WINTER ECOLOGY
OF
AMERICAN MARTEN
IN SOUTHWESTERN MONTANA

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ABSTRACT

American marten have a reputation of being easy to trap and sensitive to perturbations in the forest communities they inhabit . These characteristics have led to the designation of marten as a “sensitive species” by several USFS administrative regions, including Region 1 covering southwest Montana. A major human-induced perturbation to the species, logging, is assumed to be detrimental to marten in two ways: 1) timber harvest removes mature forest stands required by this species; and 2) roads built to accommodate logging activities will increase access available to trappers. We examined these assumptions in two study areas in southwest Montana. The Big Hole study area was selected as representative of a lightly disturbed mesic habitat, and the West Yellowstone study area was selected as a highly disturbed more xeric environment. Marten in both study areas were found to be highly mobile and capable of traversing clearcuts to access residual mature timber. During winter, they avoided early successional forest stands and made disproportionate use of mature, but not necessarily climax, conifer communities. Marten evidently selected areas with complex understories and abundant deadfall within mature stands. Habitat selection was more pronounced at sites where these conditions were relatively uncommon than at sites where complex understories and deadfall were generally available. Population densities in the two study areas were relatively low compared to northwest Montana and eastern Canada, but appeared to withstand harvest pressure applied in 1989-1992. Population persistence in both study areas may have been aided by adjacent landscapes with restricted trapper access. Harvested animals could readily be replaced by immigrants from these areas. Populations without adjacent protected areas might be more vulnerable to extirpation. An informal negative feedback system used by several trappers in our study areas provided additional protection for these populations. This voluntary feedback system resulted in lower harvest effort when trappers perceived low population density in an area. One trapper consciously reduced effort when he felt populations were too low. Other trappers reduced effort when they decided expenses exceeded the harvest return. This harvest strategy may not operate in all areas, but it has evidently allowed marten populations to persist in some insular mountain ranges, which have undergone significant habitat changes due to logging, despite more than 50 years of access by marten trappers.

CHAPTER 1

INTRODUCTION

American marten (*Martes americana*) habitat use and population ecology have been extensively investigated in most parts of the species range (Buskirk et al. 1994, Proulx et al. 1997). However, information on marten in the drier portions of the Rocky Mountains, which include southwest Montana, is limited (Photo 1.1). This lack of knowledge has created problems for agencies that are responsible for managing marten habitat and marten harvests.

The United States Forest Service (USFS) manages most of the marten habitat in southwest Montana. During the 1970s and 1980s pressure to increase timber harvest mounted on the remaining "old-growth" forests in this region. The National Forest Management Act of 1976 mandated each National Forest to select and monitor indicator species. National Forests were expected to use management models developed by the USFS which relied on the status of indicator species to gauge the ecological health of forests (Warren 1989). Status of indicator species, therefore, was a major factor in determining the extent and distribution of timber harvest within the forest. Both the Beaverhead and Gallatin National Forests of southwest Montana selected marten as one of several indicator species, but no data were available to determine if monitoring techniques and population parameters identified for marten from other northern forests were appropriate for populations in the forests of southwest Montana.

Management of marten populations fall under state jurisdiction of Montana Fish, Wildlife and Parks (MFWP). During the 1970s and 1980s MFWP came under increasing pressure to demonstrate that the agency's furbearer management policies did not adversely affect marten populations in the state. MFWP needed information to determine if regulations developed in the 1950s and 1960s, which allow an unlimited harvest of marten during a two and one-half month winter trapping season, were appropriate for southwest Montana during the 1990s. Changes in forest structure and the increase in logging roads between 1960 and 1990 could have reduced suitable habitat and/or increased accessibility by trappers enough to make current regulations for harvest seasons obsolete.

Earlier marten studies in Montana (Hawley and Newby 1957, Weckwerth and Hawley 1962, Burnett 1981) described food habits, population fluctuations, and home range sizes in the northwest part of the state, but specific information regarding habitat use was unavailable. The only information collected on marten in southwest Montana prior to 1987 had been pelt-tagging data from trappers (K. Aune, pers. comm.). In 1987, MFWP's State Wildlife Laboratory initiated marten carcass collections. Trappers throughout the state were required to turn in carcasses to MFWP personnel. From these specimens, population age and sex structure, fecundity, and food habits were determined. These data were useful, but they did not provide detailed information on population trend or on the effects of habitat alteration associated with logging. The number of marten trapped each year is influenced by fur prices, trapper effort, and weather conditions that may be independent of population levels and habitat changes.

In order to provide detailed information on population trends and habitat use patterns in managed forests in southwest Montana, the USFS and the MFWP funded a 3-year study beginning in 1989. This bulletin covers four aspects of this study: 1) home range size and movements; 2) marten habitat relationships; 3) population structure of marten populations in southwest Montana; and 4) effects of unlimited harvest on local marten populations. Two areas in southwest Montana were selected for this research based on availability of information on historic marten harvests, proximity to refugia, and presence of representative habitat types.

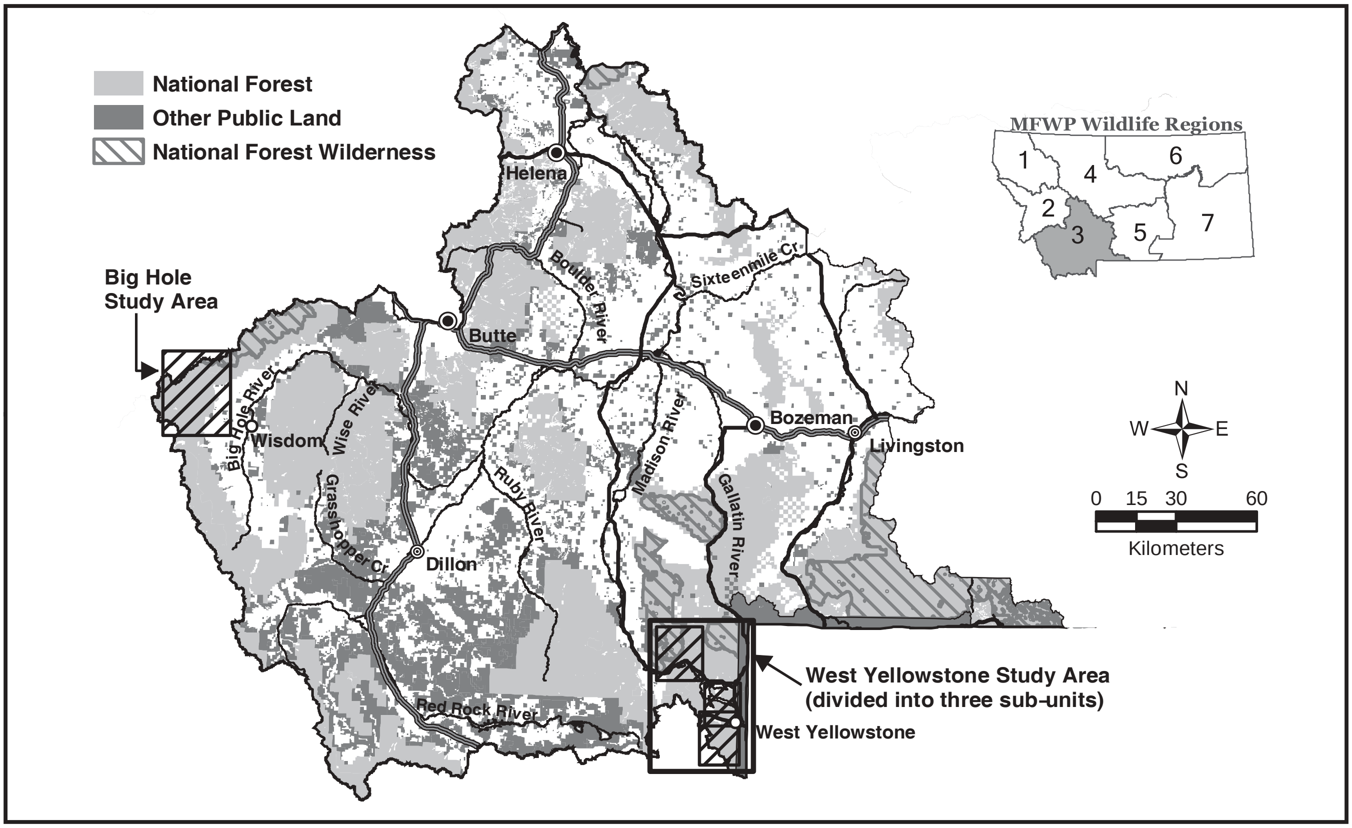


Figure. 1.1. Location of Southwest Montana study areas.

