents and residents, juveniles and adults, or males and females (M-W p>.15). Marten averaged daily movements of about 0.6 km, ranging from 0.1 to 2.8 km.

The consecutive distances of transient juveniles, resident juveniles, adult males (all residents), and adult females (all residents), as a group, differed significantly (K-W p=.01). Adult females had the shortest daily movements (mean=0.2 km, s=0.1), differing

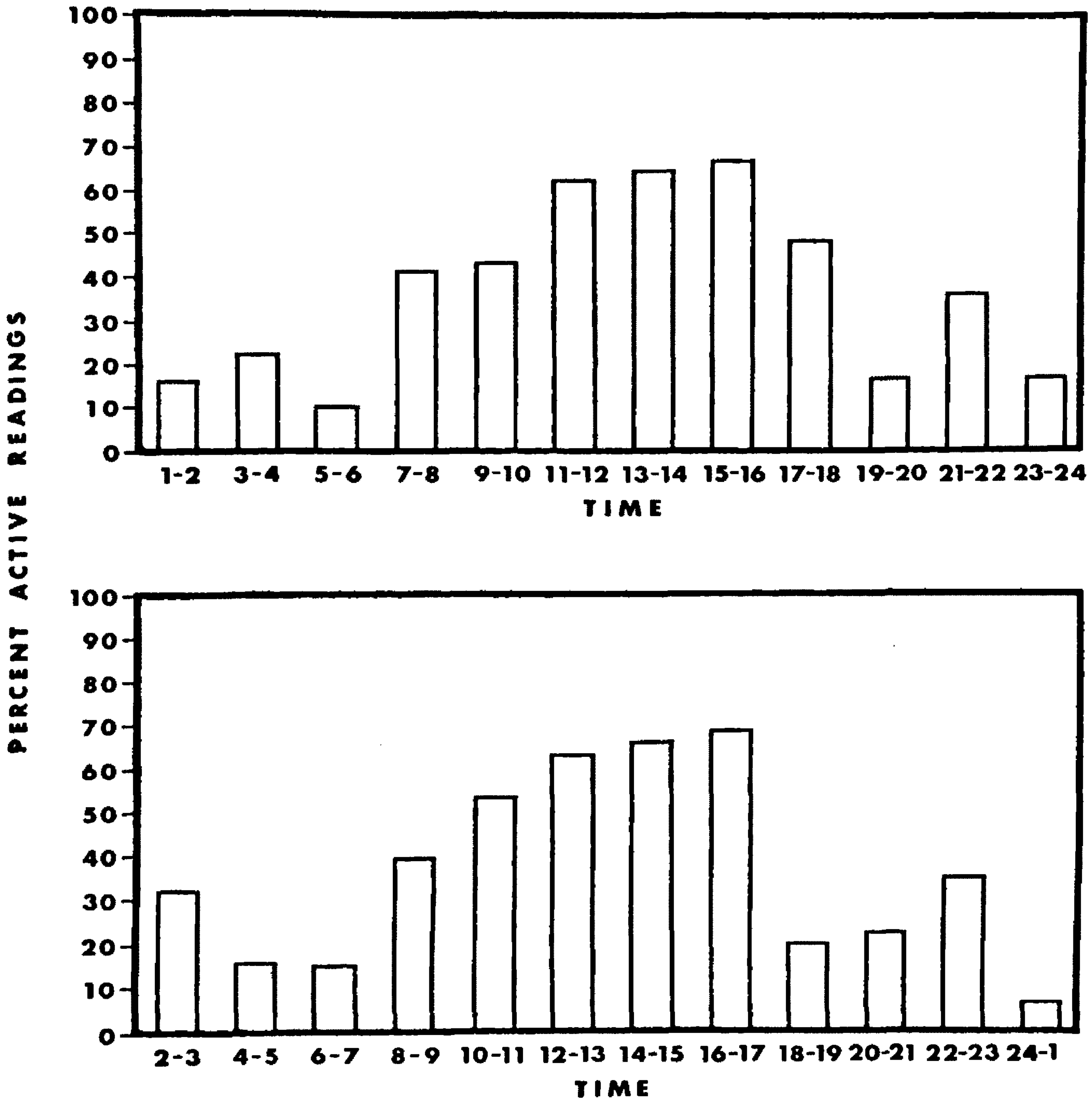


Fig. 5. Relationship between activity and hour of the day for all marten combined.

Table 13. Consecutive, successive, and collar-relocation distance estimates. See text for an explaination of the different distance estimates. N equals the number of movments, s the standard deviation.

Grouping by:	Consecutive			Successive			Collar-relocation		
Individual	N	mean	s	N	mean	s	N	mean	s
m51(R)	2	0.6	0.2	15	0.7	0.3	15	0.5	0.2
m61(N)	5	0.8	0.5	16	1.5	1.7	16	1.3	1.5
m63(N)	16	0.4	0.3	29	1.9	3.0	29	5.3	1.8
m69(R)	5	0.3	0.2	20	0.5	0.4	20	0.7	0.3
f59(N)	9	0.8	0.9	27	2.4	2.3	27	4.4	2.1
M13(R)	0	-	-	4	0.4	0.3	4	0.4	0.2
M56(R)	6	0.8	0.5	24	1.1	0.8	24	1.1	0.7
M64(R)	1	1.0	0.0	9	0.8	0.2	9	1.0	0.3
F37(R)	3	0.2	0.0	6	0.5	0.8	6	1.0	0.9
F66(R)	1	0.1	0.0	11	0.5	0.3	11	0.8	0.2
Status									
Non-residents	30	0.6	0.6	72	2.0	2.5	72	4.1	2.4
Residents	17	0.5	0.4	89	0.7	0.6	89	0.8	0.5
Age									
Juveniles	34	0.6	0.5	107	1.5	2.2	107	3.0	2.6
Adults	10	0.6	0.5	54	0.8	0.7	54	1.0	0.6
Sex									
Males	34	0.6	0.4	117	1.2	1.7	117	2.0	2.2
Females	13	0.6	0.8	44	1.7	2.1	44	3.1	2.4
Class									
Juveniles (N)	30	0.6	0.6	72	2.0	2.5	72	4.1	2.4
Juveniles (R)	7	0.4	0.2	35	0.6	0.4	35	0.6	0.3
Adult males	7	1.0	0.5	37	1.0	0.7	37	1.0	0.6
Adult females	4	0.2	0.1	17	0.5	0.5	17	0.9	0.5
Total	47	0.6	0.5	161	1.3	1.8	161	2.3	2.3

significantly from the other 3 subgroups (D p≤.043). Resident juveniles had the next shortest daily movements (mean=0.4 km, s=0.3), differing significantly from both adult males (0.9 km, s=0.5) and females (D p<.001), but not juvenile transients (mean=0.6 km, s=0.6;D p>.25). Adult males had daily movements significantly longer than any other social class (D p≤.012),

<u>Successive</u>. Juvenile successive movements (mean=1.5 km, s=2.2) did not differ (M-W p=.940) from adult movements (mean=0.8 km, s=0.7). The average male SD (mean=1.2 km, s=1.7) showed no difference (M-W p=.377) from the average female SD (mean=1.7 km, s=2.1). However, non-residents averaged 2.0 km (s=2.5) between successive locations, significantly longer (M-W p=.054) than the SDs of residents (mean=0.7 km, s=0.6).

A significant difference was found between successive distances of social classes (M-W p=.011). Non-resident juveniles averaged longer SDs (mean=2.0 km, s=2.5) than resident juveniles (mean=0.6 km, s=0.4;D p<.002) and adult females (mean=0.5 km, s=0.5;D p<.001), but not adult males (mean=1.0 km, s=0.7;D p>.40). Resident juveniles averaged shorter SDs than adult males (D p<.001), but not adult females (D p=.187). Adult males traveled farther between successive locations than adult females (D p<.001).

Note that the variance was large for non-resident marten (m61,m63,f59). This reflects the long movements of non-residents between areas of concentrated use.

Collar-Relocation. The collar-relocation distance estimates differed significantly by residential status, age, sex (M-W $p \leq .003$). Non-residents traveled over 5 times as far as residents from their points of initial capture, 4.1 km (s=2.4) compared to 0.8 km (s=0.5). Although the average female CRD (3.1 km, s=2.4) was significantly longer than the male average of 2.0 km (s=2.2), this was primarily due to the influence of non-resident f59. Similarly, the juveniles as a group averaged longer CRDs (mean=3.0 km, s=2.6), 3 times the adult average of 1.0 km (s=0.6). This was due to the long movements of non-residents, who where all juveniles.

Comparing differences between social classes, non-residents traveled the farthest from their point of initial capture (D $p<.001$). They averaged over 4 times the distance moved by adult males (mean=1.0 km, s=0.6) and adult females (mean=0.9 km, s=0.5) and over 6 times that moved by resident juveniles (mean=0.6 km, s=0.3). Resident juvenile had the shortest average CRD (D $p<.001$) because of the small area over which they traveled and the close proximity of their their home ranges to initial capture sites. The difference between adult male and female CRDS was not significant (D $p=.105$).

In summary, movement estimates indicated that adult males moved the farthest between daily locations; juvenile transients and adult males moved the farthest between successive days; and non-residents moved the farthest from the point of initial capture.

Movements of individual marten. Juvenile m63 was collared at a remote location of the core study area, he subsequently disappeared for 41 days, reappearing 13.8 km to the south (Fig. 6). Although aerial flights were made during this period no signal was received. The transmitter's 50-60 ms pulse rate may have been too slow for aerial relocations in a high relief area such as GNP. After his long distance movement (the longest recorded for any marten), he moved 5.4 km northeast and disappeared for almost 4 months, reappearing only 0.2 km due east. He then traveled 13.0 km northwest to an area 6.1 km from his original collaring site. He established temporary residency on this area for 22 days, leaving once and traveling 6.1 km southeast. After his residency, he dispersed to new areas. His collar was removed on 26 June 1980, 4.8 km from his initial collaring site. Throughout this period, he was never relocated closer than 4.5 km from his collaring site, although he traveled approximately 4 km south of it on several occasions.

The other transient male, m61, is of particular interest (Fig. 7). He established a temporary home range 2.1 km from his initial collaring site for 51 days. This was within the home range of adult M56 who was, at that time, occupying the lower portion of his range. Both males were located within their respective ranges on 17 October. On 22 October M56 was located within the temporary home range of m61, and m61 was located 2.0 km upslope, northwest of his previously used range. This juvenile was never relocated back on that area but traveled to new areas. His last location was 3.0 km from his initial collaring site, although he traveled as far away as 7.1 km from that site. This non-resident averaged longer movements between successive locations than

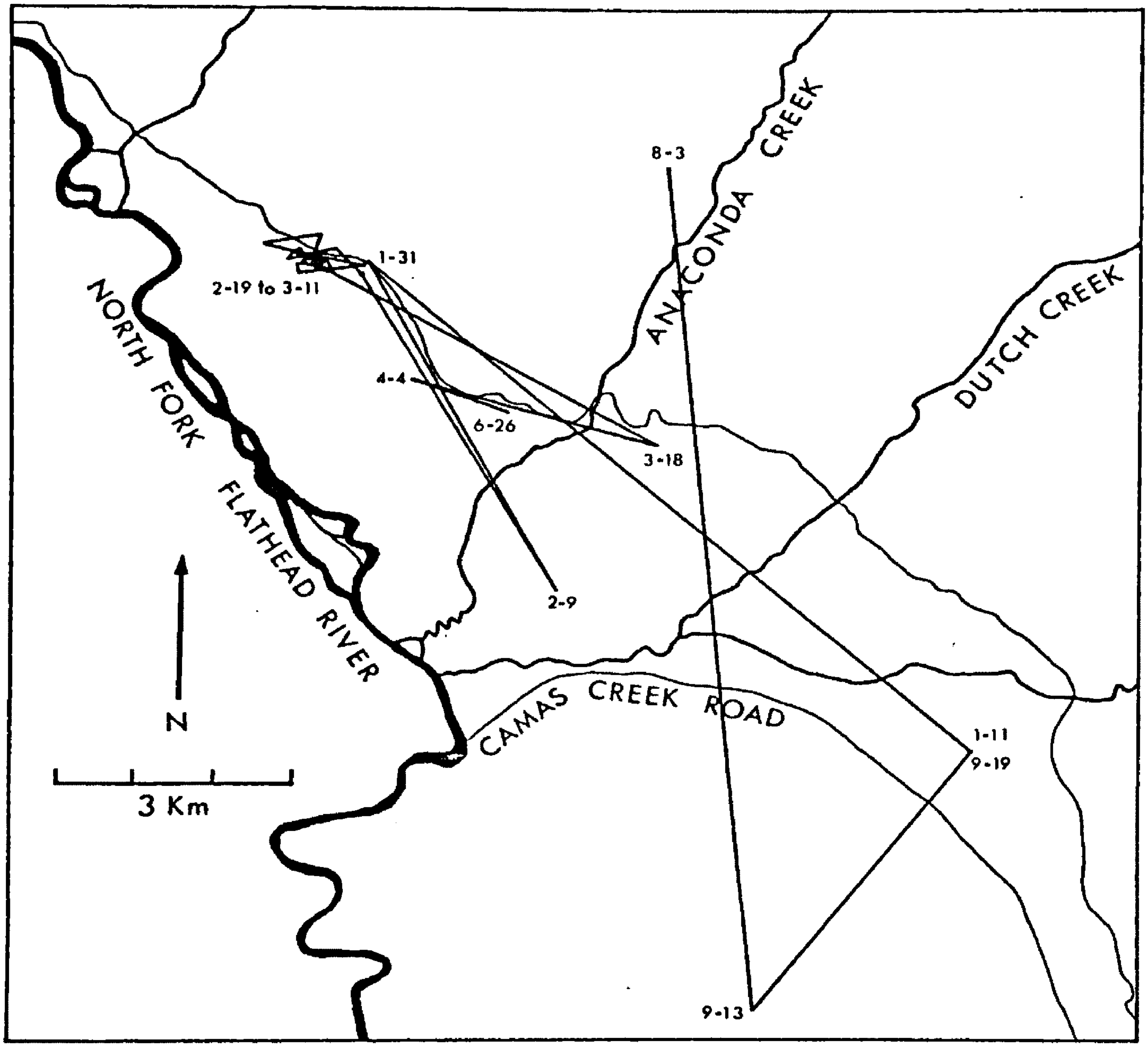


Fig. 6. Successive movements of non-resident juvenile male m63. Numerals at each location represent dates from 1979 (8-3 to 9-19) and 1980 (1-11 to 6-26).

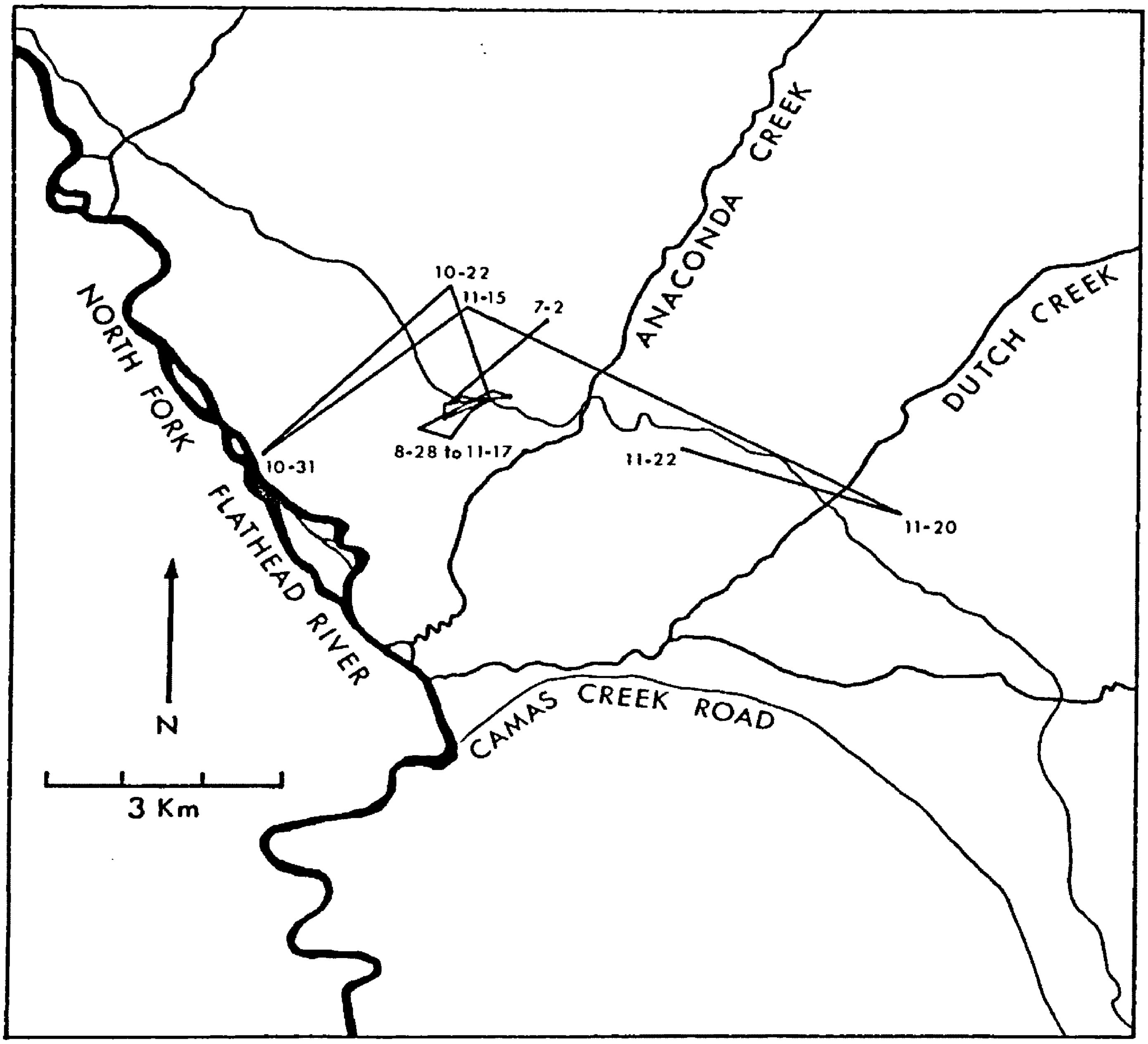


Fig. 7. Successive movements of non-resident juvenile male m63. Numerals at each location represent dates from 1979.

between his initial collar site and relocations. Possibly he had already emigrated when I collared him and he had developed an affinity for that area, or space may have been available close to his maternal home range and he did not need to disperse. However, his signal was received for a much shorter period; he may have disperse farther after he could not be located.

Juvenile female f59 dispersed widely and was never observed to concentrated her activity in 1 area longer than 9 days (Fig. 8). She traveled as far as 9.7 km from her collaring site. The area she occupied for 9 days was a floodplain island, 6.6 km from her initial location; she revisited this island 1 day after leaving for 8 days. Also notice 4 of her locations were in Dutch Creek; 2 occasions were revisits to that creek's riparian zone. Another location was in Anaconda Creek's riparian zone. As such, she showed a preference for wetter areas. The non-resident juvenile males, however, did not show this preference.

Resident M56 concentrated his activity in small parts of his large home range for extended periods (Fig. 9). He used the center during fall and early winter, concentrating his activity in the southern portion in late winter. Locations were not often made then, but the direction of signals indicated that his activity was centered farther south. He often made sallies out to the edge of his range.