The first area, the 153 km^2 Big Hole study area, was located 15 km west of Wisdom, Montana and northwest of the Big Hole National Battlefield (Fig. 1.1). Approximate boundaries were defined by Highway 43 to the south, the Continental Divide to the north and west, and the sagebush-grassland of the upper Big Hole valley to the East (Fig. 1.2). Englemann spruce (*Picea englmannii*) and subalpine fir (*Abies lasiocarpa*) were the dominant tree cover in drainage bottoms and higher elevation sites (Photo 1.2). Drier and lower elevation sites supported lodgepole pine (*Pinus contorta*) and Douglas-fir (*Psuedotsuga menziesii*). Elevation ranged from 1,950 m to 2,500 m. Annual average precipitation at the town of Wisdom averages 30 cm, with an average temperature of 1.7 C (USDC 1990). Precipitation in the study area increased with elevation. Logging, livestock grazing, and recreation were the primary land uses within this study area. Timber harvests occurred on 15% of the area between the late 1950s and 1992.

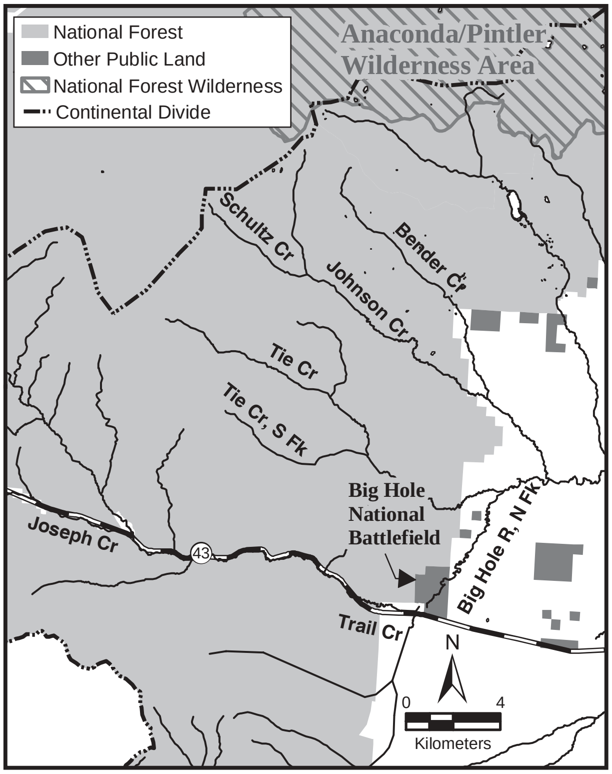


Figure 1.2. Big Hole study area.

The second study area was located near West Yellowstone and was approximately 230 km southeast of the Big Hole study area (Fig. 1.1). We divided this study area into 3 sub-units. The Flats sub-unit (64 km^2) was situated in a high elevation basin (2000 m) in the extreme southern part of Montana on the western edge of Yellowstone National Park (Fig. 1.3). Average temperature at the town of West Yellowstone is 1.6 C and average precipitation, most of which falls in the form of snow, is 56.7 cm (USDC 1990). A lodgepole pine/antelope bitterbrush (*Purshia tridentata*) habitat-type (Pfister et al. 1977) was the dominant vegetation in this area (Photo 1.3). Natural openings and clearcuts support vegetative cover dominated by grass species. Willow *(Salix* spp.) communities were scattered throughout the area primarily along perennial streams. Primary land uses were recreation, logging, and firewood cutting. Large scale timber harvesting has taken place on the study area since the late 1950s with 37% of the study area having been harvested by 1992. A flat physiographic nature permitted almost unlimited motorized access in the study area. Fur trapping has been intermittent for at least the last 50 years.

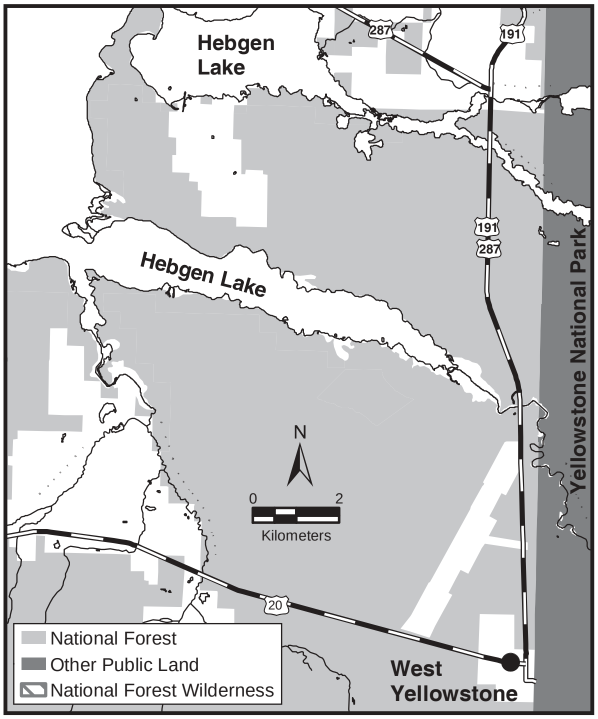


Figure 1.3. West Yellowstone Flats sub-unit.

The Beaver Creek sub-unit was northwest of Hebgen Reservoir and 14 km northwest of the Flats study site (Fig. 1.1). This sub-unit covered 32 km^2 and was bordered on the south by Highway 287, the Lee Metcalf Wilderness to the west, the Gallatin/Madison divide to the north, and Cabin Creek to the east with Beaver Creek bisecting the study area (Fig. 1.4). Mean precipitation and temperature, measured at Hebgen Dam, are 73.2 cm, and 2.2^{O} C, respectively. Elevation ranged from 2,000 m to 2,800 m. The topography of this study area was much steeper than any of the other study sites. Englemann spruce (*Picea engelmannii*) and subalpine fir dominated the riparian areas and much of the steep valley sides (Photo 1.4). Douglas-fir was a common component on all landforms. Lodgepole pine occurred in successional stands of Douglas-fir and subalpine fir habitat types. Recreation and logging were the primary land uses in this area. Big game hunting, hiking, and camping were the dominant recreational activities. Logging was limited to areas on the east side of Beaver Creek. Clearcuts were isolated and comprised approximately 6% of the area at the time of the study. The last harvest activities took place in the early 1970s. Beaver Creek has been trapped for at least the last 50 years (R. Whitman, pers.com).

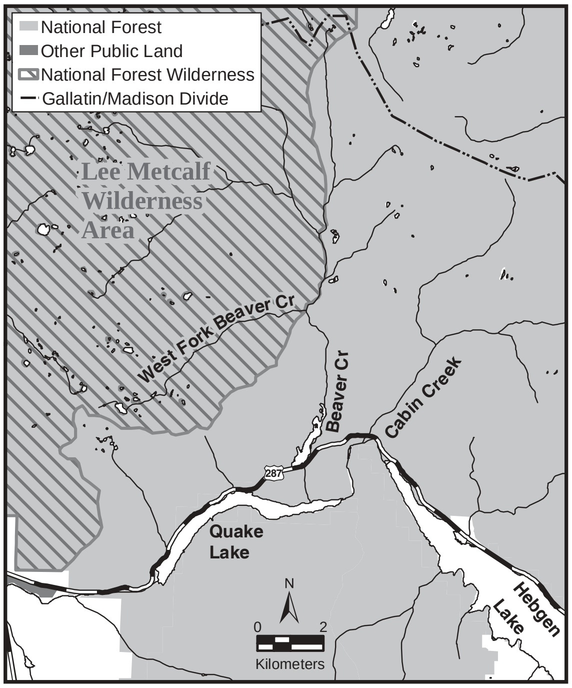


Figure 1.4. West Yellowstone Beaver Creek sub-unit.

The Mosquito Gulch sub-unit was located south of the Flats sub-unit (Fig. 1.1). This area was bounded by the South Fork of the Madison River to the east, the Continental Divide on the south and west, and the Flats to the north (Fig. 1.5). This area had a diverse topography, ranging from relatively flat benches to drainages with high topographic relief. Elevation ranged from 2035 m to 2500 m. Average precipitation is approximately 112 cm at the Madison Plateau SNOTEL site, mostly in the form of snow. Average temperatures were similar to those in West Yellowstone.

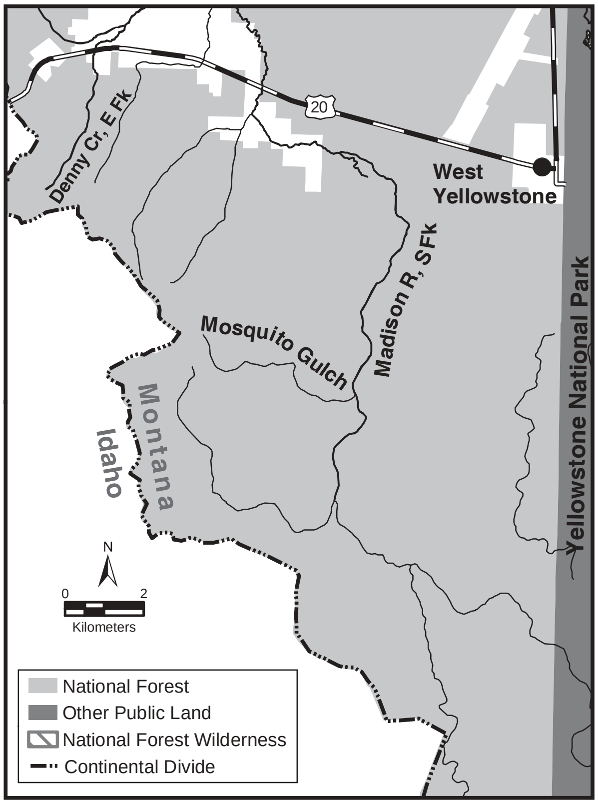
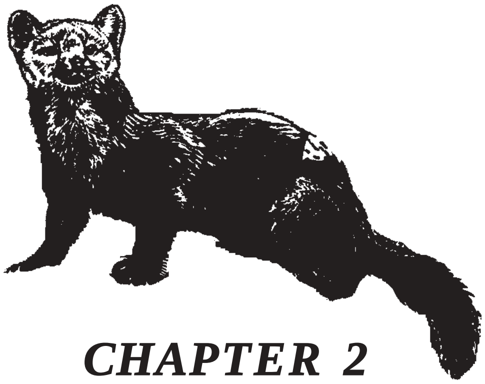


Figure 1.5. West Yellowstone Mosquito Gulch sub-unit.

Timber harvesting began in the late 1950s and was ongoing through the study period, although not at the high rate of the previous three decades. Recreation was the only other land use in this sub-unit. Hunting and sight-seeing were the primary recreational activities during the summer and fall months. Snowmobiling and cross country skiing were the primary winter recreational activities. An extensive network of groomed snowmobile trails was maintained throughout the winter and provided good access to the area. Fur trapping has taken place on the the Mosquito Gulch study area for at least the last 50 years (R. Whitman, pers. comm.). Dominant vegetation communities in this sub-unit were subalpine fir, lodgepole pine, and Douglas-fir. Clear-cuts were vegetated primarily by grass, with willow communities occurring along stream drainages.



CHAPTER 2

HOME RANGE AND MOVEMENTS

Home range is conventionally defined as the area covered by an individual animal involved in normal activities such as finding food and water, locating mates, and caring for young (Burt 1943). Calculating an area that encompasses “normal” activities is complicated by difficulties in obtaining accurate animal locations, problems with obtaining independent locations, the time interval over which locations are collected, and inherent biases in all techniques used to calculate home range size (White and Garrott 1990, Samuel and Fuller 1994). Despite these problems, home range size is often a useful index to habitat quality and may be used to determine the minimum spatial requirements necessary to support a marten population.

Calculated rates of movement and descriptions of movement patterns for individual martens can also be useful (White and Garrott 1990). Differences in movement patterns between marten using undisturbed and fragmented landscapes can provide insight into the flexibility of marten habitat use. Distances moved by individual marten provide estimates of the ability of the species to recolonize areas from which they have been extirpated.

During 1989-1992, we captured and fitted marten with radio-transmitters in the Big Hole and West Yellowstone study areas. We used locations from these animals to determine differences in home range size between study areas, between males and females, and among individuals with home ranges with different habitat configurations. We calculated movement distances and identified areas which appeared to represent barriers and areas which facilitated movement.

Methods

Marten were captured using 20 cm x 20 cm x 50 cm single-door live traps (Photo 2.1) (Tomahawk Live Trap Co., Tomahawk, WI). We trapped during September through March of 1989-1990, 1990-1991, and 1991-1992. Traps were placed in areas we identified as likely marten travel corridors (strips of uncut trees between clearcuts, undisturbed riparian forest) in fragmented habitats. On unlogged sites where marten were known to occur, we simply saturated an area with live-traps. At the micro-site level, traps were placed in slash piles, under deadfall, or at the base of trees. A "cubby set" was constructed around each trap using materials at the site including conifer limbs and snow in an effort to make the set more attractive to marten. The cubbies formed around traps also provided thermal protection for captured animals. Traps were checked at least once every 24 hours via snowmobile, truck, or by foot. Traps were baited with deer (*Odocoileus hemionus*), elk (*Cervus elaphus)* or antelope (*Antilocapra americana)* hides and/or flesh or fish carcasses. Commercial lures were also used to attract marten.

Captured marten were anesthetized with 10 - 40 mg ketamine hydrochloride (100 mg/ml) administered intramuscularly. Time from injection to release was generally under 30 minutes. Immobilized marten were placed back in the trap after processing and held until they displayed behavior similar to that observed before anesthesia. Each marten was equipped with a radio collar (Photo 2.1) (AVM Instrument Co., Livermore, CA and Telonics, Mesa, AZ.).

Marten were located diurnally in each study area between December and May by telemetry and snow tracking. Telemetry locations were obtained by ground searches, ground triangulation, and from fixed wing aircraft (Photo 2.3). Home range sizes for individual marten were calculated using the Adaptive Kernel (AK) method (Worton 1989) and the computer program CALHOME (Kie et al. 1996). Minimum Convex Polygon (MCP) (Mohr 1947) home range estimates were also calculated to allow for comparisons with other studies. We defined the isopleth containing 95% of an animal's locations as the home range boundary. We also computed 30%, 60%, and 90% isopleths (core areas) to compare the distribution of locations within home ranges between study areas. Distances between consecutive locations were used as an index of marten movement.

Home ranges were estimated for marten in the Big Hole study area and in the Flats sub-unit of the West Yellowstone study area. We only calculated home ranges for individuals with ten or more independent locations. Only locations collected during December - May (period of snow cover) were included in analyses.

Results

Adequate (>10) locations were gathered for ten marten (7M:3F) in the Big Hole study area and nine marten (7M:2F) in the Flats sub-unit of the West Yellowstone study area. Most of the 262 locations of individuals in the Big Hole study area and 242 in the Flats study area were collected during periods with snow cover.

Mean winter-spring home range sizes were larger in the Flats sub-unit than in the Big Hole study area (Table 2.1) and larger for males than females. Mean AK home range size (95% isopleth) for males in the Flats study area was 32.5 km^2 (N = 7, SD = 21.5) versus 12.5 km^2 (N = 7, SD = 4.5) in the Big Hole study area. Mean size for females from the Flats study area was 10.8 km^2 (N = 2, SD = 5.1) versus 8.9 km^2 (N = 3, SD = 5.7) in the Big Hole study area.

We were only able to follow one marten, an adult male, for more than one year. During 1991 and 1992 the mean distance between consecutive locations was the same, 2.3 km, and he occupied the same home range during both years.

Dispersal from the Big Hole study area was confirmed by marked marten captured by fur trappers. Marten 823, a juvenile male, was live-captured and marked in the Big Hole study area. He was recaptured in a foothold trap set for coyote (*Canis latrans*) in a sagebrush (*Artemisia* spp.) community 13 km from the point of live-capture. Marten 017, a juvenile male from the Big Hole study area, was marked during late summer 1990 and was killed in a trap in 1992, 34 km north of the site where he was marked. Both individuals may have dispersed from the study area. Neither animal remained in the study area for more than four weeks after their initial capture suggesting that they had not established themselves as residents. We did not identify any dispersal from the West Yellowstone study area, but more than half of the animals we radio collared died, had malfunctioning radios, or disappeared after fewer than ten locations.

Discussion

Ninety-five percent isopleths for winter-spring home ranges in marten we monitored varied from 2.0 to 43.3 km^2 using the MCP method and from 2.5 to 66.1 km^2 using the AK method. Female home ranges were substantially smaller than male ranges using both methods of calculation in both study areas. Marten home ranges monitored in the least disturbed study area, the Big Hole, tended to be smaller than those in the much more highly fragmented Flats study area. Investigators studying marten in northwest Montana (Hawley and Newby 1957) western Wyoming (Buskirk 1983), and northern Maine (Wynne and Sherburne 1984) reported home ranges smaller than those we found. Raine (1982), working in southeastern Manitoba, recorded home ranges for juveniles that were similar to adults in the Big Hole. Home range sizes in western Newfoundland were similar to the large home ranges we calculated for the Flats sub-unit (Bateman 1986).

Buskirk and McDonald (1989) hypothesized that a strong negative relationship existed between home range size and site quality in terrestrial carnivores. In Maine, Soutiere (1979) noted that marten home range size increased in areas with high levels of clear-cutting suggesting that clear-cutting reduced habitat quality for marten. This hypothesis is consistent with our findings (home ranges were generally larger in the forest-grassland mosaic of the Flats sub-unit than in the more contiguous tree cover of the Big Hole study area), but prey availability, another aspect of habitat quality for carnivores, may also affect home range size (Thompson and Colgan 1987). The prey effect can be due to prey density in different habitat types, prey vulnerability, or even to incidental subsidies.

Marten in southwest Montana depend heavily on red-backed voles during periods of snow cover when other small rodents, such as deer mice (*Peromyscus* spp.), are equally or more abundant (Aune and Schladweiler 1997, Coffin et al. 1997). Results from small mammal trapping in representative habitat types in the Big Hole and West Yellowstone study areas (Coffin 1994, Coffin et al. 1997) indicated that red-backed voles were generally more abundant in mature, mesic conifer forests than in xeric or young forests and were rare or absent in clearcuts in both study areas. Mature mesic forests were much more common in the Big Hole than in the West Yellowstone study area, and a much larger percentage of the West Yellowstone area was clearcut. This suggests that the density of preferred prey should have been higher in the Big Hole area than in the West Yellowstone area; therefore, marten would not need home ranges as large in the Big Hole as in West Yellowstone.