Resident juvenile male locations were distributed randomly throughout their home ranges with no apparent movement pattern (Fig. 10). Resident m51 was collared east of his future home range, where he

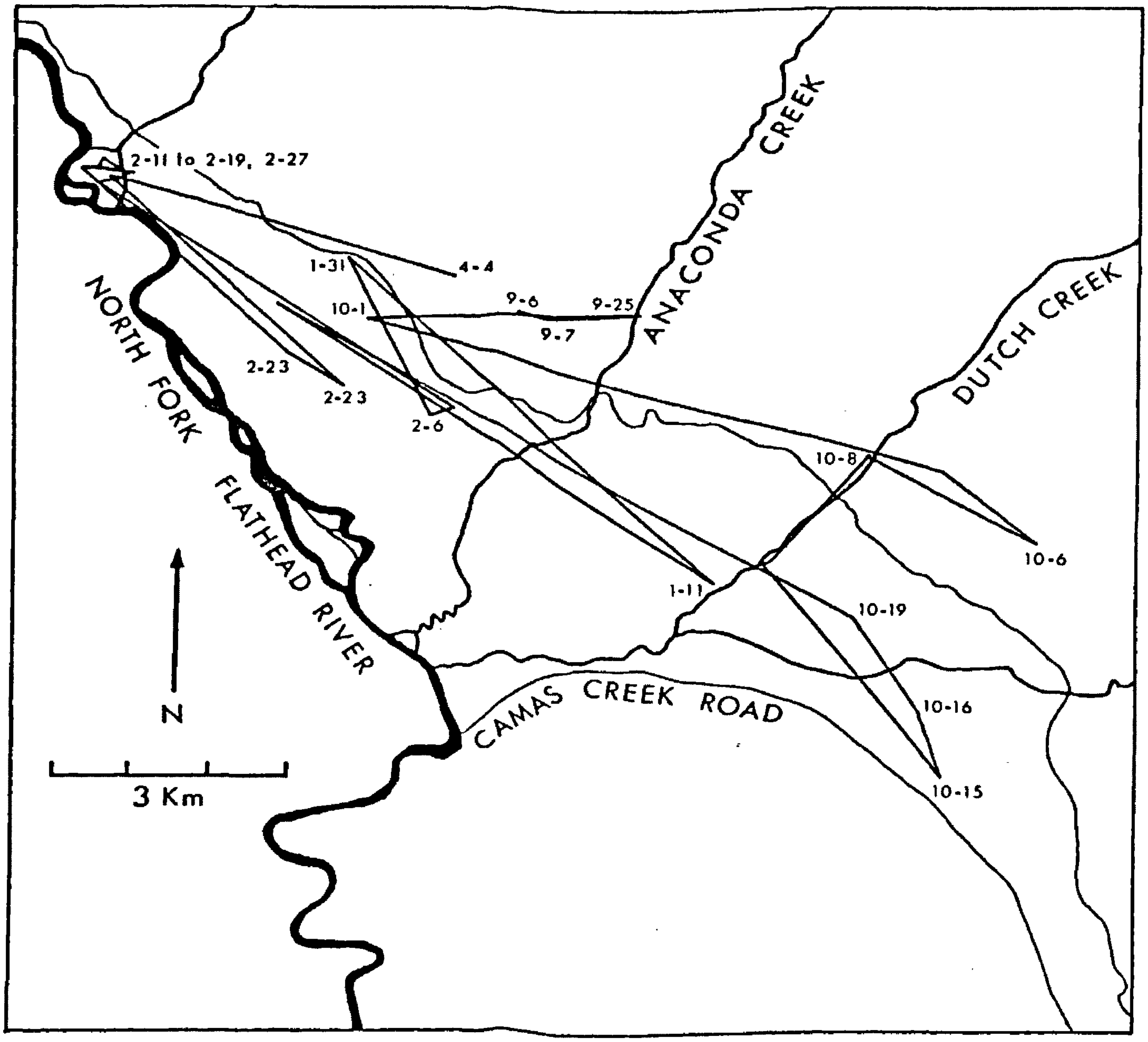


Fig. 8. Successive movements of non-resident juvenile female f59. Numerals at each location represent dates from 1979 (9-6 to 10-19) and 1980 (2-6 to 4-4).

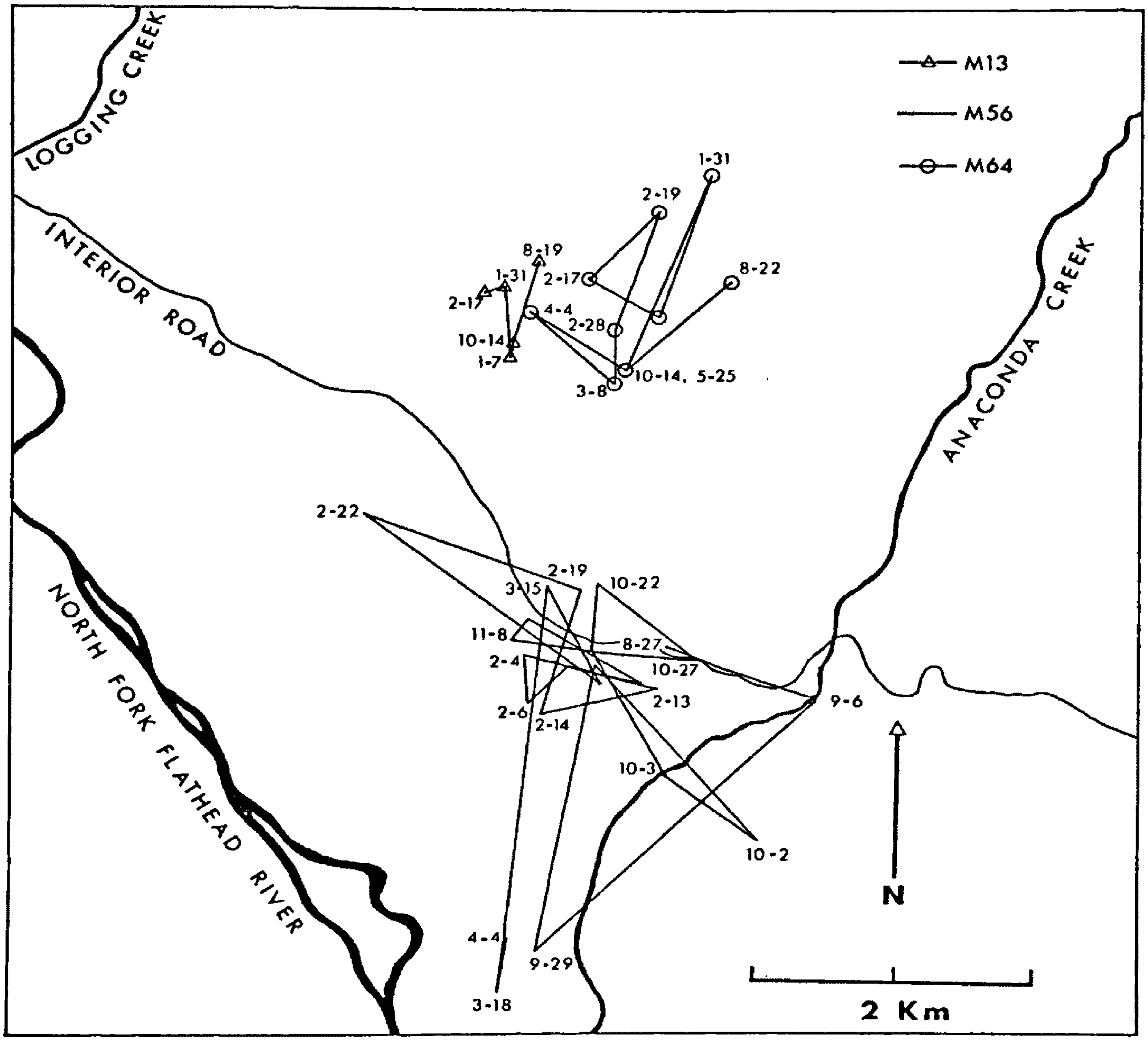


Fig. 9. Successive movements of resident adult male marten. Numerals at each location represent dates from 1979 (8-19 to 11-8) and 1980 (1-31 to 5-25).

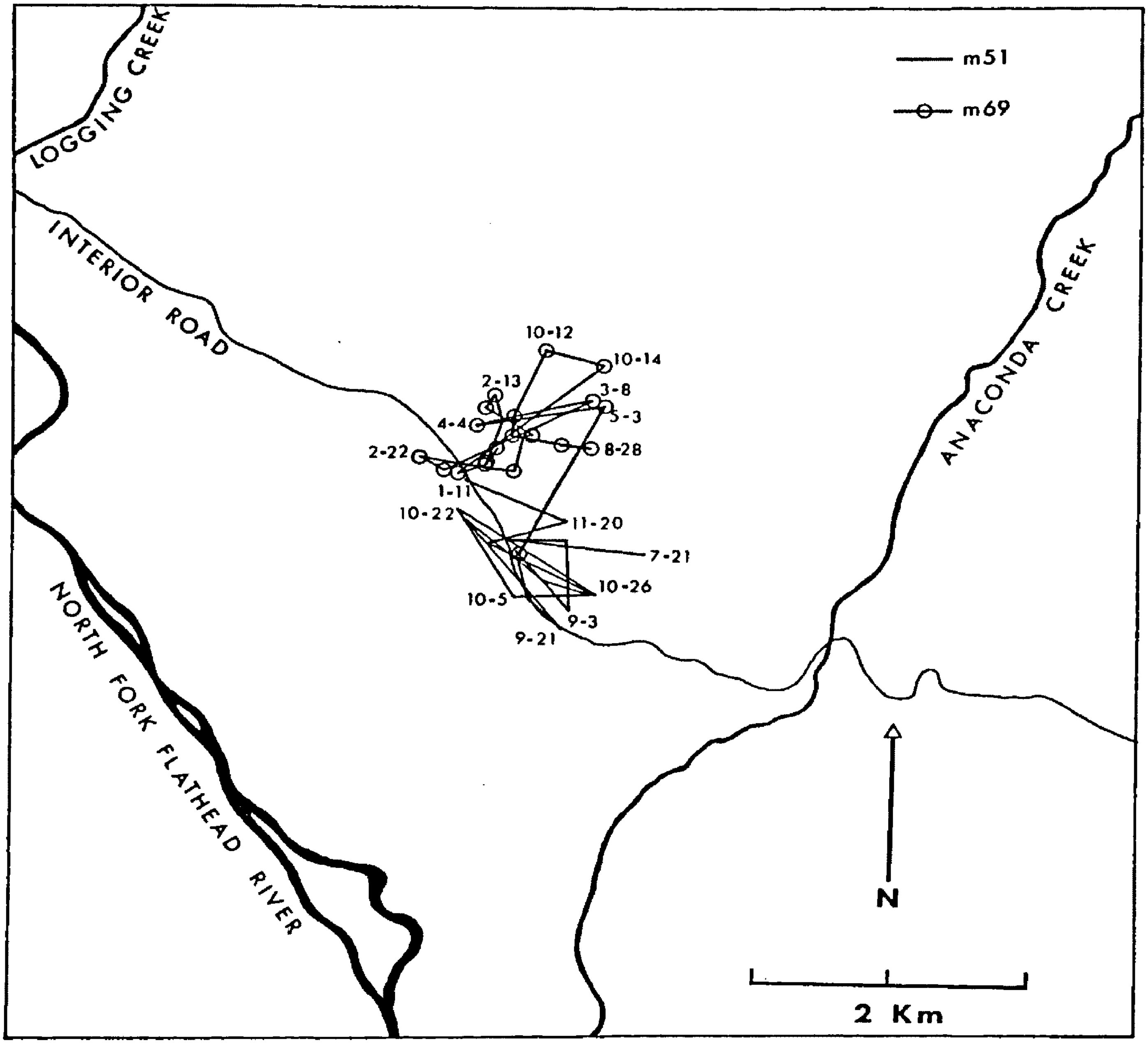


Fig. 10. Successive movements of resident juvenile marten. Numerals at each location represent dates from 1979 (7-21 to 11-20) and 1980 (1-11 to 5-3).

was subsequently found for 170 days. His last 2 locations appeared to be extensions of his home range. Resident m6, was collared in the area he continued to occupy for 361 days. His last location appeared to be a range extension; he had reached adult status at that time as evidenced by his swollen testes (he was captured at this location for collar removal). His last location was not used in determination of his juvenile home range. An adequate sample of locations was not obtained on the other residents to warrant discussion (Figs. 11 and 9).

Home Range

Radio locations (N=140) and trap captures (N=47) were used to estimate home ranges (Table 14). The JTM estimated home ranges significantly larger than the IIM estimates (T-TEST p=.035), by an average factor of 7.5. The difference between home range estimates was much higher for non-residents (18.9) than for residents (3.1), indicating that the geometric area (IIM) used by non-resident and residents showed more similarity than the geographic area (MAM) covered.

Non-residents had significantly larger JTM home range estimates than residents (M-W p=.014), while the IIM yielded no significant difference (M-W p=.414). This substantiates the theory that non-residents used similar geometric area as residents, but non-residents occupied several smaller areas separated by larger geographic areas.

The average juvenile JTM and IIM estimate showed no difference from the respective adult average (M-W p=.584). The difference between

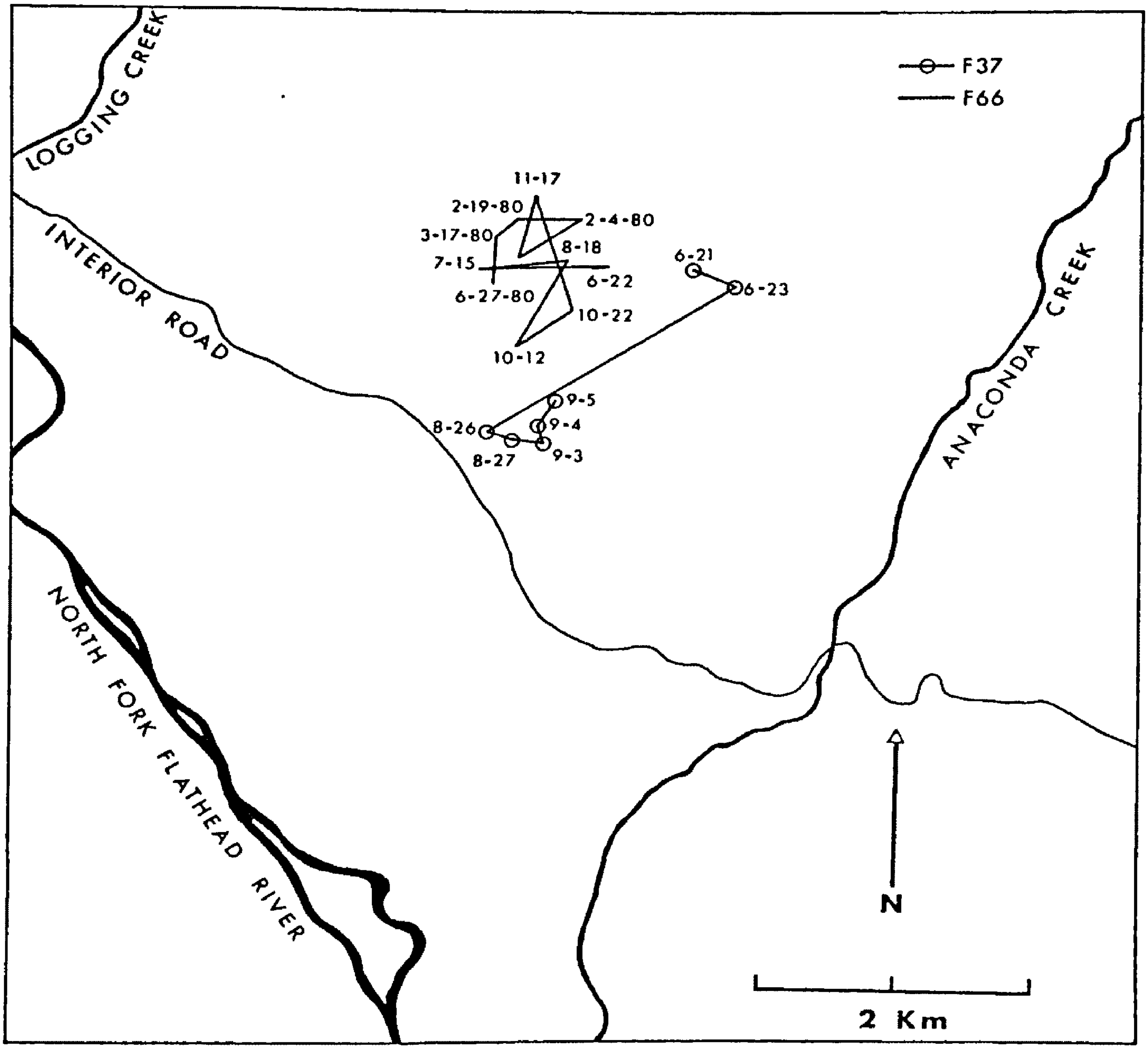


Fig. 11. Successive movements of resident adult female marten. Numerals at each location represent dates from 1979 and 1980 (80).

Table 14. Home range estimates of resident (R) and non-resident (N) marten, as determined by the minimum area method (MAM), corrected MAM (JTM), and the infinity index method (IIM).

	Males				Females		
Marten	MAM	JTM	IIM	Marten	MAM	JTM	IIM
Juveniles							
m61 (N)	12.3	29.3	1.6	f59 (N)	41.2	77.2	6.5
m63 (N)	48.0	87.4	3.3				
m51 (R)	0.7	1.8	1.8				
m69 (R)	0.8	1.6	2.0				
mean	15.4	30.1	2.2				
s	19.3	35.0	0.6				
Adults							
M13 (R)	0.8	5.8	0.8	F14 (R)	0.9	6.6	(a)
M56 (R)	6.7	12.9	3.9	F37 (R)	0.6	3.2	0.8
M64 (R)	1.2	4.2	3.3	F66 (R)	0.7	2.0	2.6
mean	2.9	7.6	2.7		0.7	3.9	1.7
s	2.7	3.8	1.3		0.1	2.0	0.9

Status	MAM		JTM		IIM	
	mean	s	mean	s	mean	s
Non-residents	33.8	19.0	64.7	31.0	3.8	2.5
Residents	1.5	2.1	3.6	1.9	2.1	1.1
Juveniles	20.6	22.5	39.5	40.9	3.0	2.0
Adults	1.7	2.5	5.8	3.9	2.2	1.3
Males	10.0	17.4	20.4	31.1	2.4	1.1
Females	10.8	20.2	22.3	36.7	2.9	2.5

Social Class	MAM		JTM		IIM	
	mean	s	mean	s	mean	s
Juveniles (N)	33.8	19.0	64.7	31.0	3.8	2.5
Juveniles (R)	0.8	0.0	1.7	0.1	1.9	0.1
Adult males	2.7	3.5	7.6	4.6	2.7	1.7
Adult females	0.7	0.2	4.0	2.4	1.7	0.9

(a). indeterminant

male and female estimates was not statistically different using either the JTM or the IIM (M-W p=1.00). Differences between those categories probably were masked by the intermixing of social classes (e.g. non-resident and resident juveniles).

Differences between social classes were significant for the JTM (K-W p=.036), but bordered on the significance level for the IIM (K-W p=.095). Further comparison of the IIM estimate between pairings of these classes showed no significant differences (D p>.300). However, 5 out of 6 pairs of classes were statistically different using the JTM (D p<.001). Non-resident juvenile marten had significantly larger JTM range estimates than 1) resident juveniles (D p<.001), 2) adult males (D p=.001), 3) and adult females (D p<.001). This shows a clear distinction between the large areas through which non-residents traveled compared to the smaller areas which residents occupied. Resident juveniles had significantly smaller JTM home range estimates than any other social class (D $p \leq .006$). The small home ranges of resident juveniles suggests that available space was limited. Adult male and adult female JTM home range estimates did not differ (D p=.421).