Incidental food subsidies had less predictable, but potentially substantial, effects at the level of individual home ranges. For example in 1992, marten 040 was located five times foraging on a moose carcass. This food source was the northern most point of his home range and may have caused a home range extension that would not have occurred had the moose not died where it did.

Marten on both study areas were very mobile and traveled long distances between consecutive locations within their home ranges. Marten on the Flats sub-unit of the West Yellowstone study area routinely moved into remote areas of Yellowstone National Park where we were unable to receive radio signals. The longest movement we documented into Yellowstone was 11 km. Radio contact was usually lost at ranges > 7 km, so the total area used by five marten (205, 521, 080, 140, and 150) we monitored are likely underestimated. Hawley and Newby (1957) documented a dispersal movement of 40 km that also required crossing a large river (North Fork of the Flathead) in northwest Montana. Raine (1982) reported a dispersal of 61 km in southeastern Manitoba. This was nearly twice as long as the maximum dispersal of 34 km we observed. Marten dispersals documented by Hawley and Newby (1957) and by us occurred in contiguous forested habitats. While marten have the ability to travel long distances within contiguous forested habitats it is generally accepted among biologists that marten do not typically cross unforested areas of larger than 5 km (Gibilisco 1994; Hawley and Newby 1957).

Logging roads, groomed snowmobile trails, paved highways and small streams did not impede movements of marten on either study area. Hawley and Newby (1957) found that some home range boundaries coincided with vegetative or topographic features, including large meadows and burns. Most water ways within our study areas could be crossed on fallen logs. However, marten 240 likely swam the Madison River between his last location in the spring of 1991 and the location of his death in December 1991. Koehler and Hornocker (1977) stated that marten avoided meadows and burns in the winter. However, the five marten with home ranges in Yellowstone National Park moved freely through the 1988 North Fork burn to reach unburned patches. This suggests that marten were willing to use crown burned areas, at least as travel routes. Bissonette and Sherburne (1992) found that marten in Yellowstone National Park used surface burns in proportion to their availability.

CHAPTER 3

HABITAT RELATIONSHIPS

Marten have been viewed as a species dependent on climax forest (Soutiere 1979, Buskirk and Powell 1994). However, research in the past decade (Fager 1991, Kujala 1993, Brainerd 1994, Coffin 1994) has shown that while marten prefer mature, but not necessarily climax forests, and may be dependent on mature forests in some seasons (Buskirk et al. 1994, Buskirk and Ruggiero 1994), they use a variety of habitats. Many factors have been identified as potentially responsible for marten dependence and/or preference for mature forests, including prey vulnerability (Coffin et al.1997), prey abundance (Sherbourne and Bisonette 1994), and subnivean access (Buskirk et al. 1989).

We were able to test several of the physical and biological parameters that might influence marten habitat selection in southwest Montana during a 3-year period that encompassed high and low population levels in two disparate landscape types. Information we collected will be useful in assessing the relative importance of these parameters, singly and in combination. Ultimately, we hope our data will be useful in development of timber harvest management plans that minimize impacts to marten populations.

Data were collected in the Big Hole and West Yellowstone study areas (Fig. 1.1). Both study sites included logged areas, regrowth following earlier logging, and uncut habitat. The Big Hole area contained the highest proportion of mesic habitats available to marten in southwest Montana. The Flats sub-unit of the West Yellowstone study area was representative of more xeric habitat. The Beaver Creek sub-unit in the West Yellowstone study area was intermediate in habitat complexity compared to the Big Hole and Flats sub-unit.

Methods

During 1989-1992, ten marten (7 M:3 F) in the Big Hole study area , nine marten (7 M:2 F) in the West Yellowstone Flats study area, and 16 marten (7 M:9 F) in the Beaver Creek area were successfully radio-collared. We defined success as locating an animal one or more times post-capture using radio telemetry. We attempted to locate each radio-collared marten one time per week from November to May. Loss of collars, marten deaths, and the logistics of backcountry travel forced us to deviate from this schedule, but no marten were located more frequently than once per day.

Each location was confirmed by close triangulation (< 50 m), and most involved sightings of the animal or its tracks (Photo 3.1). Plastic flagging was tied to the closest tree or downfall, and the site was revisited the following summer. Habitat measurements collected at random points were used for comparison with habitat measurements at marten locations. Random points were selected using random numbers tables and marked on 1:24,000 U.S.G.S. topographic maps. We used terrain features on the maps to navigate as closely as possible to the points and paced a randomly selected number of steps on a compass bearing to designate the plot center.

We recorded both large and small scale habitat information at random points and marten locations. We selected three large scale variables for comparisons of marten use versus availability at the landscape scale. Two categorical variables, stand structure and logging history, were included to determine if marten distribution within forested habitat types could be easily identified using simple structural features or site history. A third categorical variable, habitat type, identified climax plant communities based on the system developed by Pfister et al. (1977) (Table 3.1).

Small scale habitat use patterns were delineated based on characteristics measured in variable plots, 11.4-m radius (408.3 m^2) plots, and 2-m radius (12.6 m^2) plots centered on marten locations and on randomly selected points. We used standard USFS timber inventory methods (USDA 1985) for habitat measurements whenever possible. Tree species, diameter at breast height (dbh), and tree height were measured for each tree $\geq$ 12.7 cm dbh, in a variable radius plot. The variable radius plot technique is designed to insure that a minimum number of mature trees (6 or more) are sampled at individual sites to develop standardized estimates of tree basal area and density across a wide array of tree densities (Daniel et al. 1979) We used a 20 basal-area-factor (BAF) angle gauge, the sampling device most commonly used by Forest Service personnel in the forest types in our study areas, to identify specific trees included in each variable radius plot. Maximum tree ages were determined by coring the largest tree of every species in the plot (Kujala 1993).

Canopy cover estimates were obtained using a densiometer at four points within 11.4-m radius plots. Tall shrub and immature tree (< 12.7 cm dbh) densities were calculated from stem counts in 11-m radius plots. Percent ground coverage in four categories (bare ground, herbaceous plants, shrubs and trees < 2 m in height, and downfall) was estimated in 2-m radius plots.

Large downfall density was estimated using methods described by Brown (1974). One 8.2- m transect was run on an easterly bearing from plot center at all marten locations. Intercepts of woody material ≥ 7.6 cm in diameter were recorded to the nearest 2.5 cm diameter at the point of intercept and rated as sound or rotten.

Measurements at marten locations and random points were used to develop 30 variables with continuous, or approximately continuous, distributions (Table 3.2). This set of variables included indices representing forest structure, forest species composition, potential subnivean access, and ground cover characteristics.

Univariate analyses: We tested all variables using two different marten data sets: 1) unbalanced (all radio relocations); and 2) balanced (equal numbers of radio locations per individual). Both data sets were limited to months with snow (November - mid May). The unbalanced set included animals with one to >50 locations. Sites used more than once were included as multiple data points (i.e. sampling with replacement). The balanced data set included locations from seven marten in the Big Hole study area and six in the West Yellowstone study area. Locations in excess of 18 per individual were randomly deleted, and sites with multiple locations were included only once (i.e. sampling without replacement). Comparisons between the two sets allowed us to determine the sensitivity of our results to unequal sample sizes and different sampling strategies.

We chose three large-scale categorical variables for tests: logging history, stand canopy structure, and habitat type. Forested habitat types were consolidated into six habitat groups (Table 3.1) based on similar dominant species and/or structure (Fager 1991, Kujula 1993). This reduced the possibility of significant differences being identified due to small sample effects. Chi-square tests were used to determine if distribution among categories differed between marten locations and random points. Differences between use and availability in individual habitat group categories were tested using Bonferroni confidence intervals (Marcum and Loftsgaarden 1980) .

Values for continuous and ordinal small-scale variables at radio locations were compared with those at random sites using t-tests. We used untransformed data in all tests because our intent was not to emulate a controlled experiment but to develop a screening process to identify variables that were related to marten distribution. All univariate statistical tests were done using the MSUSTAT package (Lund 1989) which employs algorithms based on formulae from Snedecor and Cochran (1967).

Multivariate analyses: Multivariate analyses were based on an approach proposed by Burnham and Anderson (1992). This involved selecting a set of biologically feasible models based on our understanding of marten habitat selection and results from other studies, selecting sets of independent variables appropriate to each model from the variables we measured, and applying logistic regression (Hosmer and Lemeshow 1989) to distinguish marten locations from random sites. The models were ranked by comparing Akaike Information Criterion (AIC) scores (Burnham and Anderson 1992). The model with the lowest AIC score was assumed to be the most parsimonious (i.e. the model had a high predictive ability with the minimum number of independent variables). We calculated R^2 (the proportion of the log-likelihood explained by each model) for all models and concordance (a *post-hoc* comparison of the percentage of observations used to develop models that were classified correctly by the model) for the best models as a means of comparing efficacy of individual models.

Models based on biological hypotheses were compared to a stepup model (Hosmer and Lemeshow 1989) to determine how well these models performed compared to a model determined strictly by statistical criteria. The “best” models (lowest AIC scores and highest biological relevance) for the West Yellowstone Flats and Big Hole study sites were applied to data collected at Beaver Creek to determine how well these models predicted marten locations for a data set that was not used to develop the models.

As with univariate analyses, we tested unbalanced (all radio locations) and balanced (18 locations per individual marten and sampling without replacement) data sets. Of the small-scale variables measured at marten locations and random sites, we identified 30 continuous and two ordinal variables for use in logistic regression. All tests were run using the SAS package (SAS Institute 1994).

Results

Univariate tests: Although distribution of samples among canopy structure classes varied between marten locations and random points ($X^2 > 12.0$, $\underline{P} < 0.05$ for all radio locations versus random locations in the West Yellowstone Flats and Big Hole study sites), >80% of marten locations and random points were in the “uneven aged canopy” class (Fig. 3.1). The distribution of marten locations and random points among logging history classes was also concentrated in one class, “no logging” (Fig. 3.2). This was partially due to our sampling design. We concentrated our trapping efforts in unlogged areas where we had evidence, tracks or information on fur-trapping, of marten presence and sampled habitat in areas surrounding captured marten. Marten however, were located more frequently in historically logged stands than were random points, significantly so in comparisons using all marten locations in the West Yellowstone Flats sub-unit ($X^2 = 16.37$, $\underline{P} < 0.01$), balanced marten locations in the Big Hole study area ($X^2 = 9.72$, $\underline{P} < 0.01$), and all ($X^2 = 8.16$, $\underline{P} = 0.02$) and balanced ($X^2 = 10.59$, $\underline{P} < 0.01$) marten locations in the lightly sampled Beaver Creek sub-unit.

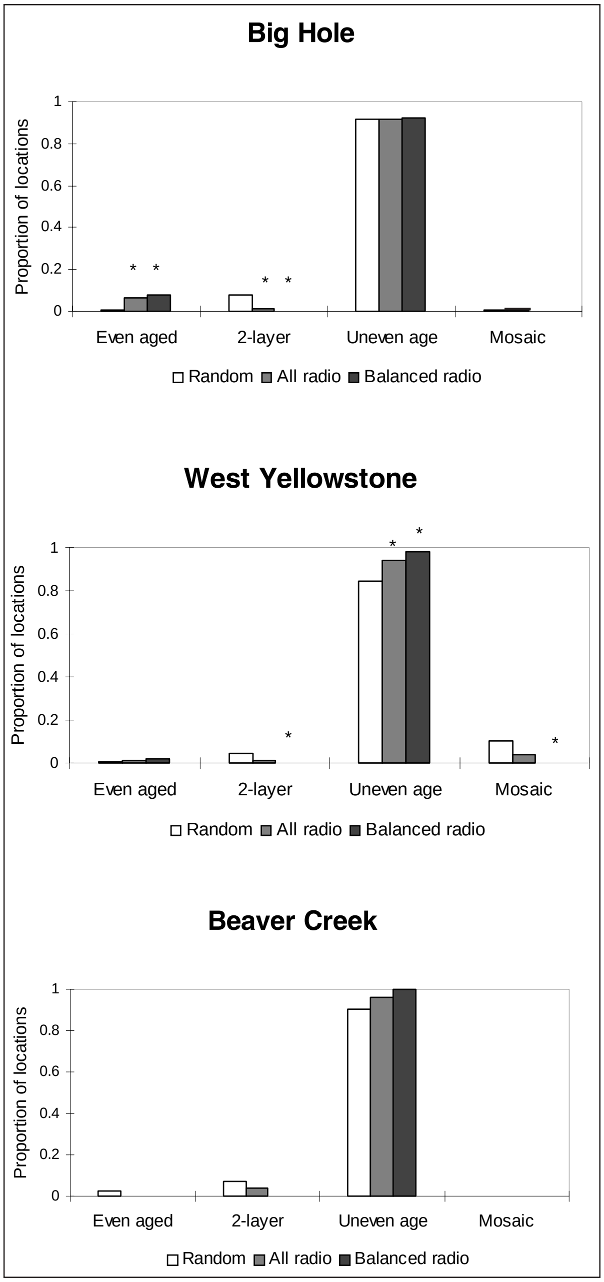
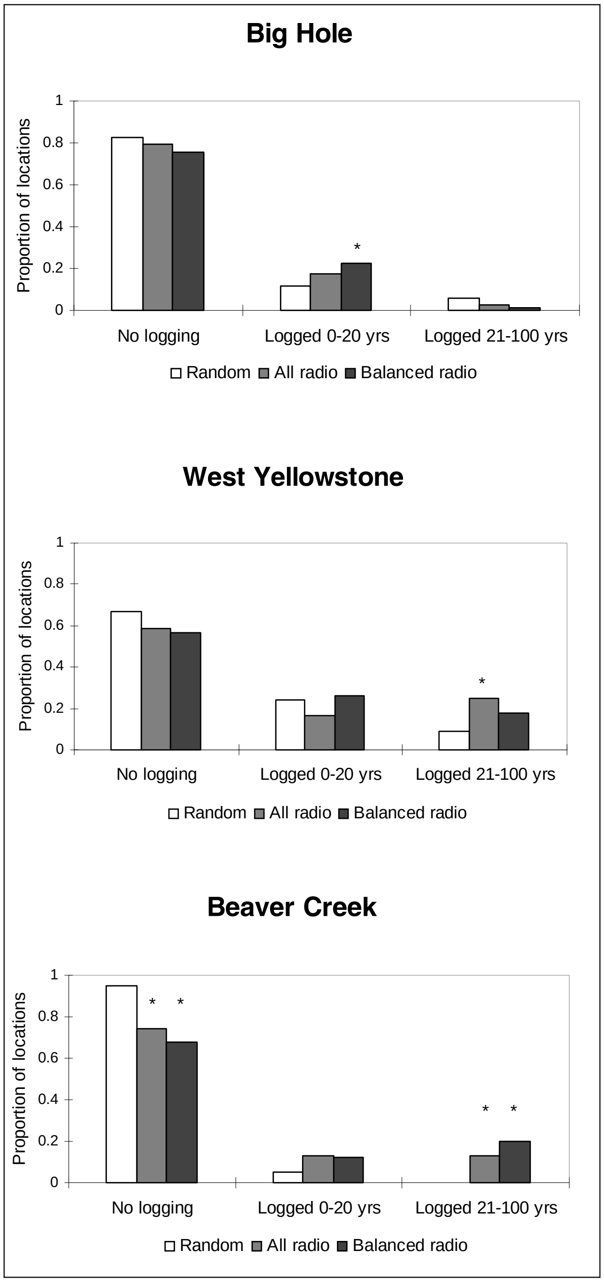


Figure 3.1. Proportion of random relocations, marten radio locations, and balanced radio locations in forest structure classes in the Big Hole, West Yellowstone Flats, and Beaver Creek study areas. Asterisks indicate use by martens differed significantly from availability (Bonferroni Z, P < 0.05).

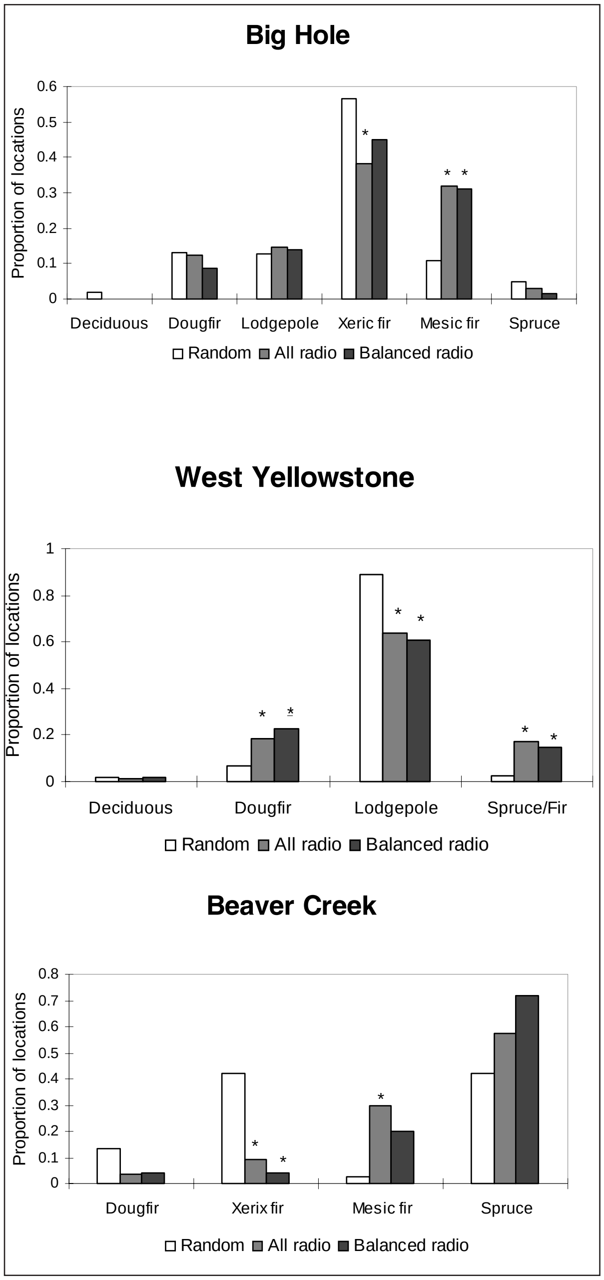
Marten locations and random points were recorded in more than 40 different forested habitat types over the three study areas (Table 3.3). When we examined use versus availability in the coniferous forest classes formed by consolidation of related habitat types (Fig. 3.3), use differed from availability at all sites and with comparisons of balanced and unbalanced radio relocation sets ($X^2 \geq 16.7$; all $\underline{P} < 0.01$). Two


Big Hole

West Yellowstone

Beaver Creek

Figure 3.2. Proportion of random relocations, marten radio locations, and balanced radio locations in logging status classes in the Big Hole, West Yellowstone Flats, and Beaver Creek study areas. Asterisks indicate use by martens differed significantly from availability (Bonferroni Z, P < 0.05).