Dispersion

Residents. Considerable overlap of the 95% confidence ellipses of resident marten locations is evident (Fig. 12). Most overlap is between, and not within social classes; the exception being residents M13 and M64. Over 2 thirds of M13 home range ellipse is within M64's (Fig. 13). This is based on only 5 locations for M13 and

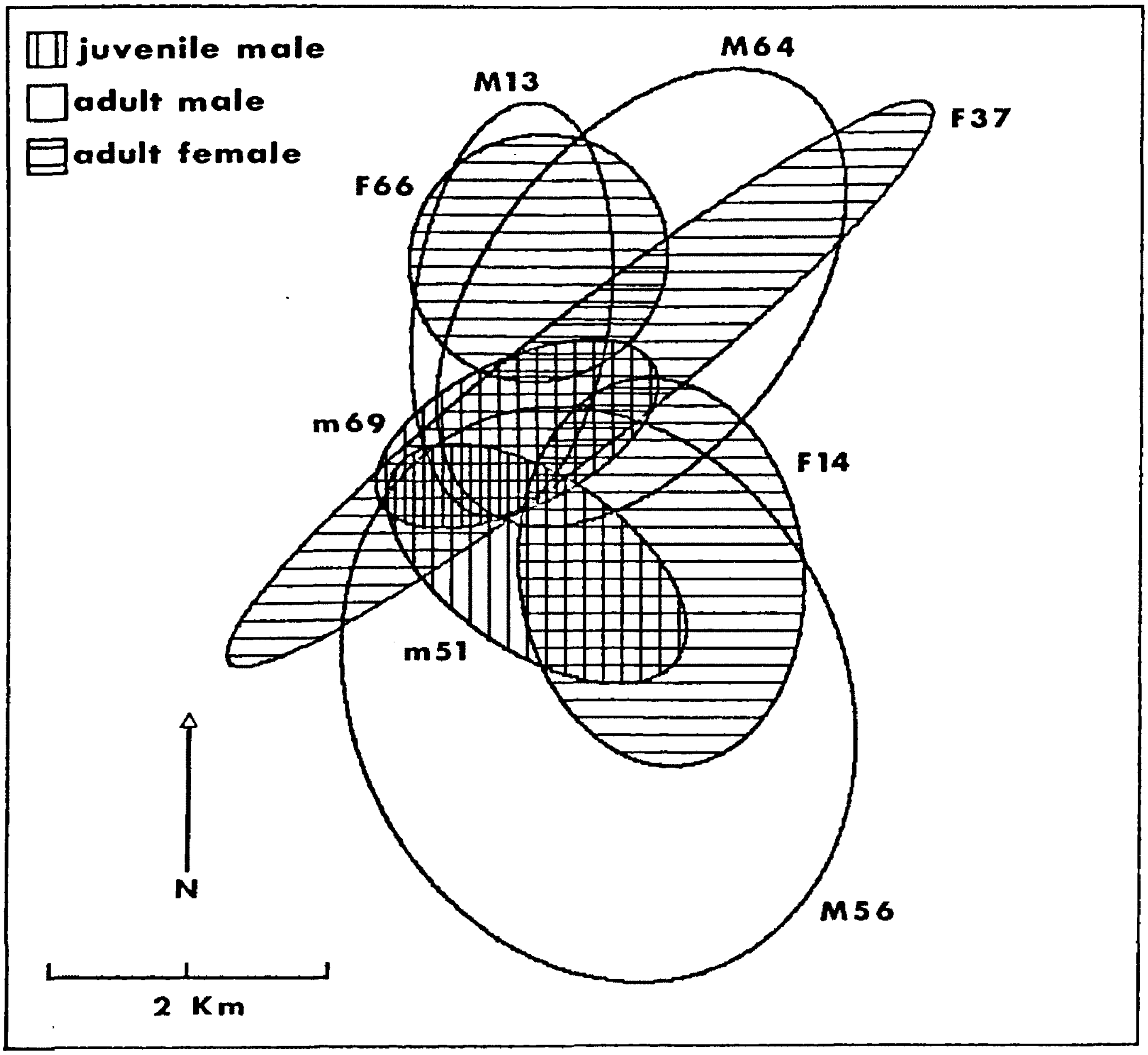


Fig. 12. Confidence ellipses (95%) of resident marten locations.

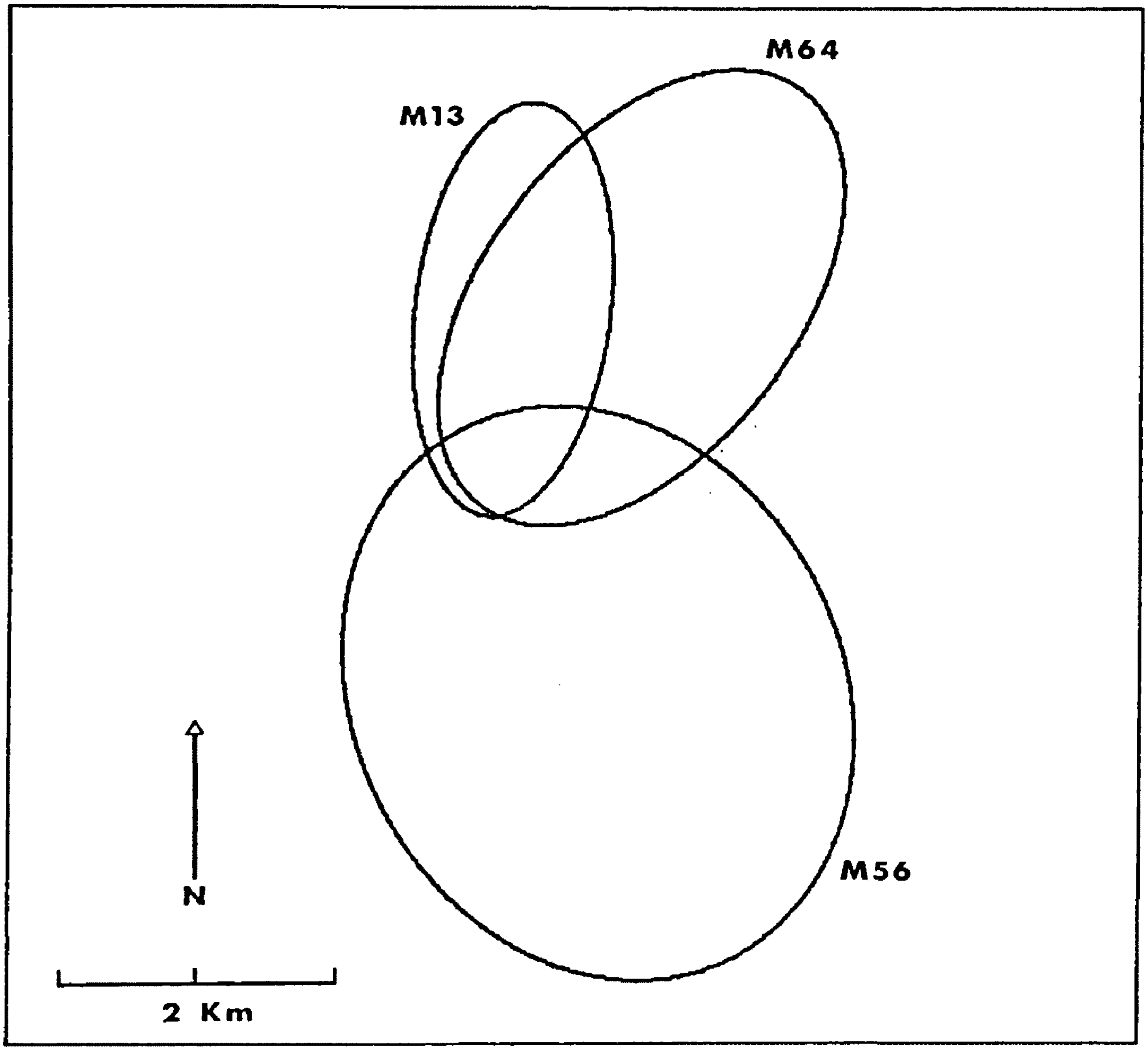


Fig. 13. Confidence ellipses (95%) of resident adult male marten locations.

may represent only a part of his range relative to the other marten's ellipses. However, recall that the ellipses represent graduating radii of use. Actual locations of the 3 adult males do not overlap, suggesting competitive exclusion. The ellipse of resident M56 also indicates little overlap despite its larger size. Although resident adult males show some overlap of, or near, their ellipse centers, overlap of resident adult female ellipses is nearer their edges (Fig. 14).

These dispersion patterns indicate intrasexual spatial separation by the resident adult marten compared to the extensive intersexual overlap of resident adult ellipses (Fig. 15). Locations of resident males and females also overlap extensively. Both M13 and M64 overlap all 3 of the adult females; M56 overlaps with 2. Thus, adult males have access to more than 1 female.

Ellipses of resident juvenile males m51 and m69 show extreme overlap of ellipses with those of resident adults, particularly where the adult male ellipses overlap (Fig. 16). Although the overlap of ellipses is almost complete, actual locations indicate spatial isolation between juvenile and adult males for resident space (compare Figs. 9 and 10). The discrepancy between overlap of locations shown by the ellipses and the actual locations suggests 95% confidence ellipses are not an appropriate model for data of this sort, possibly due to low sample size or the distribution of locations. Lower percentage confidence ellipses may more accurately represent overlap of marten locations.

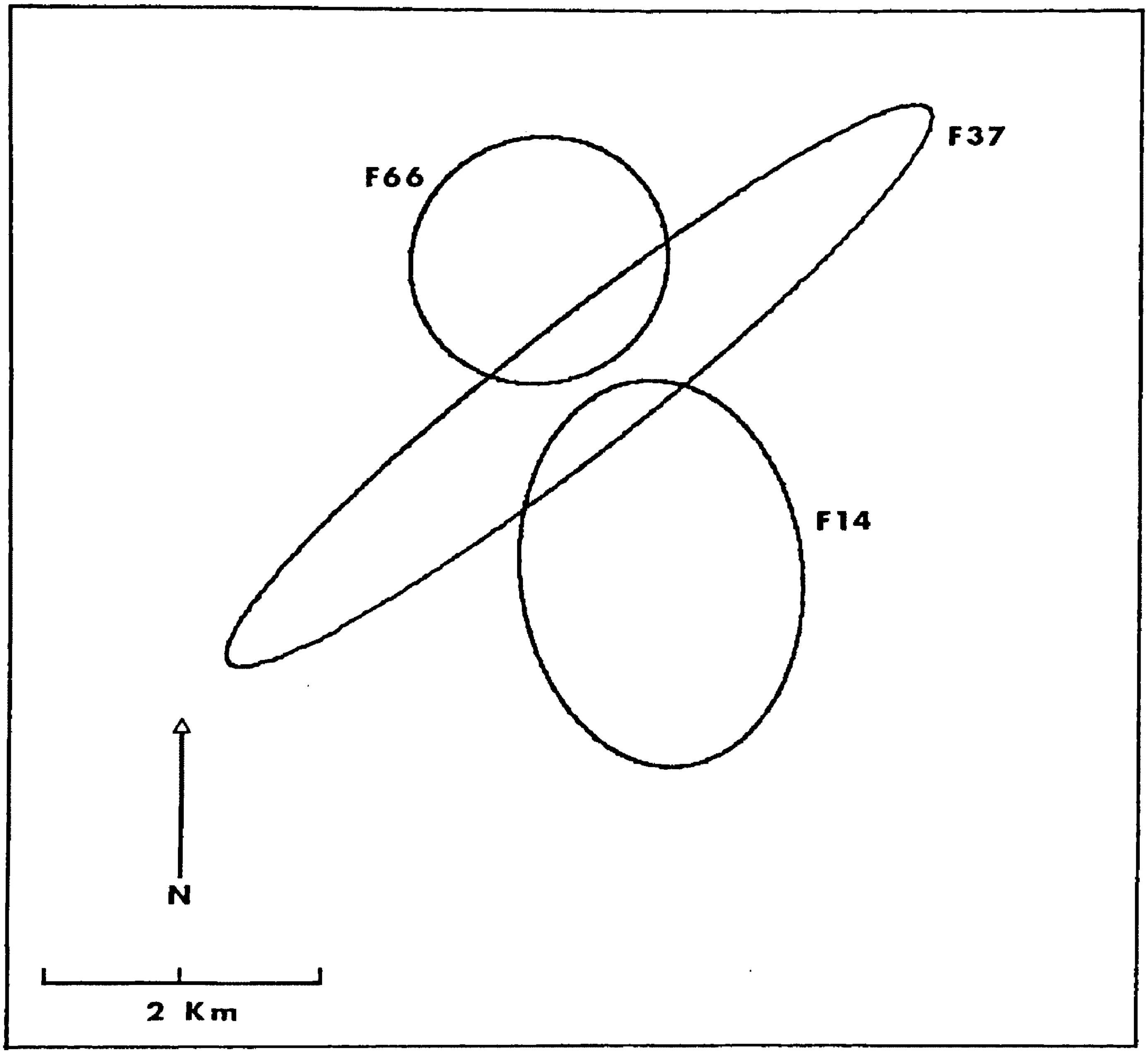


Fig. 14. Confidence ellipses (95%) of resident adult female marten locations.

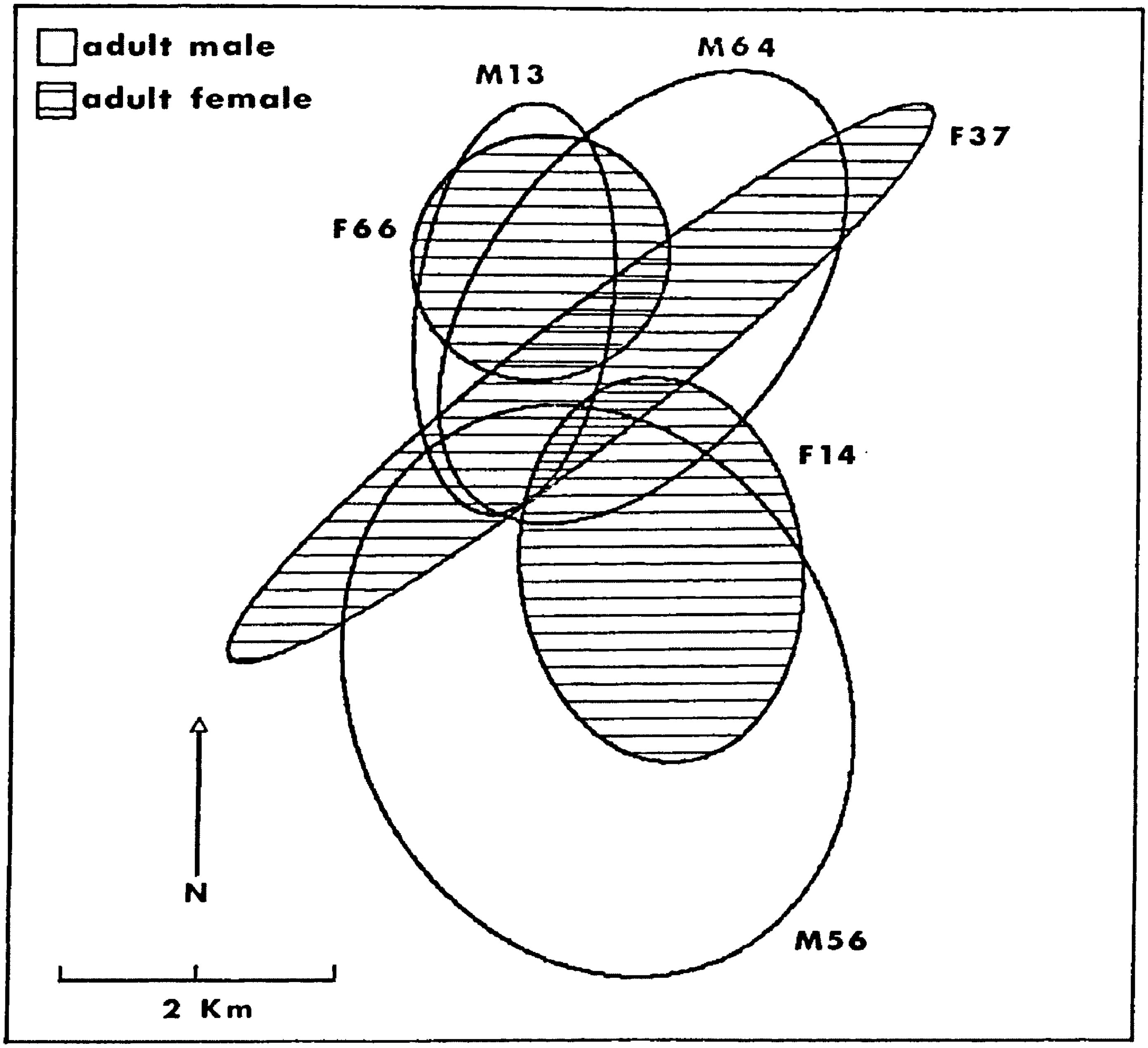


Fig. 15. Confidence ellipses (95%) of resident adult marten locations showing overlap of male and female ellipses.

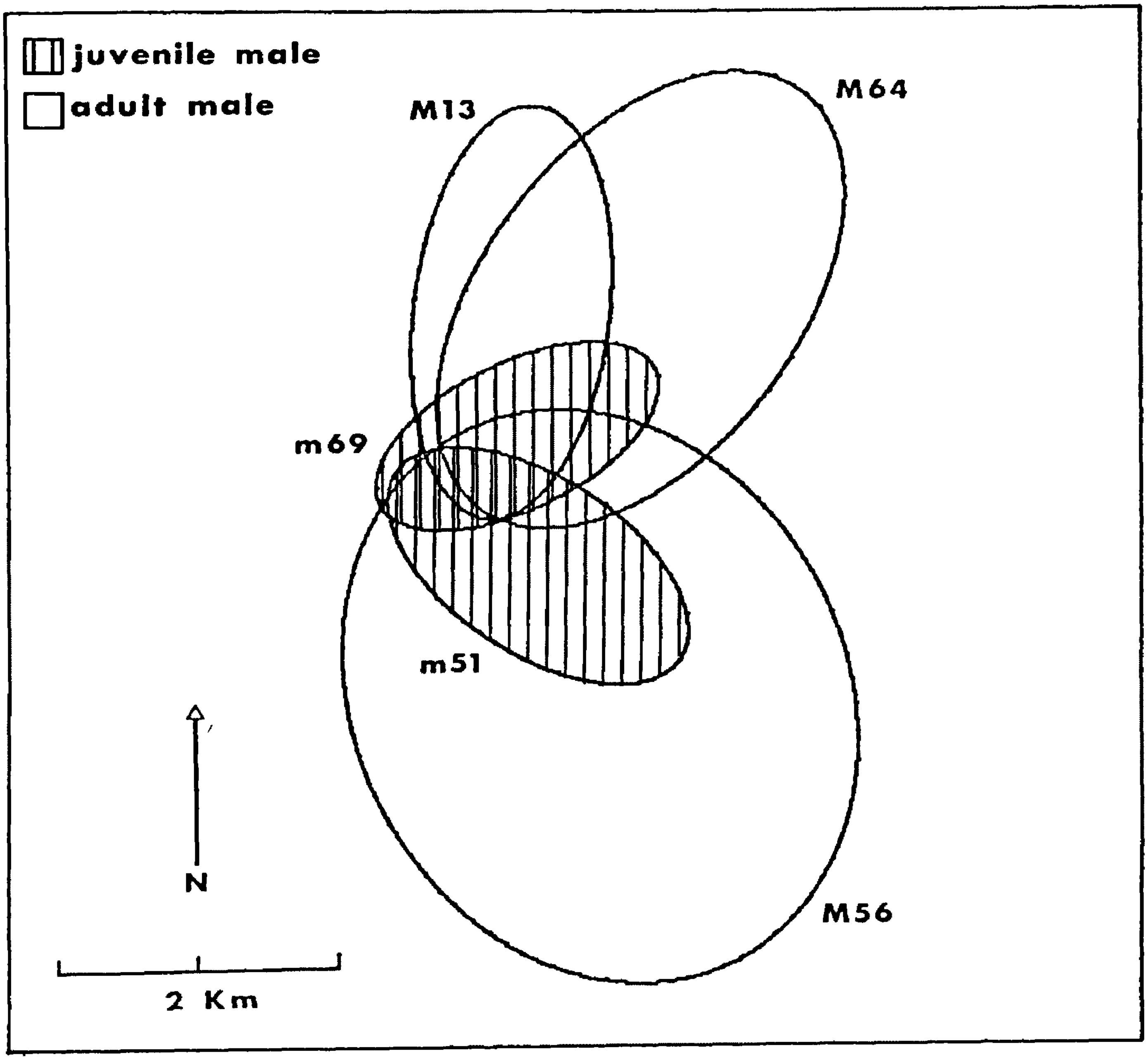


Fig. 16. Confidence ellipses (95%) of resident male marten locations showing overlap of juvenile and adult ellipses.

The home range ellipses of collared resident male marten are plotted with the known trap captures of M77, the only uncollared resident male captured (Fig. 17). All his locations are live-trap captures (3 over a 370 day period). His locations are all within the ellipses of M64, 2 lie within F13's ellipse, and 1 lies within F56's. This indicates more intrasexual overlap between adult males than movements or ellipses obtained by telemetry indicate. An inherent bias of studies based purely on radio locations is that few animals can be intensively studied. Major (1979) made similar observations when relating trapping/tracking studies to telemetry studies.

<u>Non-residents</u>. Home range ellipses of non-resident marten overlaped extensively (Fig. 18). Non-resident marten traveled through similar areas, although they separated use temporally. Non-resident m61 had a much smaller ellipse than the other non-residents, although he was monitored for a shorter period. He also established his temporary home range close to the geometric center of his locations, whereas the other non-resident's temporary home ranges were near the northwest edge of the area each occupied, resulting in larger confidence ellipses. The use of very similar areas suggested that non-resident juveniles were tolerant of each other.

Habitat Use

Recall that certain cover types were not independent of the habitat types identified at the respective site. Locations of marten in cover types are tabulated in Table 15, and habitat type locations are

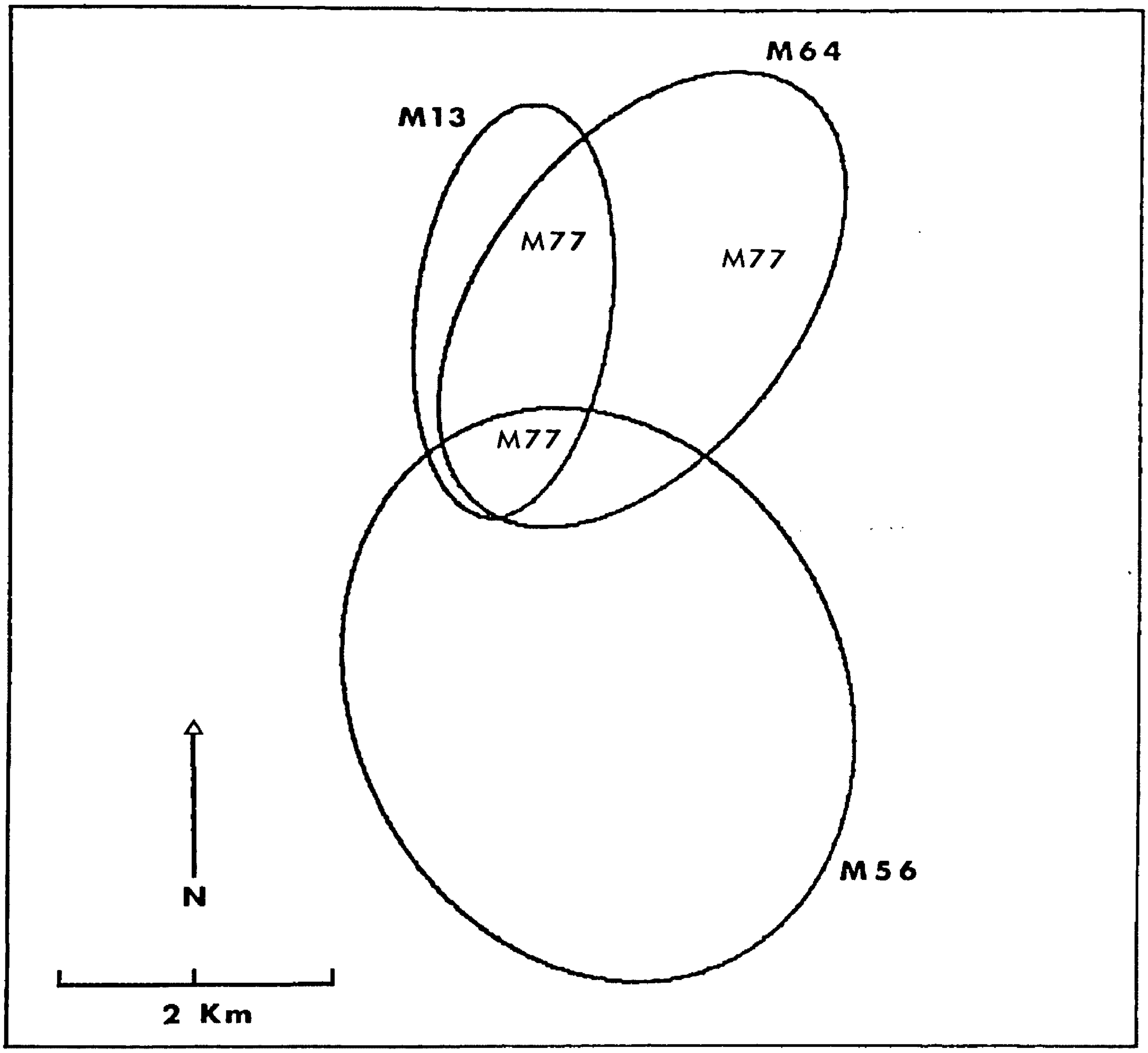


Fig. 17. Confidence ellipses (95%) of resident adult male marten locations showing overlap with trap captures of uncollared resident male marten M77.

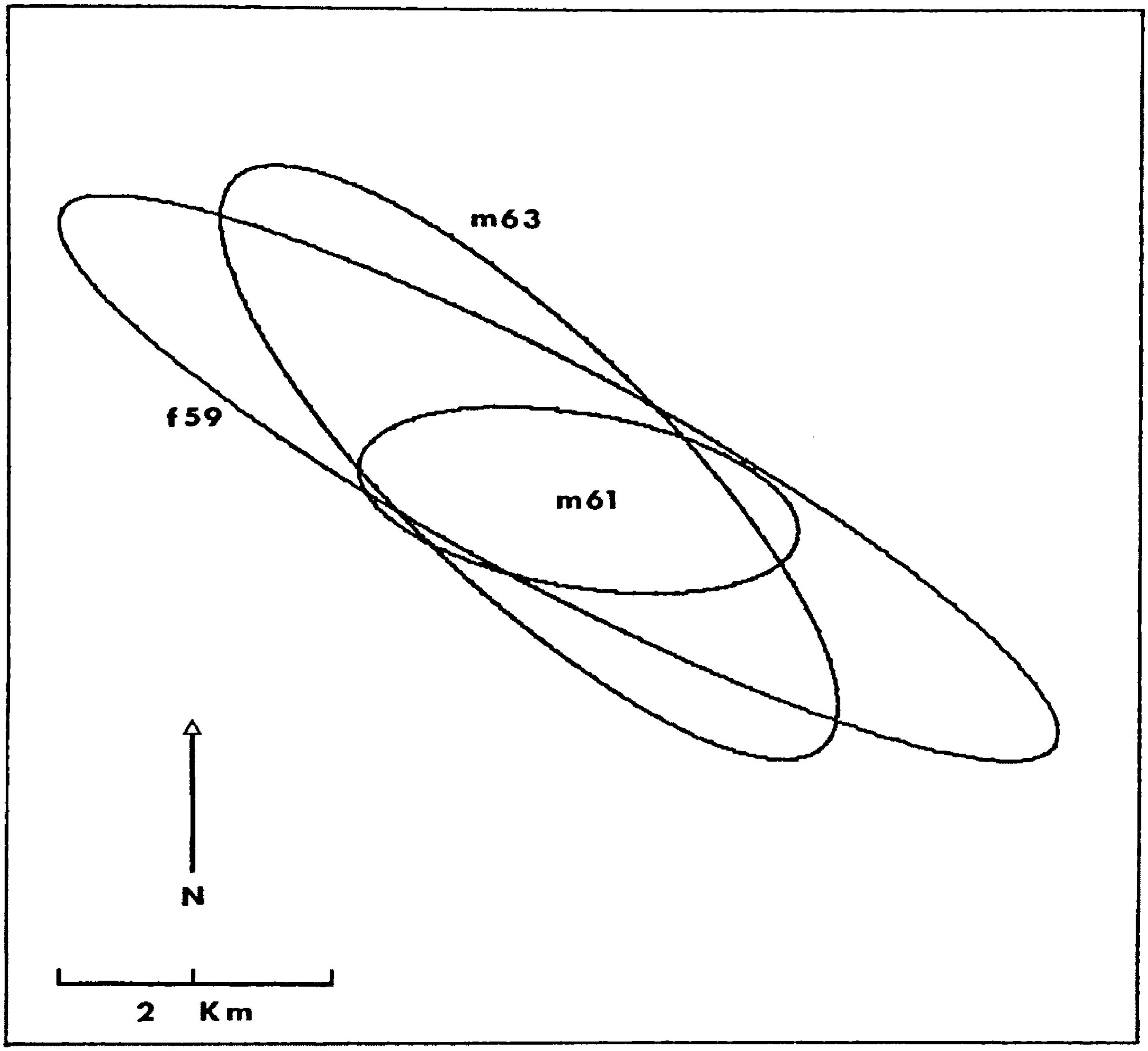


Fig. 18. Confidence ellipses (95%) of non-resident juvenile marten locations.

Table 15. Locations of marten in cover types. Status indicates the residential status of each marten.

		Cover type							
Status	Marten	PICEA	PICEA -LAOC	PICEA -PSME	LAOC	PIPO	PICO	PICO -PIPO	Total
R	m51	0	0	0	0	1	12	3	16
N	m61	1	0	0	5	0	9	2	17
N	m63	0	1	0	0	0	21	1	23
R	m69	5	0	1	5	2	5	2	20
N	f59	9	0	0	2	0	5	1	17
R	M56	1	0	0	0	0	19	2	22
R	M64	1	0	1	0	3	2	0	7
R	F66	3	4	5	0	0	0	0	12
Total		20	5	7	12	6	73	11	134

summarized in Table 16.

Cover types. Comparing each marten's use of cts, as represented by the relative rank of locations in each type, showed a significant association between marten (W $p<.05$). The most significant association of ct use was between juvenile marten (W $p<.01$); adult ct use did not associate (W $p>.50$).

Evidence was found that the non-resident juveniles proportioned their use of cts differently than resident juveniles (L $.10>p>.05$). Non-resident juveniles associated within their group (W $p<.10$), but the 2 resident juveniles showed no significant similarity (W $p>.95$). Although the non-resident juveniles use of cts associated, the resident marten as a group did not (W $p>.10$).

The above are intuitively obvious upon inspection of Table 15. Juvenile m51 and adult M56 concentrated their use in the PICO ct. This similarity is not surprising, as m51's home range adjoined M56's. The other 3 resident's use of cts was very dissimilar. M64 occupied primarily PIPO and PICO cts, F66 was found solely in the more mesic spruce cts, while m69 spread his use over all but the PICEA-LAOC ct. This resident juvenile's home range was situated along a gradient of cts, from spruce to predominantly lodgepole. This was much different than the other resident's ranges that were less varied in cover.

Juveniles as a group occupied a wider variety of cts than the adults, suggesting they had a broad tolerance for cts, a necessary characteristic for dispersal or occupation of limited habitat. The apparent strong use of PICO ct by m63 is primarily a bias inherent in

Table 16. Locations of marten in habitat types.

	Habitat type					
Marten	PICEA /VACA	PICEA /CLUN	PICEA /EQAR	ABLA /VACA	ABLA /CLUN	Total
m51	10	6	0	0	0	16
m61	6	9	1	0	1	17
m63	22	0	0	0	1	23
m69	11	9	0	0	0	20
f59	5	11	0	0	1	17
M56	18	3	1	0	0	22
M64	0	0	0	2	5	7
F66	0	2	0	0	10	12
Total	72	40	2	2	18	134

the close proximity of his PICO cover-typed, temporary home range to the core study area. It was bisected by the access road to core the study area and as a consequence m63 was located many times in this area (22 out of 30 locations).

In general, cover use by non-residents was somewhat biased. Of all non-resident locations, 14 (18.7%) were made aerially or were triangulations; no quantitative vegetative information was available for these locations. These sites were several km from the core study area. However, based on general knowledge of the area, they represented different ecological cover types, substantiating that transients were generalized in their use of cts.

Habitat types. The marten showed association in their use of hts when tested as a group (W $p<.025$). There was a strong association of hts use by non-residents as a group compared to residents (L $p<.001$), and between non-resident juveniles and resident juveniles (L $p<.001$). However, when comparing juveniles as a group and adults as a group they did not associated (L $p=.204$). Juvenile occupation of hts were similar (W $p<.01$); the discordance was apparently between adults (W $p>.50$).

Juvenile marten occupied similar habitat types, as they did cover types. Their use of PICEA/VACA and PICEA/CLUN hts was particularly high. This contrasts with the adults. M64 and F66 primarily occupied ABLA/CLUN, whereas M56 was found predominantly in PICEA/VACA.

In summary, adult marten occupied a variety of forest types, although individual adults concentrated their activity in the mesic spruce cts in ABLA/CLUN and PICEA/CLUN hts. On the other hand, individual juveniles occupied a variety of forest types, dissimilar from those occupied by adults. This, together with dispersion results, suggests that juveniles occupied areas not occupied by adults.

Canopy cover. Canopy cover averaged 35% (s=21.7) at marten locations. Only 1 location was under less than 17% canopy cover. Juvenile non-resident f59 was observed hunting on and under large diameter logs (>40 cm) in open areas (total canopy cover <1%) along Dutch Creek, part of the 1967 Apgar Mountain burn (Anonymous 1977). Although the canopy cover was very low, the large diameter logs probably provided adequate cover.

Dispersal pattern. The 3 non-resident's ellipses overlap extensively (Fig. 18), and their successive movements and temporary home ranges are symmetrically arranged (Fig. 19). The area of overlap is dominated by lodgepole pine cover types, ranging from stands of homogeneous "dog-hair" lodgepole (dbh <10 cm) to stands of lodgepole >30 cm dbh. The extreme overlap of non-residents, and the dominant lodgepole character of the area, suggests that lodgepole cover types are dispersal habitat.

Resting Sites

From the ground, 36 daytime (0900 to 1900 hours) resting sites of stationary marten were located (Table 17). Trees were used on 29 (81%) occasions, significantly more than ground sites (X p<.005) (Fig. 20).

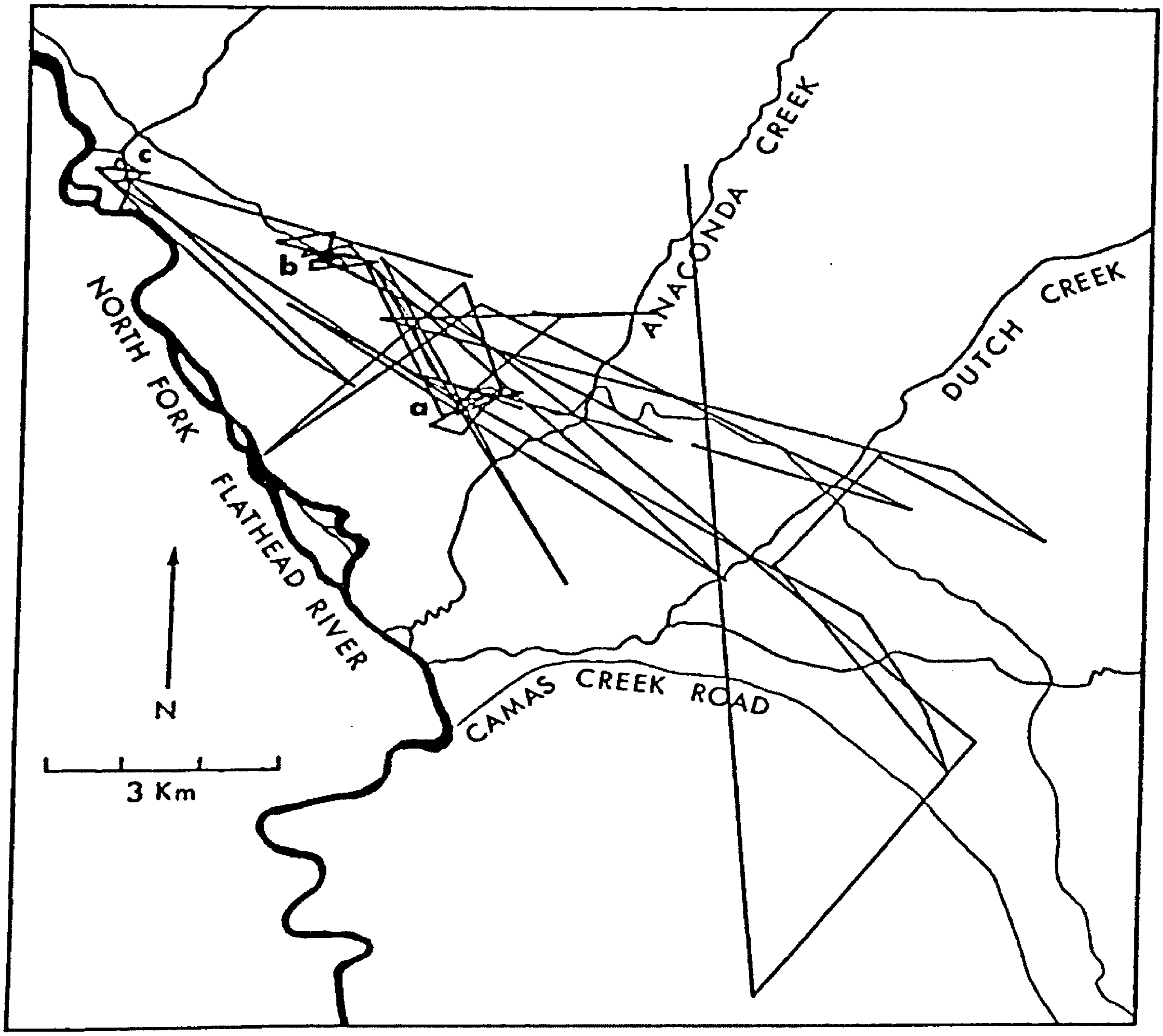


Fig. 19. Successive movements of non-resident juvenile marten. Letters represent temporary home ranges of (a) m61, (b) m63, and (c) f59. See Figs. 6-8 for successive movements of each non-resident.

Table 17. Daytime resting sites of marten showing habitat and site variables measured at each location.

				Resting site											
					Height of:										
Marten	Month	Time	Weather*	Tree spp.	Marten (m)	Tree (m)	Tree dbh (cm)	Live or Dead**	Location of marten***	Aspect	Angle of Slope	Elev. (m)	Cover Type	Habitat Type	Total cover
m51	10	12	sog;pc	-	0	-	-	-	depression	220	1	1085	PIPO	PICEA/VACA	26
m51	10	13	sog;pc	PICO	19	21	18	live	on a limb	110	2	1079	PICO	PICEA/VACA	26
m51	10	14	sog;pc	PICO	8	15	15	live	on a limb	230	3	1085	PICO-PIPO	PICEA/VACA	72
m51	10	14	sog;c	PICEA	5	18	23	live	on a limb	230	5	1079	PICO	PICEA/VACA	36
m51	10	16	sog;pc	PICO	2	19	20	live	on a limb	210	1	1085	PICO-PIPO	PICEA/VACA	62
m51	13	13	sog;pc	PIPO	0	8	64	dead	ground hole	260	1	1091	PICO	PICEA/VACA	35
m61	9	17	pc	PICEA	2	13	15	live	on a limb	210	1	1067	PICO	PICEA/CLUN	23
m61	10	15	o;s	LAOC	6	7	66	dead	cavity	230	13	1170	LAOC	PICEA/CLUN	22
m63	14	12	o;fr	PICEA	39	48	5	dead	on a limb	70	2	1085	PICO	PICEA/VACA	21
m63	14	12	sog;pc	PICO	12	16	20	dead	sq. nest	00	0	1088	PICO	PICEA/VACA	59
m63	14	16	sog;o	PICEA	3	8	10	live	dm bundle	30	5	1079	PICO	PICEA/VACA	38
m63	15	10	o;r	PICEA	6	10	10	live	dm bundle	10	5	1082	PICO	PICEA/VACA	54
m63	15	11	o;s	PICO	12	18	15	dead	sq. nest	50	10	1085	PICO	PICEA/VACA	38
m69	14	11	sog;pc	PICEA	20	23	30	live	on a limb	260	1	1109	LAOC	PICEA/CLUN	38
m69	14	12	sog;o	PICEA	15	17	33	live	on a limb	280	3	1097	PICO	PICEA/VACA	61
m69	17	13	sog;pc	PICEA	17	24	36	live	sq. nest	200	2	1197	PICEA	PICEA/CLUN	25
f10	0	-	c	LAOC	2	2	45	dead	cavity	200	5	1240	PICEA-PSME	PICEA/CLUN	70
f59	10	18	sog;c	PICO	2	31	33	live	on a limb	0	0	1085	PICO	PICEA/CLUN	45
f59	11	13	sog;pc	PICO	5	22	30	dead	on a limb	230	2	1073	PICO	PICEA/VACA	21
f59	14	9	sog;s	PICEA	0	<1	46	dead	downfall	0	0	1039	PICEA	PICEA/CLUN	80
f59	14	14	sog;c	PICEA	0	<1	5	live	downfall	0	0	1039	PICEA	PICEA/CLUN	46
f59	14	15	sog;s	PICEA	0	<1	5	live	downfall	0	0	1039	PICEA	PICEA/CLUN	46
f59	14	17	sog;o	PICEA	3	16	33	live	on a limb	0	0	1039	PICEA	PICEA/CLUN	36
M56	10	16	sog;pc	LAOC	3	4	36	dead	cavity	210	5	1097	PICO-PIPO	PICEA/CLUN	17
M56	10	16	o	PSME	8	29	71	live	on a limb	190	4	1085	PICEA	PICEA/VACA	82
M56	10	18	o	PSME	21	24	36	live	on a limb	170	5	1091	PICO	PICEA/CLUN	34
M56	10	19	sog;o	PICO	0	<1	8	dead	downfall	200	1	1085	PICO	PICEA/VACA	71
M56	11	11	sog;pc	PIPO	9	12	66	dead	cavity	160	2	1079	PICO	PICEA/VACA	23
M56	12	15	sog;o	PICO	7	14	13	live	on a limb	250	15	1091	PICO	PICEA/VACA	32
M56	14	12	sog;o	PICO	14	15	15	dead	on a limb	140	2	1079	PICO	PICEA/VACA	44
M56	14	12	sog;pc	PICO	15	18	13	dead	sq. nest	210	5	1094	PICO-PIPO	PICEA/VACA	22
M56	14	14	sog;s	PICO	19	23	23	dead	on a limb	230	3	1064	PICO	PICEA/VACA	43
M56	14	15	sog;c	PICO	3	14	18	dead	on a limb	200	15	1091	PICO	PICEA/VACA	31
M56	14	16	sog;pc	PICO	0	<1	10	dead	downfall	240	5	1070	PICO	PICEA/VACA	20
F66	11	11	sog;pc	PICEA	10	27	33	live	on a limb	290	10	1293	PICEA	ABLA/CLUN	20
F66	11	14	sog;o	PICEA	-	15	20	live	unknown	170	5	1224	PICEA	ABLA/CLUN	52

* (c)-clear; (fr)-freezing rain; (o)-overcast; (pc)-partly cloudy; (r)-raining; (s)-snowing; (sog)-snow on ground.