Big Hole

West Yellowstone

Beaver Creek

Figure 3.3. Proportion of random relocations, marten radio locations, and balanced radio locations in habitat groups in the Big Hole, West Yellowstone Flats, and Beaver Creek study areas. Asterisks indicate use by martens differed significantly from availability (Bonferroni Z, P < 0.05).

patterns were obvious in the data set: 1) estimates of use developed from all radio locations were very similar to estimates based on balanced locations (X^2 for tests of balanced versus unbalanced data sets in the Big Hole, West Yellowstone Flats, and Beaver Creek study sites were 2.68, 0.99, and 1.81, respectively; $\underline{P} \geq 0.40$); and 2) marten appeared to select for the most mesic, structurally complex forest communities available at each study site. Mesic subalpine fir sites were used in greater than proportionate availability at the Big Hole and Beaver Creek study sites. Douglas-fir and spruce/subalpine fir types were selected disproportionately in the West Yellowstone Flats area.

For continuous variables, means based on all radio relocations were not significantly different ($\underline{P} > 0.05$) from those based on balanced sets of radio locations in 100% of tests for the West

Yellowstone and Beaver Creek samples and 97% of the tests from the Big Hole study site. Therefore, we used the larger data sets, unbalanced sets which included all radio locations, to compare with means from random points.

Only three variables (forest canopy cover, the percentage of trees in variable plots made up of spruce, and the percentage of ground covered by woody debris) had significantly higher mean values for radio locations than for random points at all three study sites (Table 3.4). Only one variable, percent of trees in variable plots comprised of lodgepole pine, had significantly lower mean values for radio locations than for random points in all three study sites. For the two study sites with >200 radio locations, the Big Hole and West Yellowstone Flats, means at radio locations were greater than means for random points for seven additional variables (mean dbh of all trees in variable plots, variability in dbh, number of trees in variable plots with dbh >12.7 cm, number of live trees in variable plots with dbh >12.7 cm, number of subalpine fir > 12.7 cm dbh in variable plots, mean tree height, and percentage of the ground stratum covered by herbaceous vegetation). No additional means for radio locations were significantly lower than means for random points at both sites.

All significant differences between radio locations and random points involved means that differed by $\geq$10%. Means for random points were not statistically different from means for all radio locations in 33%, 27%, and 53% of tests for the Big Hole, West Yellowstone Flats, and Beaver Creek study sites, respectively. The larger proportion of non-significant tests at Beaver Creek was likely an artifact of the smaller sample sizes for both random points and radio locations at this study site.

Multivariate tests: We selected subsets of the ordinal and continuous variables analyzed individually to develop 10 multivariate models based on hypotheses about how marten might select habitat (Table 3.4). All 32 variables were included in a stepup procedure ($\underline{P} < 0.05$ for entry) to create a "biology free" model for comparison with those based on our knowledge of marten biology.

The most complex of the biologically based models tested, Model 1 (Table 3.4), produced the lowest AIC score for unbalanced (all radio locations) and balanced (18 locations per radio-collared marten) data sets in the Big Hole and West Yellowstone study sites. The "fit" (R^2) of this model varied from 0.44 (Big Hole unbalanced data) to 0.60 (West Yellowstone Flats balanced data). Concordance (correct *post hoc* classification of marten locations and random points) was >90% for both study sites. This model included information on site history, canopy coverage and structure; a categorical logging index; information on size, density, and variability in size of trees and deadfall; and information on ground coverage. It did not include information on habitat types, individual tree species, or physiographic (slope, aspect, terrain form, elevations, etc.) factors. It did not perform quite as well as the statistically based stepup model (Tables 3.5 and 3.6).

The logit (denominator in the probability function for predicting whether a site was a marten location) of Model 1 and the stepup model (Tables 3.7 and 3.8) differed between sites and between the unbalanced and balanced data sets. The contributions of most individual variables in Model 1 to prediction of marten presence were small (Wald X^2 tests, $\underline{P} > 0.05$), but canopy cover and percent of ground covered by deadfall were positively related (Wald X^2 tests, $\underline{P} < 0.05$) to marten presence and snag density was negatively related to marten presence in both study areas and for data sets with all radio locations and balanced radio locations. These variables were also significant, and logits retained the same signs, in stepup models for both marten location data sets and both study areas. Bare ground was negatively related to marten presence in both radio location sets and both models (Model 1 and the stepup model) in the West Yellowstone Flats. It was also consistently significant in the Big Hole study area, but the exponent had a negative sign for the unbalanced data set and a positive sign for the balanced set in Model 1 and the stepup model.

Several other variables produced significant Wald X^2 values in one or more models but not in all models for all sites. In the Big Hole study area, predictions were significantly influenced by mean tree diameter (positive in the unbalanced set in both Model 1 and the stepup model), herbaceous ground cover (positive in the balanced set in both models), and relative abundance of spruce (stepup model for balanced data set). At the West Yellowstone Flats study site, marten locations were negatively associated with the number of deadfall intercepts (both data sets in both models), mean tree diameter (unbalanced set in both models; balanced set in Model 1), and density of living trees (both models for the unbalanced data set). Variables with significant positive exponents for the West Yellowstone Flats included: variability in tree diameter (stepup model used with balanced data set), low shrub cover (Model 1 for both data sets and the stepup model used with the balanced data set), and herbaceous ground cover (both models for the unbalanced data set).

These results and results from the univariate tests suggested that a logistic model based on canopy coverage, deadfall, tree size, and an index to ground coverage of vegetation might be optimal for identifying sites likely to be used by martens during winter. Our initial model (Model 7) that included characteristics related to these variables (i.e. marten were hypothesized to select habitat based on a combination of tree physical structure, deadfall availability, and ground coverage) did not rank close to Model 1 in efficiency as indexed by AIC scores, but our subsequent analyses indicated we may have selected inappropriate variables for inclusion in Model 7. As a test, we developed a new model based on the same hypothesis, pooled all locations from the Big Hole and West Yellowstone Flats study sites, used these data to develop a logistic regression, and applied the regression to radio locations from Beaver Creek. Simply stated, the revised model was:

Marten presence = canopy coverage [positive % canopy] + tree size [positive diameter of largest tree at a site] + deadfall availability [positive % ground coverage by deadfall] + bare ground [negative % bare ground].

This model did not perform as well as Model 1 in the unbalanced data set or the balanced data set (Table 3.9), but it had moderate explanatory value in separating marten locations from random locations using both data sets. The 4-variable model accounted for 44% of the log-likelihood in the balanced data set and 40% in the unbalanced data set. When we applied the logits for Model 1 (18 variables) and the *post hoc* 4-variable model developed from the pooled data from the Big Hole and West Yellowstone Flats study sites to marten locations and random sites collected at Beaver Creek, both models performed well in classifying marten locations (Table 3.10) but only moderately well in classifying random locations.

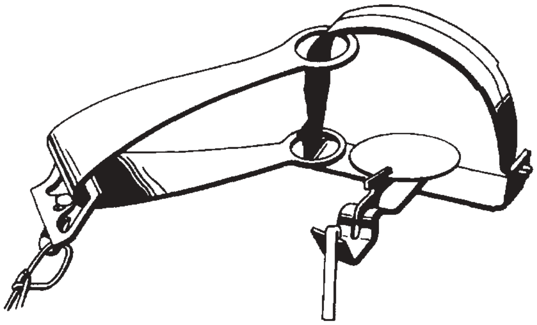
Discussion

Analyses of categorical variables suggested that the most mesic and structurally complex types available to marten were selected during winter in our study areas. Analysis of individual small scale variables supported this pattern. Canopy cover, tree diameter, variability in tree diameter, and variability in tree heights in plots all were significantly greater at marten locations than at random points in the Big Hole and West Yellowstone Flats study areas. All of these traits would be expected to be greater in mature, mesic forests than in xeric or early succession forests (Mannan et al. 1994).

Ground coverage of deadfall was greater at marten locations than at random points. This is an indication of a mature forest (i.e. sufficient time for woody material to grow, die, and drop to the forest floor), but it also suggests a preference for sites which provide easy access through winter snow cover. The high ground cover of herbaceous plants at marten locations compared to random points might not be expected if martens are selecting for areas with high canopy cover provided by large trees, but it is logical when probable small mammal densities are considered. Marten feed heavily on rodent species which feed on herbaceous vegetation on the forest floor (Aune and Schladweiler 1997, Coffin et al. 1997). These rodents should be more abundant where herbaceous vegetation is abundant.

The results of the logistic regression analysis demonstrated what many marten researchers (Buskirk and Powell 1994, Brainerd et al. 1994, Coffin et al. 1997) already realize: marten do not make decisions on habitat selection based on single variables. During winter in southwest Montana, marten were not climax forest obligates, but they did select forests with high canopy cover. Within these forests, they tended to use sites with large live trees, abundant deadfall, and well developed vegetation in the ground stratum (Photo 3.2). In areas where one or more of these factors were deficient, marten tended to seek sites that included higher than average values for the deficient variable (Photo 1.3). In areas, where this desirable habitat configuration was widely available, marten were less likely to show selection for sites with higher than average abundance. Canopy fires tended to eliminate all four factors, at least in the short term (Photo 3.3).

The consistently good performance of the most complex model we tested suggests that more subtle habitat selection may be occurring, but a simple, 4-variable model was adequate to distinguish between marten locations and random sites with a high degree of consistency across disparate habitat types. In southwest Montana, a site with well developed canopy coverage of mid-seral to climax coniferous forest with moderate to abundant deadfall of >10 cm (>4 in) diameter and moderate (>30%) ground coverage by herbaceous vegetation in any common coniferous forest community should be suitable habitat for marten during periods of snow cover.



CHAPTER 4

POPULATION CHARACTERISTICS

Home range, movements, and habitat use provide useful information about marten ecology, but knowledge of population dynamics is required to determine if a population is successful. Marten populations are difficult to monitor (Buskirk and Ruggiero 1994). Marten typically have low population densities; they are relatively small and very inconspicuous; and they live in habitats that limit their visibility to biologists trying to monitor them (Strickland et al. 1982). Zelinski and Kucera (1995) published a comprehensive guide to monitoring marten populations after our fieldwork was completed. Although we did not have access to their publication when we designed our study, we used several of the approaches they recommended.

Marten we captured and marked for our home range and habitat use investigations provided us with an opportunity to use mark-recapture models (Lancia et al. 1994) to estimate population size. Martens that we captured and martens harvested by fur trappers in our study areas allowed us to monitor population age and sex structure and to compare results from population indices based on catch-per-unit effort and total harvest with mark-recapture models. We also tested track intercept transects (Thompson et al. 1989) against result from mark-recapture models.

Photo 1.1. American Marten in Southwest Montana.

Photo 1.2. Big Hole study area depicting characteristic vegetation composition and topography.

Photo 1.3. West Yellowstone Flats sub-unit depicting characteristic vegetation composition and topogrphy.

Photo 1.4. Beaver Creek study area depicting characteristic vegetation composition and topography.

Photo 2.1. Marten captured in Tomahawk Live-trap.

Photo 2.2. Radio-transmitter being attached to study animal.

Photo 2.3. Researchers radio-tracking study animals by ground triangulation.

Photo 3.1. Characteristic marten track trail pattern in winter.

Photo 3.2. View representing "Good" quality marten habitat (note large trees, well-developed canopy cover, large diameter deadfall, and abundant herbaceous ground cover).

Photo 3.3. View representing "Poor" quality marten habitat (note minimal canopy cover, small diameter deadfall, and absence of herbaceous ground cover).

Photo 4.1. Captured study animal after radio-collar attached and physical characteristics assessed prior to release from live-trap.

Photo 4.2. Trapper harvested marten.

Photo 5.1. Season's catch of prime marten pelts.

Our objectives were:

1) to evaluate consistency among approaches to monitoring population structure and density.

2) to determine variability in population parameters among winters and among study sites in southwest Montana.

3) to determine if marten populations in southwest Montana fell within parameters described for self-sustaining marten populations in other regions of North America.

Methods

Age and sex structure: Live-trapping and harvest provided information on age and sex structure of marten in our study areas. Live-trapping procedures are described in Chapter 2. Each captured animal (Photo 4.1) was examined to determine sex, and trapped animals were classified as either juveniles or adults based on sagittal crest examination (Marshall 1951) and canine wear.

Fur trappers in the study areas were asked to provide the location, date of harvest, and sex for all marten they harvested. Trappers were also required to submit marten carcasses to the MFWP State Wildlife Laboratory where carcasses were examined for secondary sexual characters and aged through measurements of tooth pulp cavity size and/or tooth cemental annuli counts (Aune and Schladweiler 1997). We obtained age and sex information on most marten harvested in our study areas from trappers or the MFWP State Wildlife Laboratory. Carcasses of animals harvested in the Beaver Creek sub-unit of the West Yellowstone study area in the 1990-1991 and 1991-1992 trapping seasons were mixed with carcasses trapped in an adjacent drainage (Teepee Creek). We were unable to separate the locations of these carcasses unambiguously so age and sex structure data for the 1990-1991 and 1991-1992 seasons in the Beaver Creek sub-unit represents combined data from Beaver Creek and Teepee Creek. Differences between years and study sites for both live-trapped and harvested animals were analyzed using chi-square tests.

Population density, harvest rate, and indices of abundance: All live-trapped marten were marked with numbered eartags prior to release. Marked animals captured by fur trappers enabled us to calculate population estimates for individual study areas and years using the Lincoln - Petersen mark-recapture model (Lancia et al. 1994). Population estimates were based only on animals captured and marked prior to the beginning of the fur trapping season in each year. We converted population estimates to estimates of density (marten/km^2) by dividing population estimates by the size of each study site.

Harvest rates were calculated for study sites and years in which we had eartagged marten and active fur trapping. Harvest rates were calculated by dividing the number of marked individuals harvested by the total number of marked animals in the study site.

Information on numbers of marten captured and trap-nights (number of traps set multiplied by the number of nights each trap was set) required to capture them was available for all our live-trapping efforts and for most of the fur trappers in our study areas. We used these data to calculate indices of marten abundance based on trapping effort and/or success. Separate indices were calculated for live-trapping and harvest trapping, and indices affected by study area size were standardized by dividing calculated values by the size of individual study areas. Trap-nights per km^2, the total number of trap-nights recorded in a study site in each year divided by study area size, was an index of the effort invested in capturing marten for marking (live-trapping) or for fur. Trap-nights per capture was a measure of trapping efficiency or the net return on trapping effort for live-trapping and harvest. Total captures per km^2 represented the gross return on the investment in time and equipment that trappers made in each study site and, for data collected from live-trapping efforts, served as an estimate of minimum population density. Because of logistical problems and decisions by trappers not to trap in some years, we were unable to obtain estimates for all indices in all study sites in all years of the study.

We used counts of tracks on transects as another index of marten abundance. Thirteen 1-km track transects were established in three of the study sites (5 in the Big Hole, 4 in the West Yellowstone Flats, and 4 in Beaver Creek) in 1989 and monitored by methods described by Thompson et al. (1989) for the three winters of the study. Each transect was examined 12-96 hours after a snowfall that was likely to have covered existing tracks. We repeated transects from December through March of each winter. The mean number of marten track-sets intersecting each transect divided by the length of each transect was used as an index of population density.

We compared population density and indices of abundance using a correlation matrix. There were only six sample points for which values were available for all indices based on trapping (data from the Big Hole in 1989-1990, the West Yellowstone Flats in 1989-1990, Beaver Creek in all three winters, and Mosquito Gulch in 1991-1992). We chose a slightly different set of sample points for examining associations between trapping indices and track transects (data from the Big Hole in 1989-1990, the West Yellowstone Flats in 1989-1990 and 1990-1991, and Beaver Creek in all three winters). This data set was the largest we could achieve (6 sample points) within our data array, but it did preclude some comparisons. Because all associations in our matrix were based on small sample sizes, we did not attempt to calculate statistical significance. Instead, we assumed correlation coefficients ≥ 0.75 (i.e. $\geq 56\%$ of the variation was explained by the association) indicated that the associations between variables were of sufficient interest to note and should be worth investigation in future studies.

Results

Age and sex structure: Ninety-two individual martens were captured in live-traps during the study. When samples from individual study sites were summed over three years, age ratios (Table 4.1) of marten in live-trapped samples did not statistically differ among study sites ($X^2 = 3.6$, df = 1, $\underline{P} = 0.16$). Over three years, equal numbers of adults and juveniles were captured in the Big Hole study area while captures of adults on the West Yellowstone Flats and Beaver Creek sub-units exceeded those of juveniles.