** refers to status of resting tree. Dead PICO are the result of mountain pine beetle attack.

*** sq. nest = squirrel's nest; dm bundle = dwarf mistletoe bundle; depression = a depression of pine needles next to tree.

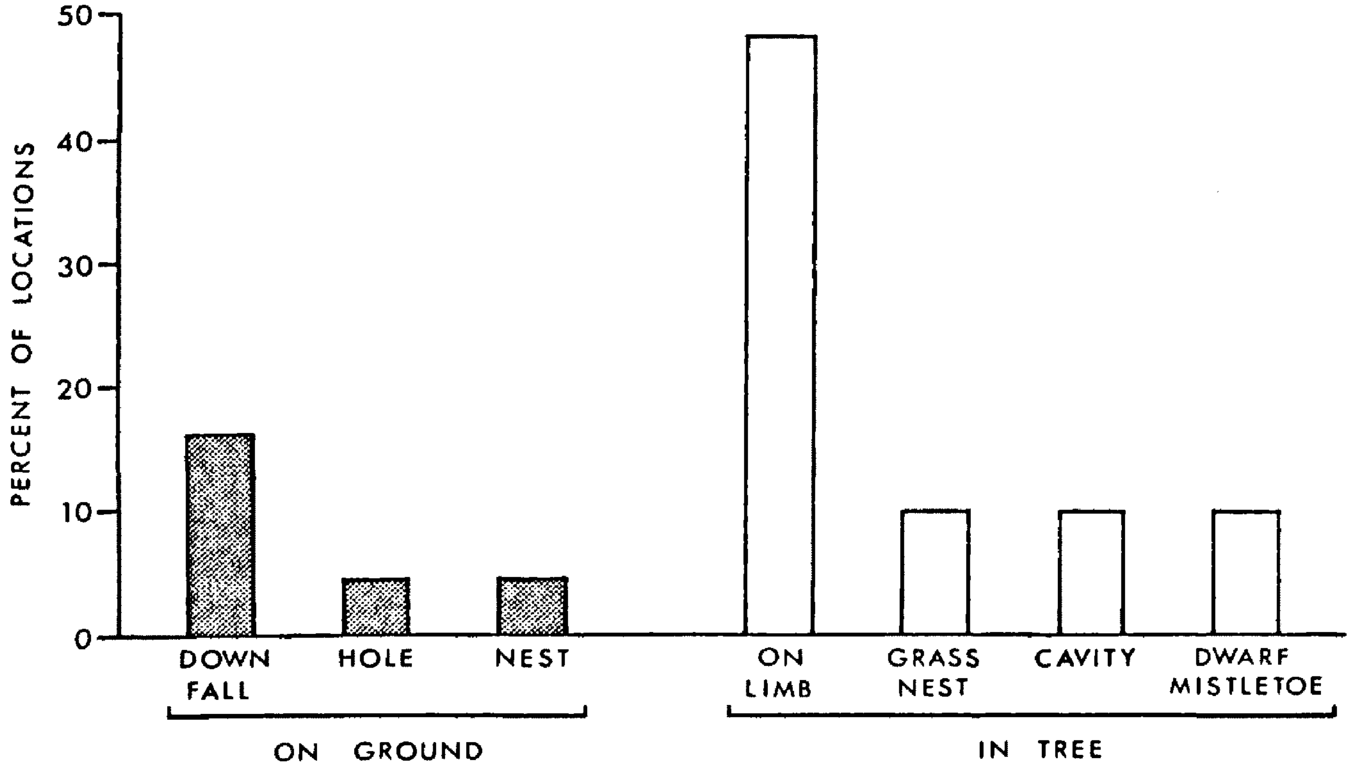


Fig. 20. Daytime resting sites of marten.

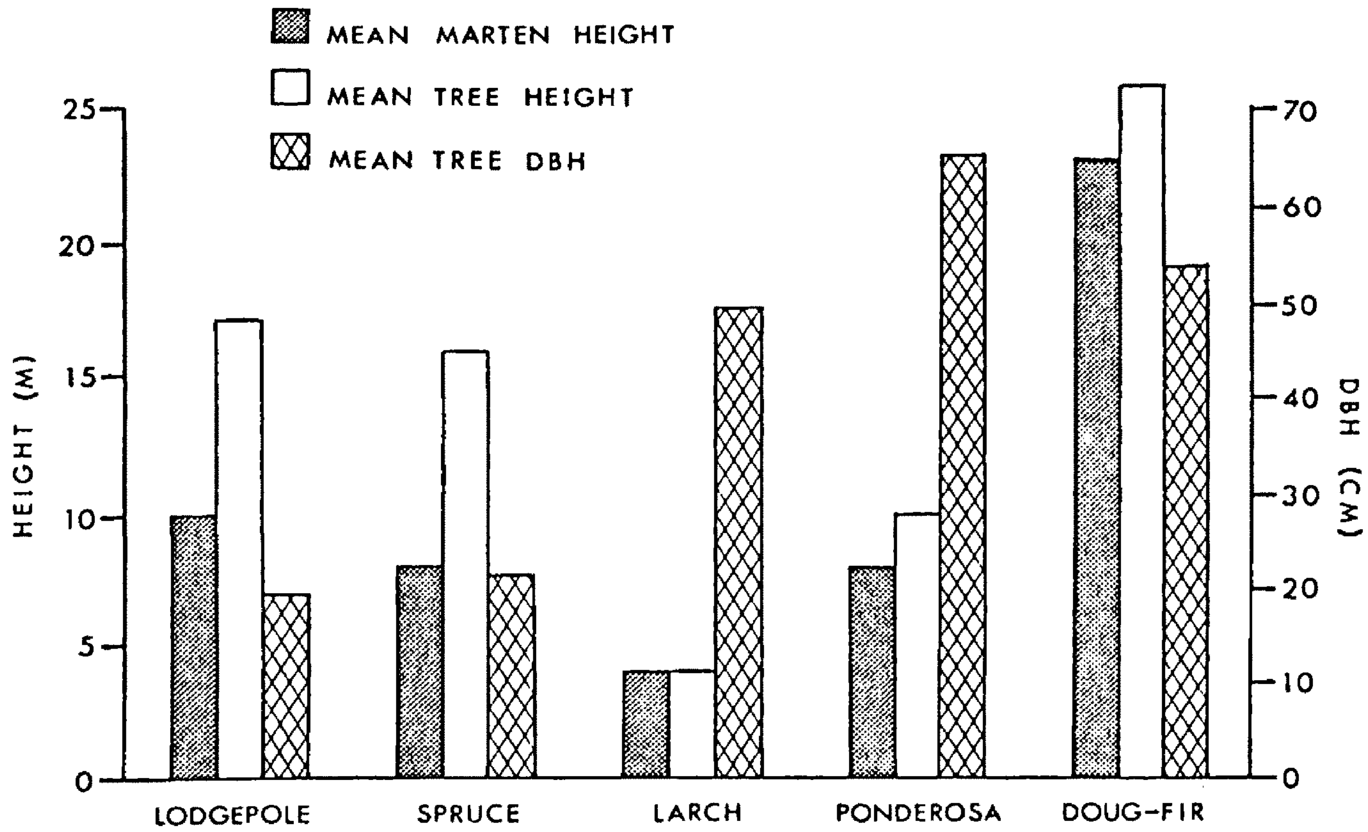
Of all the resting sites in trees, 15 (54%) were on a tree limb, usually next to the trunk, with the marten supported on the limb (Fig. 21). This was significantly higher than use of other resting sites in trees (X $p<.005$). Marten were also found resting in grass nests (N=4), cavities (N=4), and dwarf mistletoe bundles (N=2) in trees.

Resting sites were found in lodgepole pine trees on 12 occasions. Of these locations, 8 (67%) were found on a limb and 3 (23%) in a grass nest in the canopy, presumably an abandoned squirrel nest.

Marten rested in spruce 11 times; 8 sites were on limbs, 2 in dwarf mistletoe bundles, and 1 in a squirrel nest. Non-resident m69 was responsible for 2 of these locations. He used 2 separate mistletoe bundles in his lodgepole cover-typed, temporary range. He returned to 1 of these bundles when I was following him. That location was recorded as a non-resting site because it was used as an escape tree on that occasion. The remaining spruce resting site was in the upper crown of a mature tree. The exact location was not observed.

The remaining tree locations were evenly divided between western larch, ponderosa pine, and Douglas-fir (2 each). All the western larch and ponderosa pine were snags, with the marten resting in a natural cavity. The Douglas-fir sites were all on limbs.

Of the ground sites (Fig. 20), 4 (67%) were under downfall; all but 1 of these were winter locations where snow had covered the downfall, providing shelter. Of the remaining ground sites, 1 was a hole under a western larch snag, and the other was a depression formed of ponderosa pine needles next to the tree's base. Non-resident



	LODGEPOLE	SPRUCE	LARCH	PONDEROSA	DOUG-FIR
NUMBER	12	10	2	2	2
% SNAGS	0	0	100	100	0

Fig. 21. Daytime resting sites of marten in trees.

f59 used a sheltered downfall site twice while occupying her temporary home range on the floodplain. She also was located resting above a deer carcass beside the southern outlet of Logging Creek.

Sheltered vs. unsheltered resting sites. When comparing sheltered and unsheltered resting sites, no relationship was found between cover type (X $p=.703$) or habitat type (X $p=.421$) at the sites. No difference was noted in the number of sheltered ($N=16$) compared to unsheltered ($N=20$) locations (X $p>.05$). No difference occured between sheltered or unsheltered sites when compared by sex, age, residential status, or social class (X $p>.05$). Marten apparently were not selective in their use of daytime resting sites. However, resting sites on a limb were more sheltered in the mature spruce trees used in spruce cts than in the lodgepole pine trees used in the pine cts.

The density of potential resting sites on the study area is unknown, although lodgepole pine is the dominant cover species in the south half of the study area where most of the telemetry locations are recorded. The availability of spruce is considerably lower in lodgepole cover types than the more mature spruce types, as are dwarf mistletoe bundles. Snags are rare in lodgepole pine types, but relatively common in the mature spruce types.

Marten exhibited primarily diurnal activity, and unsheltered resting sites probably represented short stops while hunting. Many sheltered resting sites showed evidence of repeated marten use. Night-time resting sites may have been considerably more selective.

CHAPTER V

DISCUSSION

Marten Populations

Weckwerth and Hawley (1962), working on the GNP core study area, reported a marten population which fluctuated from 40 marten (2.6/sq km) in winter 1954 to 12 marten (0.8/sq km) in early spring 1957. Continued trapping in fall 1957 showed an increase to 21 marten (1.3/sq km). This increase was primarily the result of 9 juveniles remaining on the core study area as residents.

In Ontario, Francis and Stephenson (1972) trapped 17 marten (1.5/sq km) on their study in 1956. The population increased to 26 marten (2.2/sq km) in 1957, the result of more juvenile marten on their study area. Clark (1978), in Grand Teton National Park, Wyoming, studied marten populations that decreased from 10 marten (0.6/sq km) to 3 marten (0.2 sq/km) during 9 months of trappings.

From 1979-80, I trapped 29 marten (1.9/sq km) on the GNP core study area. Judging by Weckwerth and Hawley's (1962) results, the study area's marten population was at about 75% its carrying capacity.

This study and others cited above, indicated marten populations were not stable from year to year. Population fluctuations were largely a result of changes in the number of juveniles remaining on the study areas. Hawley and Newby (1957) also indicated that loss of adult females contributed to population declines.

The long range study reported by Weckwerth and Hawley (1962) indicated that the abundance of small mammals was directly associated with the abundance and composition of the marten population on their study area. The association they found between fluctuations in prey species and marten numbers indicated that changes in small mammal densities were sufficient to affect the carrying capacity of the area for marten. Other evidence they found on population composition, physical condition of the marten, dispersal, and home range relationships of marten supported the idea that food availability was a limiting factor for marten.

Clark (1977) also surmised that marten populations may have been limited by availability of food resources. He suggested that male territories were maintained until early fall, the end of the breeding season, ensuring that males had exclusive contact with females in their range. At this time, increased aggression caused dispersal of young to unoccupied habitat.

I found evidence that a juvenile was forced to leave his established home range due to competition from a resident adult. Juvenile male m61 left and never returned to his temporary home range when adult male M56 reoccupied that area. Weckwerth and Hawley (1962) indicated that juveniles were unable to compete with residents, or to establish resident home ranges when the population was at maximum densities.

Even at the dense population level found on the core study area in 1979, space was available for 2 juveniles to establish residency. However, 3 juveniles did not become resident, although 1 male established a temporary home range. Apparently, when population densities approached the saturation level certain juveniles traveled out of their maternal home range in search of a suitable home range.

The overlap of resident adult males on my study area may have been a reflection of the dense prey level. The variation of dispersion patterns reported in the literature may have stemmed from cyclic prey levels, resulting in cyclic changes in marten densities and hence a fluctuating dispersion pattern.

Food Habits

Marshall (1946) reported the analysis of marten scats collected over two winters in Montana. Red squirrel was the most important food item while the northern flying squirrel (*Glaucomys sabrinus*), the red-backed vole, and the snowshoe hare (*Lepus americanus*) ranked next in order of decreasing importance. During winter studies in Ontario, Clem (1975) found that the red squirrel was important in December, making up to 20.7% of the marten's diet. The snowshoe hare contributed 41.5% of that December diet and was close to 20.0% for the November, January, and February diets. The red-backed vole was important in November and January, making up 43.1 and 25.1% of the diet, respectively. Clark (1978), working in Wyoming, reported that flying squirrels rated second in importance to red-backed voles in the marten diet.

Microtines were the most common prey found in the marten's diet in Alaska (Lensink et al. 1955), Canada (Cowan and Mackay 1950, Quick 1955, Francis and Stephenson 1972), Idaho (Koehler 1975), Montana (Weckwerth 1957), and Wyoming (Murie 1961, Clark and Campbell 1977). Red-backed voles and <u>Microtus</u> spp. were the most common species found in each study. Red-backed voles were usually preyed upon in similar proportion to their high abundance in snap trap plots, while <u>Microtus</u> spp. were often found in scats well in excess of their relative abundance on small mammal plots (Weckwerth and Hawley 1962, Francis and Stephenson 1972).

Summer and fall studies of marten food habits also indicate microtines, primarily red-backed and meadow voles, are the main mammalian food sources (Cowan and Mackay 1950, Quick 1955, Lensink et al. 1955, Murie 1961, Weckwerth and Hawley 1962, Francis and Stephenson 1972, Koehler et al. 1975, Clark and Campbell 1977). Fruits, berries, nuts, insects (primarily Hymenoptera), and birds and their eggs may comprise up to 30% of marten's summer diet.

The above studies indicate that red squirrels are not as heavily preyed upon as once popularly believed. However, during certain winter months they may be an important part of the marten's diet in certain habitats. It is also apparent that marten are opportunistic predators, feeding on seasonal harvests of vegetation, insects, etc. During winter months, however, marten show a strong preference for small mammals, especially microtines.

Results from my study indicated an abundant small mammal population compared with Weckwerth and Hawley's (1962) results. The mesic spruce cover types averaged higher per plot catches than the more xeric lodgepole and ponderosa pine cts, although the summer 1980 trapping yield on plot 1 (PICO ct) was higher than any other plot. This was due to a high catch of meadow voles (Microtus pennsylvanicus) on this plot. Plot 1, while identified as PICO ct, was wetter than the other lodgepole cover types on the core study area. The northern portion of that plot was within a small marsh.

Koehler (1975:7) found that "mesic habitat types supported the greatest number of rodents (microtines)" in Idaho. He cited several articles indicating microtine mice "apparently require a heavy cover of vegetation or logs." Mesic sites provided this cover while xeric sites were inadequate for microtines.

It appears that marten prey on species which are most abundant at any given time. Abundance, however, is not the only factor influencing prey use. Availability, marten preference, and the accessibility of other foods should also be considered (Weckwerth and Hawley 1962, Francis and Stephenson 1972, Clark and Campbell 1977). This explains the findings of several authors that deer mice and red-backed voles are often found in similar local abundance, although deer mice do not comprise a significant part of the marten's diet as do red-backed voles (Weckwerth and Hawley 1962, Koehler et al. 1975, Clark and Campbell 1977). This can be partially explained by higher densities of deer mice on xeric sites, versus higher numbers of red-backed voles on mesic sites. Forested areas tend to be mesic, while clearings reflect xeric conditions. Marten avoid clearings during winter months, and therefore are not likely to encounter deer mice as often as red-backed voles. Although Soutiere (1978) reports a higher abundance of meadow voles in clearcuts (0-15 years old) than in partially cut (40% reduction of basal area) or uncut forests in Maine, marten usually prey more heavily on the seasonly abundant foods (e.g. insects, berries) found in clearcuts during non-winter months. In addition, the actual availability of prey during winter may be reduced in clearcuts. Clearcuts remove many features such as snags, down logs, slash piles, and other logging debris, which marten use to gain access to prey beneath the snow (Koehler 1975, Clark and Campbell 1977, Steventon 1979, this study).

Habitat Use

DeVos and Guenther (1952) stated that lodgepole cover did not appear to be suitable marten habitat; they noted the marten's need for climax cover types. Devos et al. (1959) later documented higher numbers of marten produced in areas dominated by mature conifer cover than in areas with little of this cover. In Wyoming where the overstory of the study area was largely lodgepole pine, the marten population was considerably less dense (Clark 1978) than in Montana (this study, Weckwerth and Hawley 1962).

In the Whitefish Range west of GNP, Thompson (1950) found that over 98% of all marten were in spruce-dominated stands. Francis and

Stephenson (1972) reported significantly fewer marten caught in hardwood forests than in conifer or mixed stands in Ontario. The conifer and mixed stands had a ground cover with numerous logs and stumps, which the authors state probably contributed to their greater use by marten during both summer and winter.

Marshall (1942) also found that marten lived primarily in conifer stands, but he believed that conifer stands dominated by lodgepole pine were not suitable habitat. He concluded that marten were adaptable in their use of cts. However, he later reported that marten had a high ratio of use in the Douglas-fir-spruce timber type, and an even stronger preference for fir timber types (Marshall 1951b).

Koehler et al. (1975), using marten captures and tracking observations, indicated that marten use a variety of forest communities during the winter. However, they found the greatest marten activity in mesic, spruce-subalpine fir communities older than 100 years with a canopy cover greater than 30%. Their findings are consistent with Marshall's (1951b) data from south-central Idaho.

Steventon (1979) found that clear-cut areas (3-18 year old regeneration) were used less than their proportional occurrence within his study area or within marten home ranges. Marten used more than the available uncut softwoods stands and partially cut mixed stands (average basal area cut 50%).

Hawley (1955) reported on marten cover type use as indexed by live-trap captures. Although he stated that it was not possible to determine the influence exerted upon 1 habitat by another adjacent type, his results were the only quantitative information I found on marten habitat use in undisturbed habitat. He indicated that marten used a variety of types and that the heaviest usage was in the mature, mixed conifer types and the reproduction lodgepole types (3-10 cm dbh). He also reported marten habitat use as the greatest along the edges between a fairly mature type and a reproduction type. He felt that this was the result of the quality of each adjacent type rather than a preference for the edge habitat.

In the Blue Mountains of Oregon and Washington, Thomas et al. (1979) indicated that marten feed in pole-sapling (11-39 year stands) or older successional stages of mixed conifer, grand fir (Abies grandis), lodgepole pine, subalpine fir, and alpine meadow communities. However, marten were reported to only reproduce in 80-year-old or older successional stages of the mixed conifer, grand fir, and subalpine fir communities.

During my study, adult marten occupied a variety of cover and habitat types, but each adult's locations were concentrated in just a few types. An adult female showed a strong preference for the mesic cover types in the ABLA/CLUN habitat type. One adult male also had a preference for those types, although the other adult male primarily occupied the xeric PICO cover type in the PICEA/VACA habitat type.

Juveniles, both residents and non-residents, also occupied a variety of forest types, but each juvenile used a broader range of types. They were located in xeric cts (PIPO, PICO, PICO-PIPO) at 68.1% of the sites. As indicated, only 1 adult male occupied a range dominated by xeric conditions, although this may be a reflection of my low sample size for adults.

Hunting Sites

Clark and Campbell (1977) refered to hunting sites as places were marten went below the snow's surface. Thirteen of 14 hunting sites they found were in association with fallen trees whose tops were caught in an adjacent tree at angles varying from 30 to 80 degrees to the snow's surface. Twelve of the trees were in association with lodgepole pine, and 13 were dead. Access to the presumed extensive network of logs under the snow's crust was gained by following snags, logs, or other debris which protruded through the snow (Marshall 1951b). Koehler et al. (1975) also noted that these were the easiest places for marten to gain access to the prey base under the snow. Murie (1961) indicated that much of marten's hunting activity during the winter took place under the snow. Thomas et al. (1979) indicated that logs in all stages of decomposition were used by marten as hunting sites. I found use of similar hunting sites (Appendix J).

Resting Sites

Marten in this study showed a significant preference for daytime resting sites in trees rather than on the ground. At the tree sites marten rested on a limb significantly more than at other locations. Masters (1980) also found that marten had an apparent preference for tree sites in the Adirondack Mountains of New York. All

5 daytime resting sites he found were in trees.

Francis and Stephenson (1972) stated that hollow logs were frequently used as daytime resting sites in Ontario. Of 13 daytime resting sites located in northern Minnesota by Mech and Roger's (1977), 12 were in ground burrows, rock piles, or rock crevices. Only 1 was in a tree, a jack pine (Pinus banksiana), up about 2 m on a limb. Steventon (1979:12) examined 31 resting sites in Maine, finding that 19 were in ". . . natural cavities in hummocks formed around large decayed stumps. . . ", 2 were under standing snags, and 7 were under hummocks of unknown origin. He stated marten showed repeated use of particular sites. Marshall (1951b) indicated that re-use was rare, although I found reuse of 2 resting sites on 3 occasions.

Clark and Campbell (1977) located resting marten in Wyoming on 23 occasions. Marten used large (mean=48.5 cm ± 8.1 cm, range 35-61 cm), dead, rotten englemann spruce and subalpine fir significantly more than other resting sites. Woodpecker holes were always present in the trees used. Dwarf mistletoe bundles in the tops of subalpine fir were also used. Marshall (1951b:33) reported similar resting sites, as well as the use of sheltered locations under "large" logs. Clark and Campbell (1977) observed one male using slash piles created during road construction. Similarly, Steventon (1979) observed 3 instances of marten using bulldozer created hummocks as resting sites.

I found that marten used dwarf mistletoe bundles at 3 sites. Bulldozer created sites mentioned above probably served the ecological equivalent of downfall sites.

Marten had a wide adaptability for daytime resting sites, although they apparently prefered sheltered locations over unsheltered sites. Resting sites were almost always found under forest cover rather than in open areas. However, Major (1979) stated that no significant differences were found among habitats at resting site locations. I found no significant differences between cover or habitat types at sheltered or unsheltered resting sites. As such, a variety of cover types were suitable resting habitat for marten.

Denning Sites

In Idaho, Marshall (1951b) found that 13 of 16 dens were in hollow logs; 3 were in hollow stumps. Francis and Stephenson (1972), working in Algonquin Provincial Park, Ontario, located 3 dens, 2 among boulders within 91 m of small lakes in spruce-fir forests. The other was in a hollow cedar log. O'Neil (1980) found a maternity den in a granite outcrop in Montana. Lester (pers. comm., Kalispell, Montana) located a maternity den in a lodgepole pine snag (25 cm dbh) near the GNP study area. Inspection of that den revealed it was a natural cavity formed where a limb had broken off the trunk. The female had moved the young when I returned for a second visit. Other authors refered to marten denning sites in cavities in snags and hollow logs, or in burrows under boulders (Thomas et al. 1979, Verner and Boss 1980), indicating that natural holes were important.

Hawley (1955) suggested that mature forest types contain more denning and cover sites than less mature types. He stated that the forest floor in the more mature types were thickly covered with down logs and debris, while the younger age types were recently burned, and generally lacked these items.

The use of denning sites by female marten needs more attention. At present marten are known to be more selective in their choice of denning sites than resting sites.

Home Range Comparisons - the minimum area method

Comparisons of home range estimates from the literature are hindered by the variation of techniques used. The techniques are all designed to measure the same variable, but many yield different results. Much of this discrepancy concerns the proper method of estimating home range size using the minimum area method (MAM).

Diagrams of convex polygons connecting the outside points of capture were given by Dalke and Sime (1938), although they did not indicate that a convex polygon was used. Mohr (1949) used a polygon and the minimum area method, but also gave no explicit definition of his method. Hayne (1949), citing Mohr's paper and several others that use the MAM, directed to connect the outside points of capture to form a polygon. As such, the polygon was subject to individual interpretation and has led to authors using polygons varying from those with many reentrant angles to those with none (i.e. convex).

Odum and Kuenzler (1955:129) proposed to connect the outermost locations "with straight lines so as to include all other points . . ." But their "outermost points" could represent different points depending on individual interpretation. However, Southwood (1966:262) stated that ". . . all re-entrant angles must be avoided for the depth to which they are drawn will depend on individual judgement and thus different results may be obtained from the same set of data". This defined a convex polygon for the MAM.

Following Southwood's procedure will standardize future comparisons between home range size estimates.

Home Range Size of Marten

Early studies of marten home ranges were often based on trapper's reports and on tracking records (Grinnel et al. 1937, Davis 1939, Thompson 1950, Marshall 1951b, Lensink 1954). They reported home ranges (males and females) ranging from 26.0 sq km to 65.0 sq km. These estimates were much larger than the home ranges of residents determined in live-trapping or telemetry studies.

However, my results indicated that non-resident juvenile marten occupied home ranges which fell within the range reported by early researchers, averaging 33.8 sq km (range 12.3 to 48.0). The early studies may have been tracking non-resident marten. They also may have tracked more than one marten when obtaining their results.

Hawley and Newby (1957), working on the GNP core study area in the 1950's, calculated marten home range sizes of 2.4 sq km for resident males and 0.7 sq km for resident females. Their estimates for some marten would have been higher using convex rather than concave polygons for their area delineation. Clark and Campbell (1977) gathered information on a study area dominated by lodgepole pine with a subdominant cover of subapline fir. Their study area was similar to the majority of area monitored by telemetry in GNP. They found that the home ranges of adult males in Wyoming averaged 2.3 sq km, and adult females averaged 0.9 sq km. These ranges were determined using the polygon plus boundary strip method (Stickel 1954); areas estimated with the MAM would have been smaller.

Home ranges of adult resident marten on my study area, as determined by the MAM, were 2.9 sq km for males and 0.7 sq km for females. These were in close agreement with the results from the previously mentioned GNP and Wyoming studies.

Effects of Habitat Quality on Marten Home Range Size

Steventon (1979) and Major (1979), working on the same study area in Maine, used concave polygons (Kohn and Mooty 1971) to estimate home range size. They reported that adult resident males used home ranges of 9.5 sq km, and adult females had ranges as large as 2.5 sq km. Their study area was comprised of a mosaic of 32% clearcut softwoods, 31% uncut softwoods, 18% hardwood-dominated partial cut (50% basal area reduction) mixed-wood, and 12% softwood-dominated, partial cut mixed-wood. Their home ranges estimates were over 3 times larger than those found in my study, Weckwerth and Hawley's (1962), and Clark and Campbell's (1977).

Soutiere (1978) surmised that home ranges were larger in the commercial clearcut forests than in the uncut or partially cut forests.

Soutiere found that the marten population in clearcut forests (50% clearcuts, 25% partially cut) was 33% the density found in partially-clearcut (40% basal area reduction) and undisturbed forests. Miller et al. (1955) also attributed inconsistent home range size to the variability of habitats where marten populations have been studied.

In Ontario, Francis and Stephenson (1972), using convex polygons, found that adult resident males averaged home ranges of 3.6 sq km, and adult resident females 1.1 sq km. The larger size of home ranges there, as compared to Montana, may have resulted from differences in forest types. Uncut hardwoods and mixed hardwood/conifer cover dominated the Ontario study area, while conifer cover predominated in Montana. However, the Ontario estimates were smaller than home ranges reported above from Maine, supporting Soutiere's summarization that clearcutting caused an increase in marten home range size.

Mech and Rogers (1977), working in Minnesota where the forest types were similar to those in Ontario, found adult resident male home ranges averaged 15.7 sq km, and adult resident female home ranges averaged 4.3 sq km. Their ranges were considerably larger than any of the previously mentioned, including Ontario. Possibly the Minnesota study area included more hardwood cover, which has been indicated as lower quality marten habitat.

Canopy Cover

Many authors reported that marten showed a seasonal difference in use of habitat, using open areas with little canopy cover in summer, but avoiding openings >100 m wide in winter (Dice 1921, Grinnel et al. 1937, Hagmeier 1956, Streeter and Braun 1968, Ingram 1973, Herman and Fuller 1974, Koehler 1975, Clark and Campbell 1977). Hawley and Newby (1957) felt that open areas served as a "psychological barrier" to marten. Susceptability to aerial predation may have been a deterrent for using open areas when cover was inadequate (see Appendix I).

Major (1979) found that marten were located less often than expected in clear cuts in Maine, selecting for uncut softwood stands. He believed that while one male increased his use of regenerating clearcuts after the onset of the raspberry (Rubus spp.) season, such regenerating cuts were less suitable marten habitat for hunting small mammals than uncut or partially-cut habitats. Clark (1977) indicated marten did not use logged blocks within the first year after timber harvest in Wyoming.

Steventon (1979) found that adult males often crossed clearcuts while traveling between isolated patches of residual forest cover. However, females were only located in large residual forest blocks with less than 25% cut area, and they rarely crossed clearcuts. Soutiere (1978) also stated that males traveled freely across clearcuts between habitat islands, but females were more restricted to the larger blocks of uncut or partially cut timber. He captured proportionally fewer transient and juvenile marten in clearcut forests.

Marten on my study area showed a strong preference for canopy cover greater than 17 %; stands used by marten averaged 35% canopy cover. However, they often traveled along the ecotone between forest cover and open areas such as marshes, riparian channels, and meadows. Marshall (1951b) indicated that marten moved along the edges of breaks in the topography. As I stated previously, Hawley (1955) reported marten traveled extensively along the ecotone between mature and reproduction stands.

The above studies on marten avoidance of open or clearcut areas suggested marten may have avoided the activities of man associated with logging operations, rather than the open habitat itself. However, Soutiere (1978) stated marten tolerated the activities of men and machines during timber harvest operations, concluding that habitat removal affected the marten population. Koehler et al. (1975) reached similar conclusions. In general, marten have easily habituated to man and his activities.

Fire Effects on Marten Habitat

Marten avoidance of open areas suggested that wildfire may reduce the quality of an area as marten habitat. However, Koehler (1975) stated that fires in areas not previously controlled for forest fires maintain a habitat mosaic beneficial in the long-term for marten and other animals, provided burns are not excessively large. /

Even though GNP has a history of fire suppression, 70 years of enforcement has not resulted in any proven change in the potential for drastic fires. However, continued fire suppression within GNP may lead to such a change and alter the beneficial mosaic of cover types.

Dispersal

Dispersal from refuges may have been an important factor for stabilizing marten populations adjacent to refuges or for restocking populations depleted from overtrapping (Lensink 1954). DeVos (1951a) demonstrated the overflow of marten from the Chapleau Crown Game Preserve in Ontario affected the neighboring area up to 40 km from the reserve.

Results from my study and others indicated juveniles were the most common transients in marten populations, responsible for a majority of the population fluctuations (Quick 1956, Weckwerth and Hawley 1962, Francis and Stephenson 1972, Clark and Campbell 1977). The wide range of cover types used by juveniles during this study indicated that cover types did not act as a dispersal barrier.

Jonkel (1959), working in the NFFR drainage, reported dispersal distances averaged 15.7 km (s=12.6) for juvenile males (N=7) and 12.1 km (s=7.6) for juvenile females (N=4). DeVos and Guenther (1952) found that males traveled as far as 11 km from the point of initial capture, and females almost 9 km. There was no indication whether they were adults or juveniles.

Non-resident juveniles I monitored averaged collar-relocation distances of 4.1 km. However, the average of each juvenile's longest collar-relocation distance was 10.1 km. They dispersed far from their collaring site but, established temporary home ranges close to those sites, suggesting that they had an affinity for "familiar" areas.

Dispersal radius

Based on the above movements an average dispersal radius of 10 km from habitat refuges is a reasonable estimate for both male and female juvenile non-residents. Restocked populations may have to be near saturation for juveniles to travel that average distance to find suitable unoccupied habitat. It will take a few years for those populations to reach their saturation point, as marten populations have a low biotic potential (Marshall 1942, Lensink 1953) and, as indicated previously, they may exhibit cyclic density fluctuations. As such, marten will not be capable of restocking adjacent unoccupied areas at a rate of 10 km per year. More likely, I estimate the rate would average 2-3 km per year over several years.

Dispersal period

Immigration and emigration of marten in Wyoming was most common from August to November (Clark 1977). Weckwerth and Hawley (1962) found similar dispersal periods. However, results from my study documented that non-resident juveniles continued to disperse into spring. This indicates that although open areas may not block dispersal during non-winter periods when marten use open areas with adequate shrub cover, dispersal may be hindered or even completely blocked through areas devoid of cover during snow-covered months.

CHAPTER VI

MANAGEMENT IMPLICATIONS

General Discussion

American marten were classified as "status undetermined" by the USDI (1973), meaning that not enough information was available for evaluation. The Sierra Club petitioned the USDI to list marten as an endangered species in the eastern United States (Anonymous 1976), where the distribution of marten has been reduced drastically.

Loss of habitat has contributed to the elimination of marten from many areas in the United States. Old-growth spruce-fir forests in the western United States provide much of the remaining optimum marten habitat. These forests are quickly disappearing as a result of timber harvest; replacement stands will be harvested under short rotation systems in the future. On the Flathead National Forest, Montana, 135,720 acres were harvested from 1945 to 1974; 64% of this acreage was clearcut (Lennartz and Bjugstad 1975).

As the loss of old-growth habitat continues, reserves such as GNP will become increasingly important. The management challenge in such reserves is to accept and reinstate natural processes (e.g. fire, insect attack, windthrow) rather than trying to suppress them. These processes can perpetuate forest mosaics that support healthy marten populations over the long-term. Reserves may then provide a surplus of marten that can serve as a restocking source for adjacent, intensively harvested lands.

Overexploitation outside reserves also has contributed to the disappearance of marten from many areas, although trapping can be compatible with healthy marten populations. A surplus of juveniles is normally produced, and they can be harvested with little affect on the breeding population. However, removal beyond the surplus will limit dispersal into unoccupied habitat. In addition, overtrapping of breeding females can severely limit the marten population. The recent recovery of pelt prices in Montana and the increasing use of snowmobiles by trappers could result in an overharvest of marten.

Marten Habitat

The following definitions and the characteristics in Table 18 relate forest cover to quality as year-round marten habitat, based on my results and a through literature review.

Optimum Habitat

Optimum habitat provides the necessary cover for marten activities and the prefered prey species of marten. It will support self-perpetuating, resident subpopulations of marten if totaling at least 150 sq km, and it is not completely isolated from other subpopulations.

Table 18. Characteristics of marten habitat.

Marten habitat	Cover type	Percent canopy cover	Understory character	Moisture class	Limited marten sites
Optimum	mature or old-growth spruce-fir	>30	-well established down log (>10 cm dia.) and shrub cover -lush forb cover	mesic	none
Suitable	mature or old-growth spruce-fir	20-30	-well established down log(>10 cm dia.) and shrub cover -lush forb cover	mesic	none
	medium-age class spruce-fir	>30	-well established down log (>10 cm dia.) and shrub cover	mesic	none
	75 % pine with well established spruce-fir component	>30	-established down log (>10 cm dia.) and shrub cover	mesic to xeric	denning hunting
Marginal	any forest cover with adequate canopy	15-30	-minimal down log (>10 cm dia.) and shrub cover	mesic to xeric	denning hunting

Suitable Habitat

Suitable habitat provides cover for marten activities, but lower densities of prefered prey reduce the carrying capacity and reproductive output of the area. It will also support self-perpetuating, resident subpopulations of marten if totaling at least 150 sq km, and it is not completely isolated for other subpopulations.

Marginal Habitat

Marginal habitat supports an adequate prey base for resident males and non-resident females or males, but probably not for resident females with kits. Marginal habitat is primarily important as overflow habitat to support dispersing individuals (mostly juveniles) during their search for unoccupied suitable or optimum habitat. It will not by itself support self-perpetuating marten populations.

Specific Recommendations

Reserved Lands

The following recommendations reflect the role reserved lands should play in perpetuating natural ecosystems.

1) Accept and reinstate the role of natural processes (e.g. fire, insect attack, windthrow) in maintaining forest mosaics.

Rationale: Natural processes recycle forests, creating a habitat mosaic beneficial to marten and other animals in the long-term.

Dead, insect attacked trees and windthrow contribute to the availability of the cover required by marten preferred prey. Although the immediate effects of fire may reduce that cover for marten and their prey, the long-term effects of low intensity fires may be beneficial to marten populations. Fires perpetuate the forest mosaic that supports a diversity of marten food types and contributes to the succession of marten habitat over time, resulting in more stable marten populations.

2) Snags (>23 cm dbh) should not be cut at campgrounds, picnic areas, or on other sites receiving recreational use.

Rationale: Snags provide potential denning and resting sites for marten. Marten use snags with woodpecker holes more than other sites. Lester (1980) stated that snags >23 cm are most suitable for nesting woodpeckers. Snags also provide critical habitat for hole-nesting birds and certain mammals (McClelland 1977).

Commercial Lands

The following recommendations provide managers of commercial lands with basic guidelines for management of marten and their habitat in spruce-fir habitat types in western forests. Recommendations are based on my results and a thorough literature review. Managers should adapt general guidelines to the unique qualities of each site.

In addition to the following recommendations, interested managers could read further in Koehler et al. (1975), Soutiere (1978), Steventon (1979), and Major (1979) for other guidelines relating to the management of marten on commercial timber lands.

1) Give the highest priority marten management to sites were marten have been seen, where scats have been found, or to sites that are within the same drainage as known marten populations.

Rationale: These are sites that will definitely support marten populations.

2) Plan forest mosaics with 150 sq km of contiguous optimum or suitable habitat in major drainages in northwestern Montana to retain self-perpetuating marten populations. These mosaics should be at lower elevation sites; each residual stand of marten habitat in the mosaic must be large enough to accommodate a resident female, i.e., 70 ha of optimum or suitable habitat. An effort should be made to leave old-growth spruce or fir communities if they are not isolated from contiguous marten habitat.

Rationale: Each 3 sq km block of optimum or suitable habitat will support 1 adult male and 4 adult females, on the average. Recent evidence indicates that a population size of 50 is necessary to minimize the effects of inbreeding (reduced fecundity and viability), which can lead to local population extinction (Franklin 1980, Soule 1980). The effective population size is determined by the number of reproductively active individuals that mate, essentially at random. However, in a polygamous species such as marten, where 1 male breeds with several females, the theory indicates the minimum, short-term subpopulation would have to be comprised of 50 males and 200 females, breeding at random. Franklin (1980) proposed the long-term size for isolated populations should be 500. This may be high for carnivores, but the retention of travel corridors between blocks of habitat will allow dispersal, reducing any effects of inbreeding caused by the insularization of subpopulations (Hooper 1970, Avery 1978).

Marten habitat will be improved over the long-term by perpetuating a forest mosaic. This can be accomplished by removing timber in small clearcuts (less than 70 ha), and leaving similarly sized blocks of optimum habitat uncut, or partially cut (retain 30% canopy cover). Forest mosaics produce a diversity of prey species marten use.

3) Give special consideration, following guidelines in recommendation 2, to timber sale sites where a marten den is found or suspected.

Rationale: Breeding females are particularly important and sensitive in marten populations. Maternal den sites should be brought to the attention of the area wildlife manager. At present, identification of marten habitat quality is rather coarse. Any information that helps define the quality of forest sites as marten habitat is needed.

4) Retain corridors of marginal or better habitat connecting habitat islands to contiguous habitat.

Rationale: Males travel through relatively small clearcuts to reach isolated forest stands. Females, however, are restricted by clearcuts, and probably will only remain in residual forest stands. Corridors will allow resident females to travel between blocks, and juveniles to disperse from maternal home ranges to adjacent areas. All marten avoid areas >100 m in width that lack canopy cover.

5) Do not clearcut isolated islands of optimum or suitable habitat. Partial cuts are recommended, leaving a minimum of 30% canopy cover over the area. Scarification of the top soil and shrub layers should be minimized.

Rationale: Soutiere (1978:50) stated, "Clearcuting is detrimental to marten and its use should be avoided in those areas essential to the maintenance of threatened remnant populations." Densities of marten populations were lower in clearcut forests than in uncut or partially cut forests. Disturbance of the understory should be kept to a minimum if the retained habitat is to support preferred prey species.

6) Increase the edge development of cut sites.

Rationale: Marten may select for ecotones between cover types, primarily between mature types and reproduction or open types. This effect could be enhanced when harvesting timber by making cut edges infolded rather than straight.

7) Snags (>23 cm dbh) should not be cut on timber sale sites identified as marginal or better habitat, at campgrounds, picnic areas, or on other sites receiving recreational use.

Rationale: Snags provide potential denning and resting sites for marten. Thomas et al. (1979) suggests a minimum dbh of 38.1 cm for snags suitable as marten denning sites. Marten use snags with woodpecker holes more than other sites. Lester (1980) states that snags

>23 cm dbh are most suitable for nesting woodpeckers. Snags also provide critical habitat for hole-nesting birds and certain mammals (McClelland 1977). McClelland provides a review and gives specific guidelines for forest managers in relation to management of snags on commercial timber lands.

8) Retain slash piles, down logs, or other logging debris that will protrude through the snow.

Rationale: Ground cover that protrudes through the snow provides marten access to prey beneath the snow during winter months, enhancing the suitability of open areas as marten habitat. DeVos (1952) suggested that leaving slash piles in logged areas will improve denning and cover habitat. To further improve the potential for marten denning sites, scattered logging debris should be left to serve as potential woodpecker feeding sites, encouraging hole-nesters to use the area (McClelland 1977).

9) Develop regulations that limit the number of trappers operating in an area, or the harvest quota. Closely follow the ratio of juvenile:adult marten harvested, and communicate with informed local trappers to monitor marten densities.

Rationale: Presently, regulations do not limit these factors. Current practices could have a devastating effect on local marten populations in popular trapping areas. Closure of certain areas during the trapping season will protect resident females, allowing trappers to harvest surplus marten that disperse into adjacent areas. Repeated trapping in certain areas can exhaust local populations.

Marten populations may be cyclic. During low density years populations will be more susceptible to overtrapping. Low density years will require setting trapping limits in, or closing, certain areas with heavy trapping pressure, or in islands of isolated marten habitat.

Several authors recommend monitoring the ratio of juvenile:adult marten harvested (deVos 1951, Marshall 1951b, Lensink 1954, Quick 1956). This can be determined by examining the skulls of marten taken by trappers. A mandatory requirement that trappers turn in a marten skull for each skin tagged should be established. The breeding stock is probably being depleted if the relative number of juveniles exceeds half the catch, and the area in question should be closed for 3 years to allow recovery of the breeding population. This procedure will ensure a sustained yield of marten.

10) Encourage local trappers to space trap lines 1.5 km apart in optimum or suitable habitat.

Rationale: This is twice the width of an average female home range. Spacing will protect strips of breeding females to allow continual reproduction and overflow from the area.

11) Substantially increase the permit fee for trapping in Montana.

Rationale: Trapping permits have not kept up with inflation. A good trapper can easily afford to pay more than the current $10 fee for a season in which he earns several hundred or thousand dollars from his trade. Raising the fee will not discourage this type of quality trapper, but will generate revenue which should be allocated to the fur division of Montana Fish, Wildlife, and Parks.

12) Continue marten research, emphasizing the habitat requirements of denning females, and the effects of habitat alteration on marten dispersal.

Rationale: Present information indicates availability of denning sites may limit marten populations in certain forest types. However, data are limited to descriptions of denning sites. Information documenting critical habitat components at maternal den sites is needed.

Dispersal of marten between isolated subpopulations is necessary to maintain self-perpetuating marten populations. Presently, the extent to which habitat alteration effects this dispersal, and the management options needed to prevent creation of dispersal barriers are unknown. As insularization of subpopulations increases, resulting from loss of habitat, this information will become increasingly critical.

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APPENDIX A

FUR HARVEST OF MARTEN IN MONTANA SINCE 1955

Season	Number of marten harvested	Average price paid/pelt($)
1955-56	721	7.86
1956-57	494	5.65
1957058	434	4.66
1958-59	272	5.12
1950-60	391	5.55
1960-61	382	8.75
1961-62	338	4.14
1962-63	291	4.40
1963-64	435	4.77
1964-65	336	5.42
1965-66	340	4.74
1966-67	360	5.26
1967-68	490	5.22
1968-69	225	4.90
1969-70	675	5.00
1970-71	314	3.68
1971-72	173	5.11
1972-73	671	7.32
1973-74	369	7.54
1974-75	482	5.88
1975-76	972	9.34
1976-77	2086	16.61
1977-78	2341	17.04
1978-79	767	13.15
1979-80	1542	19.57
1980-81	1727	16.61

APPENDIX B

WEATHER AT LOGGING CREEK RANGER STATION, 1980

Date	Early morn. temp(C)	Maximum daily temp(C)	Snow depth (cm)	New snow (cm)	Precip- itation	Wind	Cloud cover
Jan. 9	-22	-19	28	15	s	t	o
10	-18	-7	30	3	n	0	sc
11	-14	-4	33	3	s	0	o
15	-4	0	51	-	n	t	o
16	-	-	52	2	s	-	-
17	-1	4	56	4	n	2	pc
18	-11	-4	56	0	n	1	c
19	-24	-	-	0	-	-	-
27	-29	-14	53	0	n	0	c
28	-29	-	-	-	-	-	-
Feb. 3	4	-	-	-	n	0	o
4	0	4	51	2	s	3	sc
5	-9	-1	51	0	n	0	o
6	-3	-1	51	1	s	0	o
7	-3	-	56	5	s	1	o
11	-2	0	48	0	n	0	o
12	-4	-2	56	8	s	0	o
13	-12	-12	58	3	n	2	c
14	-16	-12	-	-	s	4	o
15	-19	-	52	3	-	0	o
18	-2	3	51	4	s	0	o
19	1	7	51	0	r	1	o
20	-1	-	58	8	s	0	o
22	-7	4	21	0	n	0	c
23	-13	-	-	-	-	0	c
27	1	7	-	0	n	0	pc
28	2	6	46	0	r	0	-
29	0	4	-	1	n	0	o
Mar. 5	-24	-1	51	8	n	0	o
6	-9	-2	50	0	n	0	-
7	-	-	51	1	s	0	o
9	-7	1	52	3	s	0	o
10	0	2	51	0	s;r	0	o
11	0	4	51	0	r;s	2	o
12	-	-	51	4	s	0	pc
13	-	-	64	13	s	2	pc
14	0	2	66	5	s	1	o
15	-3	2	60	-	-	-	-
17	-3	2	58	0	s	1	o
18	-2	4	58	0	n	0	o

Key Daily precipitation: n) none; s) snowing; r) raining.
Wind: 0) none; 1) slight; 2) moderate; 3) heavy.
Cloud cover: c) clear; o) overcast; pc) partly cloudy.

APPENDIX C

SNOW DEPTHS ON THE STUDY AREA, 1980

	Date	Snow depth (cm) at station*		
		1	2	3
Jan.	19	38	23	-
Feb.	4	29	18	-
	5	29	18	-
	6	34	-	-
	14	39	22	-
	19	36	18	-
	20	42	20	-
	22	37	18	-
	23	37	18	46
	27	33	15	46
	28	32	15	-
	29	30	-	41
Mar.	6	36	15	-
	10	36	17	46
	11	32	13	-
	13	45	23	-
	14	46	20	57
	17	41	18	53
	18	41	18	55

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* Station locations.

1) on the Interior Park Road at the extreme western edge of the core study area. Canopy cover was 0%.

2) 20 m north of station #1. Canopy cover was 45%.

3) on the Interior Park Road half way between station #1 and Anaconda Creek. Canopy cover was 0%.

APPENDIX D

HABITAT TYPING INDICATOR SPECIES

Species number	Scientific name	Common name
1	*Alnus sinuata*	Sitka alder
2	*Arctostaphylos uva-ursi*	kinnikinnick
3	*Berberis repens*	creeping Oregon grape
4	*Cornus canadensis*	bunchberry dogwood
5	*Holodiscus discolor*	ocean spray
6	*Junierus communis*	common juniper
7	*Ledum glandulosum*	Labrador tea
8	*Linnaea borealis*	twinflower
9	*Menziesia ferruginea*	menziesia
10	*Oplopanax horridum*	devil's club
11	*Physocarpus malvaceus*	ninebark
12	*Prunus virginiana*	chokecherry
13	*Purshia tridentata*	bitterbrush
14	*Ribes* spp.	gooseberries
15	*Shepherdia canadensis*	buffaloberry
16	*Spiraea betulifolia*	white sipraea
17	*Symphoricarpos albus*	common snowberry
18	*Symphoricarpos oreophilus*	mountain snowberry
19	*Vaccinium caespitosum*	dwarf huckleberry
20	*Vaccinium globulare*	blue huckleberry
21	*Vaccinium scoparium*	grouse whortleberry
22	*Agropyron spicatum*	bluebunch wheatgrass
23	*Andropogon* spp.	bluestem
24	*Calamagrostis canadensis*	bluejoint
25	*Calamagrostis rubencens*	pinegrass
26	*Carex geyeri*	elk sedge
27	*Festuca idahoensis*	Idaho fescue
28	*Festuca scabrella*	rough fescue
29	*Luzula hitchcockii*	wood-rush
30	*Actaea rubra*	baneberry
31	*Antennaria racemosa*	woods pussytoes
32	*Aralia nudicaulis*	wild sarsaparilla
33	*Arnica cordifolia*	heartleaf arnica
34	*Athyrium filix-femina*	lady fern
35	*Balsomrhiza sagittata*	arrowleaf balsamroot
36	*Clematis pseudoalpina*	virgin's bower
37	*Clintonia uniflora*	queencup bedlily

Appendix D (continued).

Species number	Scientific name	Common name
38	*Equisetum arvense*	common horsetail
39	*Equisetum* spp.	horsetails & scouring rush
40	*Galium triflorum*	sweetscented bedstraw
41	*Gymnocarpium dryopteris*	oak fern
42	*Senecio streptanthifolius*	cleft-leaf groundsel
43	*Senecio triangularis*	arrowleaf groundsel
44	*Smilacina stellata*	starry Solomon's seal
45	*Streptopus amplexifolius*	twisted stalk
46	*Thalictrum occidentale*	western meadowrue
47	*Valeriana sitchensis*	sitka valerian
48	*Viola orbiculata*	round-leaved violet
49	*Xerophyllum tenax*	beargrass

APPENDIX E

COVER CLASS OF INDICATOR SPECIES ESTIMATED AT TRAP SITES

Indicator species number refers to Appendix D. The trap sites are shown in Figure FTS. Cover classes are: 0-absent; T-rare to 1%; 1-1 to 5%; 2-5 to 25%; 3-25 to 50%; 4-50 to 75%; 5-75 to 95%; 6-95 to 100%.

	Indicator species number
	1111111111222222222233333333334444444444
Trap site	1234567890123456789012345678901234567890123456789
5	00T1000200000TT1T0T200003000000010002002000102000
8	00TT000300000TT120T0000040000000100T20010001020T0
10	0TTT0003000000T2201T0000400000001000200T000102000
11	00TT00030000000TT01100004000000010002000000101000
12	00000000000000014000000020000T000000000000010T000
13	01T000020000000T100110004T0000101000000000000T00T
14	01T0000200000002T0T200004T0000001000000000000T000
16	0TT10002T000000100T200003000000010002002000102000
17.5	00TT0002T00000022012000020000000100030020002020T0
17	001T000200000T02202100004000000010003002000102000
18.5	00T20002T0000T0T20TT000030000T00100030020001T2000
18	001T0002T0000T0T10100000400000002000200T000T02000
19	10TT000300000T0T2020000020000000T000200T000202000
20	10TT000300000T0T2020000020000000T000200T000202000
21	102T000200000T01202000002T000T001T002TT1T00T12000
22	T01100010000010T20T00000020000T00T00020020002020T0
23	10020001000001013000000030000T0000002002T002T30T0
24	T011000200000T0130T0000020000T0T10002002T001T3000
25	10020001000001013000000030000T0000002002T002T30T0
26	T00T000T000T0T01400000002000000000000100TT00101000
27	001T000T00000T0130000000300000000000T001000T01000
28	00TT000T0000010130000000030000T000000T001000102000
29	T0TT00020000020130TT000010000T000000T001000T01000
30	T0TT0002T0000T0230T10000200000001000200T000T03000
32	00T0000200000012T020000040000000000000000000000T000
32.5	00100000000000T0102000004000000000000000T000000000
33	0020000200000012T020000030000000000000000000000T000
34	01T000020000001T00T0000040000000000000000000000T000
35	02100001000000TTT020000040000000000000000000000T000
36	01100000000000T1T0200000400000000000000000000000000
37	01T00001000000T11T020000300000000000000000000000000
38	0TT00001000000T20020000030000000000000000000001000

Appendix E (continued).

	Indicator species number
Trap site	1111111111222222222233333333334444444444 1234567890123456789012345678901234567890123456789
39	00T00002000000212020000030000000T000100000000T000
40	0000000100000023T02000003000000000000000000000000
41	01000003000T0012001000003000000000000000000000000
42	00T00002000000212020000030000000T000100000000T000
43	0TT00001000000T3202000003000000000000000000T0T000
44	0T10000200000012T0T00000300000000000000000000T000
45	02TT00020000002110100000300000000000100000000T000
46	00T2000100000022T0T00000400000000000T00000000T000
47	T0TT000100000012201000003T0000000000200000020T000
48	0TT000000000001T20T00000TT00000000000000000202010
49	03T000000000003200200000400000000000000000000T000
50	02T0000200000023101000001200000000000000000000000
51	0T000000000T000120000000200000000000200T000101000
52	0021000100000T2010T0000030000000000000000000010T0
53	002200020000000310000000300000000000T00000000T000
53.5	002T000000000T0220TT000020000000000000000000020T0
54	002T00000000010110000000T0000T000000100T0000000T0
54.5	00TT000200000T0120T000002000000000000T0T000100010
55	00T1000300000021010000003000000020000000000T01000
56	001000000000000310T0000040000000T000000000010T000
57	00T00000000000031000000040000000T000000T000T0T000
57.5	0000000TT00000021000000010000000T0001001000002000
58	00000000000000022010000050000000000000T00000T000 0
59	020000010000000T2T02000004 0000000T000000000000T000
60	010T000200000002202000004 0000000T000T00000010T000
60.5	30T2000200000T02T0000000T0000T00000030010002020T0
61	00120001000001T101200000T0000T00T000100T0001010T0
62	00T10001000000 2T0000000000000000T000200100010 20T0
63	10T100010000T0TTT0T00000T0000000T000100T000T00000
64	00TT000T0000000T0TT000000T000000T000T00T000T0T000
65	00TT000T000T000TT0T00000T0000000T000T00T000000000
65.5	00TT000T000T000TT0T00000T0000000T000T00T000000000
66	00TT000100000T0010T000002 0000000T000T00T000T01000
67	00T0000T00000T0200T000004000000000000000000001000
68	0000000000000000000000000000000000000000000000000
69	0000000000000000000000000000000000000000000000000
70	00T0000T0000000120T00000200000T00000T00T000001000
71	00T0000T0000000120T00000200000T00000T00T000001000
77	0210000300000T2200300000500000001000000000000T000

Appendix E (continued).

Trap site	Indicator species number 1111111111222222222233333333334444444444 1234567890123456789012345678901234567890123456789
78	0210000300000T2200300000500000001000000000000T000
79	02T2000300000T2200200000300000002000100T000T00000
80	01T2000200000111T0T0000020000000100020010000020T0
81	T0T10001T0000T12201T100030000T00T0001001000T03000
82	T0T10001T0000002102T100010000T000000100T000113000
83	T0T10001T0000002102T100010000T000000100T000113000
84	10020002T000020T201T20002000010000001002000113000
85	21TT00010000020T2020200030000100100002TT1000T13000
86	21TT00010000020T2020200030000100100002TT1000T13000
87	1003000200000200T0202000T0000T0000002002000TT2000
88	TT020002200000T12020200021000T0000002TT1000TTT000
89	11100T03000000311020200030000T0000001TTTT00TT2000
90	01T00T0200000022T02020003000000000000000000000T000
91	T0TT0002T0000T02101220002000000020000T000000002000
92	1099000220000112100300001000000920001009000002010
93	T0T20002000T0T0220T30000200000002000200T000003000
93.5	T0TT00020000010T2012000020000000T0003001000T020T0
94	T2T10T03000000210030T0003000000000000000000000000
101	00T1000200000T0T20010000T000000000002001000102000
102	T012000200000TT1000200001000000000002001T00TT1000
103	00TT000T00000T00100T0000T00000000000T00TT00T0T000
104	00TT000T00000T01300000003000000000001001000102000
105	00TT00010000000T100T0000200000000000T00T000T0T000
106	001T000TT000000TT0T2000020000T000000100T100T0T000
107	10T0000TT0000002T01T000040000T0000003003T00103000
108	00T1000310000T02T0T30000400000000000100T00000T000
109	00T2000210000T0TT0T30000200000000000200T00010T000
110	000T000TT000020T2000000010000T000T0020T2T00T02000
111	000200020000020TT001T00020000T0000002002000T03000
112	00T20003000002T0T02T000040000000T0001001000T01000
113	TTT10T0300000022T030T00040000000000000000000000T0

APPENDIX F

INDIVIDUAL CHARACTERISTICS AND BEHAVIORS OF TRAPPED MARTEN*

Marten number	Date	Weight (gm)	Breed. cond.	Sagital crest	Body color	Throat patch	Teeth cond.	Eat	Drink	Release behavior
m25	7-13-79	750	1	0	1	4	1	y	y	2
m26	7-11-79	775	1	0	1	1	1	n	n	1
m26	7-12-79	790	1	0	1	1	1	n	n	4
m26	7-14-79	835	1	0	1	1	1	y	y	4
m29	9-9-80	1025	1	1	-	-	-	y	y	-
m51	7-21-79	900	1	1	3	4	1	y	y	2
m51	8-26-79	1000	1	1	3	4	1	y	y	2
m51	9-9-79	-	1	1	3	4	1	y	y	4
m61	7-2-79	850	1	0	1	2	1	y	y	4
m61	8-28-79	1100	1	1	1	2	1	y	y	1
m61	9-7-79	-	1	1	1	2	1	y	y	3
m63	8-3-79	900	1	1	3	6	1	y	y	1
m69	8-26-79	900	1	1	2	6	1	y	y	-
m69	8-28-79	875	1	1	2	6	1	y	y	2
m69	9-7-79	-	1	1	2	6	1	y	y	2
m69	10-12-79	1050	1	1	2	6	1	y	y	4
m69	10-14-79	-	1	1	2	6	1	n	n	4
f10	8-2-79	625	3	0	2	3	1	y	y	3
f16	7-2-79	575	3	0	1	6	1	y	y	4
f32	7-27-79	650	3	0	3	4	1	n	y	1
f32	8-18-79	-	3	0	3	4	1	y	y	1
f35	7-28-79	675	3	0	1	4	1	y	y	2
f59	9-6-79	700	3	0	2	6	1	y	y	2
f59	9-7-79	675	3	0	2	6	1	y	y	2
M11	7-23-79	-	-	4	2	2	4	y	y	1
M11	8-28-79	1150	2	4	2	2	4	y	y	4
M13	8-19-79	1100	2	3	1	6	-	y	y	4
M13	10-14-79	1125	1	3	1	6	-	y	y	4
M30	5-18-80	1025	1	1	2	3	2	y	y	4
M34	8-16-79	1150	2	4	1	2	2	y	y	2
M38	7-2-80	1125	2	2	2	4	2	y	y	3
M56	8-27-79	1125	2	4	1	2	2	n	n	3
M56	8-29-79	1085	1	4	1	2	2	y	n	-
M63**	6-26-80	800	2	2	3	6	2	y	n	1
M64	8-22-79	1100	1	3	2	6	2	y	n	4
M64	10-14-79	-	-	3	2	6	2	y	n	2
M64	5-25-80	1085	1	3	2	6	2	y	n	4
M69**	6-27-80	900	2	1	2	6	1	n	n	1
M72	6-12-79	1200	2	3	1	3	2	-	-	1
M72	6-24-79	1085	2	3	1	3	2	n	n	2

Appendix F (continued).

Marten number	Date	Weight (gm)	Breed. cond.	Sagital crest	Body color	Throat patch	Teeth cond.	Eat	Drink	Release behavior
M75	6-11-79	1125	1	4	3	5	-	n	n	1
M75	6-21-79	1075	1	4	3	5	-	y	n	2
M75	8-18-79	-	-	4	3	5	-	y	n	4
M77	6-21-79	1250	1	3	3	6	3	y	n	4
M77	8-21-79	1200	2	3	3	6	3	y	n	2
M77	6-25-80	1175	1	3	3	6	3	y	n	2
F14	6-30-79	675	4	2	1	3	3	y	y	4
F14	7-19-79	700	4	2	1	3	3	y	y	2
F14	7-20-79	675	4	2	1	3	3	y	y	4
F14	6-28-80	650	3	3	1	3	3	y	y	3
F14	7-2-80	675	3	3	1	3	3	n	n	1
F23	7-12-79	625	4	2	1	3	2	y	y	4
F23	7-28-79	700	3	2	1	3	-	y	n	4
F27	7-14-79	700	-	2	1	1	2	y	y	2
F27	7-20-79	675	3	2	1	1	2	y	y	2
F27	8-3-79	700	4	2	1	1	2	n	y	3
F28	5-25-80	-	-	1	2	3	2	y	y	2
F28	6-26-80	700	3	1	2	3	2	y	y	2
F31	5-19-80	-	-	1	2	3	2	-	-	1
F31	5-25-80	650	3	1	2	3	2	y	y	4
F37	6-21-79	650	3	1	1	3	2	y	y	1
F37	6-23-79	650	3	1	1	3	2	y	y	4
F37	8-26-79	700	3	1	1	3	2	y	y	4
F37	8-27-79	650	-	1	1	3	2	y	y	2
F66	6-20-79	750	3	1	1	1	2	y	y	3
F66	6-22-79	700	3	1	1	1	2	y	y	2
F66	7-15-79	625	4	1	1	1	2	y	y	2
F66	8-18-79	700	4	1	1	1	2	n	n	2
F66	9-12-79	625	3	1	1	1	2	n	n	2
F66	6-27-80	650	3	1	1	1	2	y	y	2

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* Key to table. - indicates missing data.

Breeding condition: 1) testes no enlarged; 2) testes enlarged;
3) vulva not swollen or bloody;
4) vulva swollen or bloody.

Sagital crest: 0) no keel; 1) 0-1 cm, keeled; 2) 1-2 cm, keeled;
3) 2-3 cm, keeled; 4) >3 cm, keeled.

Body color: 1) light brown; 2) medium brown; 3) dark brown.

Throat patch: 1) small, unmottled; 2) small, mottled;
3) large, unmottled; 4) large, unmottled;
5) medium, unmottled; 6) medium, mottled.

Teeth condition: 1) juvenile; 2) adult, none or slight damage;
3) adult, moderate damage;
4) adult, extreme damage.

Eat/Drink: n) no; y) yes.

Release behavior: 1) fled on ground; 2) fled on logs;
3) fled on combo of tree, log, ground;
4) fled on combo of logs and ground.

** These 2 adult males were m63 and m69 before maturity.

APPENDIX G

RESPONSE OF MARTEN TO KETAMINE HYDROCHLORIDE

Marten number	Marten weight (gm)	Dose (mg)	Time in (min)	Time out (min)
m09	975	5.0*	4.0	8
m51	1000	12.0	1.4	12
m61	1100	13.0	2.0	**
m63	800	10.0	2.0	11
m63	900	10.0	1.5	12
m69	800	10.0	1.0	5
m69	875	10.0	1.9	12
m69	950	11.0	1.0	6
f10	625	6.0	1.6	15
f59	675	6.0	1.1	9
M11	1150	13.5	1.6	11
M13	1125	11.0	2.1	15
M56	1125	13.0	1.8	15
M64	1100	12.5	2.0	13
M77	1200	22.0***	1.3	17
F37	700	6.0	1.0	9
F66	625	6.5	1.3	6
F66	650	6.5	0.9	4

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* this represents an underdose. I gave him an additional injection of 5 mg after time out.

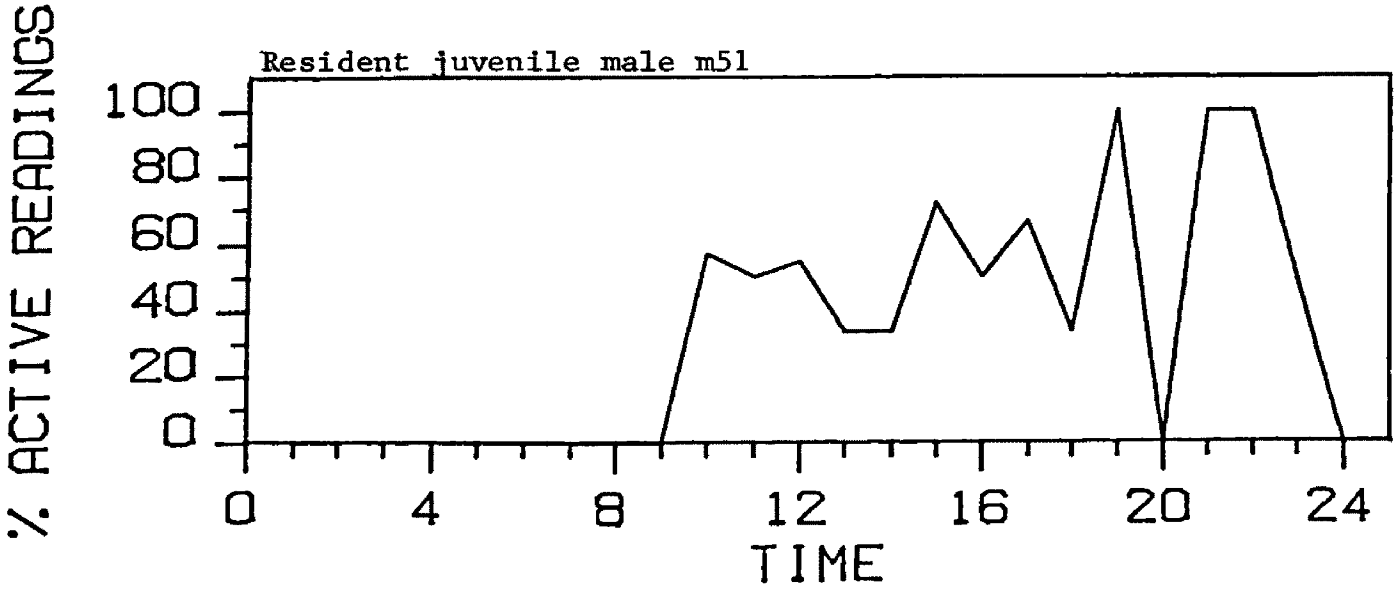
** this male never went completely under even after an additional injection of 10 mg.

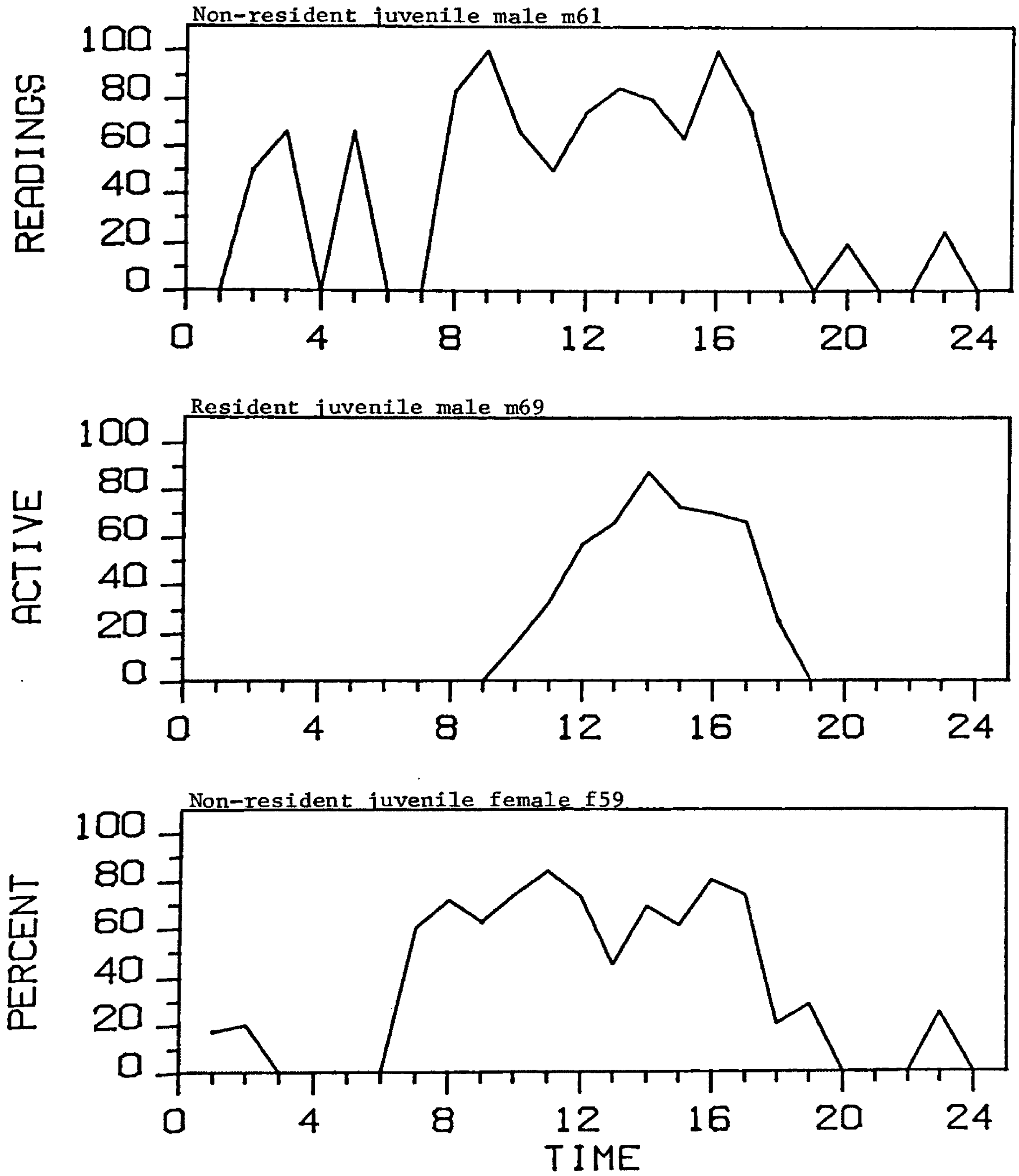
*** this represents an overdose. The marten completely recovered.

APPENDIX H

ACTIVITY PATTERNS OF INDIVIDUAL MARTEN

The activity pattern of marten collectively averaged a peak around dusk. Activity patterns of individual marten varied from this pattern, although all marten showed diurnal activity, with an inactive period just before dawn. The following activity patterns represent individual marten for which adequate samples of activity readings are available from 0000 to 2400.

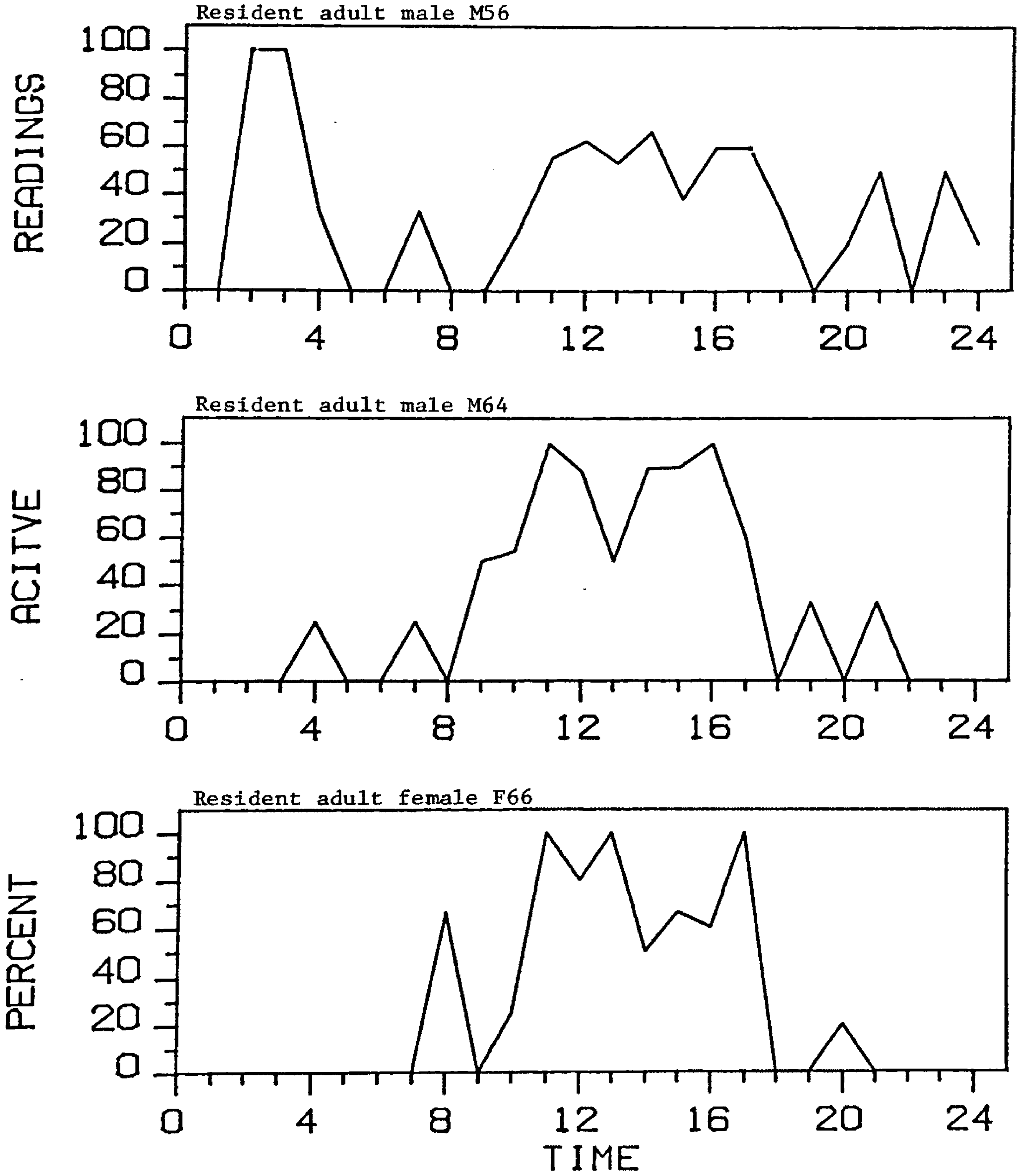




Non-resident juvenile male m61

Resident juvenile male m69

Non-resident juvenile female f59



Resident adult male M56

Resident adult male M64

Resident adult female F66

APPENDIX I

ESCAPE SITES

Marten were often active, presumably hunting, when found by telemetry (N=68). Marten remained active on the ground at 42 (61.8 %) sites. At 26 locations marten stopped, escaping to trees 24 times, remaining on the ground only twice. As a rule, marten climbed higher as I approached the escape tree. Francis and Stephenson (1972) stated that 7 marten were frightened into trees that they soon descended. However, Clark (1977) indicated that trees were seldom used for escape. Marten nearly always moved away on the ground.

Marten avoided openings >100 m across during winter (Dice 1921, Grinnel et al. 1937, Marshall 1951, Hagmeier 1956, Hawley and Newby 1957, Streeter and Braun 1968, Koehler 1975, Clark and Campbell 1977), or traveled faster through (Steventon 1979) and used less than available (Major 1979) clearcuts versus uncut or partially cut stands. The use of trees for escape sites may have been an important factor for marten's avoidance of open areas when snow covers the ground. Other authors (Seton 1929, Grinnel et al. 1937, Schmidt 1934 cited in Lensink 1953) reported the major predators of marten to be great-horned owls (_Bubo virginianus_) and golden eagles (_Aquila chrysaetos_). Avian predators could easily take marten in the open compared to under a closed canopy. Herman and Fuller (1974) also concluded marten traveling in open areas were vulnerable to predation by great-horned owls.

APPENDIX J

HUNTING SITES

The ease of access and open character of non-resident juvenile m63's temporary home range made visual observations of this marten economical. He was followed for several hours, during which time multiple observations of his hunting behavior were noted. He traveled extensively on top of the snow often sniffing at the surface, walking in an open stance. On 7 occasions he was observed to stop and cock his head back and forth. Presumably he was listening for small mammals under the snow cover. After waiting for a time, 1-5 minutes, he would leap straight into the air about a body's length and dive head first into the snow, digging as he came in touch with the surface. All but the tip of his tail would disappear. After less than 30 seconds of digging, he would stop; only twice did he resume digging. He was never observed to come to the surface with any prey. Those diggings were not in association with any trees, logs, or downfall.

Diving behavior was primarily observed when the snow was slushy. When the temperature dropped below freezing the snow encrusted, and his diggings did not reach ground level. He then concentrated his efforts along snow covered logs and downfall. Steventon (1979) noted similar response to encrusted snow cover.

APPENDIX K

SCENT MARKING

Juvenile male m63 was observed to scent mark on several occasions. He would briefly rub his abdominal scent gland (Ewer 1973) on the ground or snow and then continue. He did this by lowering his hind quarters, spreading his hind legs in the process. Herman and Fuller (1974) made note of similar scent marking behavior in the Northwest Territories. No apparent attempt was made to repeatedly mark in the same areas.