Over all samples, sex ratios (male:female) of live-trapped marten did not differ among study areas ($X^2 = 1.9$, df = 1, $\underline{P} = 0.38$) (Table 4.1). For summed samples over three years, nearly equal numbers of males and females were captured in the Big Hole and Beaver Creek study sites (Table 4.1). The largest deviation from a 1:1 ratio for a 3-year period was recorded in the West Yellowstone Flats sub-unit where live-trapped males outnumbered females 2.5:1.

Marten were harvested in the Big Hole study area only during 1989-1990. Trappers harvested 50% more individuals than we live-trapped (9 versus 6). Samples from harvested animals were skewed towards adults and males compared to live-trapped samples (Table 4.1).

In the West Yellowstone study area, trappers harvested marten in the Flats sub-unit in 1989-1990 and 1990-1991, but data on sex and age of harvested animals were only available for 1990-1991. Compared to 1990-1991 live-trapped samples, trappers took 28% fewer individuals (5 versus 7). Harvest was skewed towards juveniles and males compared to the live-trapped sample (Table 4.1).

Marten were harvested in the Beaver Creek sub-unit of in all three years of our study. We live-trapped more marten than were harvested in 1989-1990 but fewer than were harvested in 1990-1991 and 1991-1992 (Table 4.1).

For the total samples over three years, harvests were skewed towards adults compared to live-trapping. Sex ratios in harvest and live-trapping samples were similar and close to 1:1.

We had information on harvests in the Mosquito Gulch sub-unit for 1990-1991 and 1991-1992, but we only live-trapped the drainage in 1991-1992. When we compared age and gender of the three animals we live-trapped to 27 harvested in 1991-1992, harvested animals had a similar age structure, but the sex ratio was skewed towards males (Table 4.1).

Population density, harvest rate, and indices of abundance: We were able to use marked animals and recaptures of marked animals by trappers to obtain density estimates for the Big Hole study area in 1989-1990, the West Yellowstone Flats sub-unit during 1989-1990 and 1991-1992, the Beaver Creek sub-unit during all three years, and the Mosquito Gulch sub-unit in 1991-1992 (Table 4.2). The highest pre-trapping season density was recorded for Beaver Creek in 1991-1992 (1.19 marten/km^2), and the lowest was for the West Yellowstone Flats in 1989-1990 (0.06 marten/km^2). We were only able to calculate density estimates in more than one year for two study sites. Density estimates increased over three winters for the Beaver Creek study site and two winters for the West Yellowstone Flats study site.

Estimated percent harvest, based on the proportion of animals marked prior to the trapping season that were harvested, varied from 12% (Big Hole 1989-1990) to 100% (West Yellowstone Flats 1989-1990). All sub-units in the West Yellowstone study area had average estimated harvest rates exceeding 50%.

Indices of abundance based on live-trapping were not uniformly consistent with indices based on fur trapping. We live-trapped marten in the Big Hole study area during three winters, but marten were harvested in the study area only during 1989-1990. Two trappers who traditionally trapped our study area ran their lines from snow machines. They did not trap in 1990-1991 or 1991-1992 because of what they perceived as low fur prices and high costs for fuel. In 1989-1990, we were more efficient in trapping than were fur-trappers (75 trap-nights per live-trapped marten versus 188 trap-nights per harvested marten), but captures per km^2 was similar between live-traps and foothold traps (Table 4.3). Differences in live-trapping efficiency among winters approached significance ($X^2 = 5.3$, df = 1, $\underline{P} = 0.07$). Efficiency in 1990-1991 was less than half of that in 1991-1992, but the number of captures per km^2 remained relatively constant through the three winters.

Up to four trappers per year ran lines using snow machines on the Flats sub-unit of the West Yellowstone study area in 1989-1990 and 1990-1991. No trappers were active in 1991-1992. We were less efficient than trappers in 1989-1990. We were unable to determine the number of trap-nights devoted to harvest in 1990-1991. Live-trapping efficiency varied among years ($X^2 = 14.8$, df = 1, $\underline{P} < 0.01$) while the number of marten live-trapped per km^2 remained relatively constant over the three winters. Our efficiency in live-trapping (trap-nights/marten) increased through the study, but average live-trapping efficiency (mean of 3 winters) was lower in the Flats sub-unit than any other study site (Table 4.3). The Flats sub-unit (lowest) and the Beaver Creek sub-unit (highest) contributed most to the observed difference in efficiency among study sites ($X^2 = 40.1$, df = 1, $\underline{P} < 0.001$).

The Beaver Creek sub-unit of the West Yellowstone study area was the only study site in which data were available for live-trapping and harvest efficiencies during all years of the study. Marten were harvested by one trapper during the first year of the study and by two trappers during the 1990-1991 and 1991-92 seasons. One individual trapped using vehicles (truck or snow machine) along 8 km of road that bisected the study area. Another trapper skied an 8 km loop starting at the end of the Beaver Creek road. Marten harvests in Beaver Creek increased each year with 48 marten harvested over three seasons. This site required, on average, fewer live trap-nights to capture a marten than any other study site. Our live-trapping was more efficient than trapping for harvest in all three years, but trends in efficiency were inversely related (Table 4.3). We required an increasing number of nights per capture through the study ($X^2 = 24.9$, df = 1, $\underline{P} < 0.01$) while trap-nights per harvested marten declined. Captures per km^2 followed a similar pattern.

In the Mosquito Gulch sub-unit of the West Yellowstone study area, we had complete data for harvest and live-trapping efficiency only for 1991-1992. One trapper was active in Mosquito Gulch in 1991-1992. He ran a 48 km trap-line from a snow machine and set approximately two traps per linear kilometer to harvest 27 marten.We did not live-trap as intensively, but we required fewer trap-nights to capture a marten than he did (Table 4.3).

Track counts from 1 km track transects indicated marten densities were highest in Beaver Creek followed by the Big Hole and West Yellowstone Flats study sites (Table 4.4). Track counts fluctuated within and among years. Highest mean densities were recorded in 1989-1990 in the Big Hole study area and in 1990-1991 in the Flats and Beaver Creek sub-units of the West Yellowstone study area.

A matrix of correlations between density estimates and indices of abundance based on trapping and track counts (Table 4.5) yielded five correlation coefficients ≥ 0.75 (Table 4.5). The only index strongly associated with estimates of density based on mark-recapture models was the number of marten harvested per km^2 ($r = +0.77$). Minimum density and live-trap nights per km^2 were positively associated ($r = +0.92$) with trap-nights per harvested marten. Live-trap nights per capture was positively associated ($r = +0.93$) with live-trap nights per km^2, and harvest trap-nights per km^2 was positively associated ($r = +0.89$) with the number of marten harvested per km^2. Correlations between track counts and all other indices were weak ($r < 0.50$).

Discussion

Sex and age ratios: Population indices based on age and sex ratios are appealing because they do not demand knowledge of actual numbers or density, and they can be developed from data provided by fur trappers, if trappers are required to give the information. The absolute values for age and sex ratios we recorded are less important than their position in a continuum of published values that indicate low to high quality population characteristics in other areas.

Juveniles (< 1.5 years of age) made up 50% or more of the harvest we recorded except in the Big Hole study area during the 1989-1990 season and in the Mosquito Gulch sub-unit of the West Yellowstone study area in1991-1992. Juveniles made up approximately 50% of the captures we made in live-traps in the Big Hole study area but only one-third of the live captures we made in the West Yellowstone study area. We cannot explain why juvenile marten were more vulnerable to capture in foothold traps than box traps in the West Yellowstone area, but juveniles are assumed to be more vulnerable to trapping in general, than adults (Strickland et al. 1982). Juveniles have not established home ranges and tend to wander more than adults, making them more likely than adults to encounter traps. Lack of experience may also make them more susceptible (Strickland and Douglas 1987).

Quick (1956) considered juveniles to be more abundant than any other age class and believed they could sustain the brunt of trapping pressure. Strickland et al. (1982) estimated ages for 1,300 marten caught by trappers from 1973 to 1978. Approximately 60% were less than 12 months of age, and most juvenile marten were harvested early in the season. They suggest that an early trapping season can be used as a management method to select for young, non-breeding animals. If fur quality is considered, the earliest trapping season feasible in southwest Montana would be November - December.

Juvenile to female ratios in harvests are more likely to provide information on population status than juvenile to adult ratios (Strickland et al. 1982). The ratios of harvested juveniles to adult females ($\geq$ 1.5 years old) ratios in our study ranged from 1:1 to 5:1. Strickland and Douglas (1987) believed that as long as the ratio in the harvest was more than three juveniles to one adult female $\geq$ 1.5 years old, harvest levels were acceptable for populations of marten in Ontario.

A better indicator of population status (Strickland and Douglas 1987), ratios of juveniles to breeding females (females $\geq$ 2.5 years) was calculated for a sub-sample of animals harvested during our study (Coffin, unpubl.). Values in the Big Hole and West Yellowstone study areas ranged from 2.7:1 to 10:1. This suggested that harvest in our study areas during 1989-1992 was within limits that, at least in Ontario, marten populations could withstand.

Proportions of juveniles harvested throughout Montana showed a marked decrease during the 1991-1992 trapping season compared to 1989-1990 and 1990-1991 (Aune and Schladweiler 1997). We detected this trend in our study areas. Juveniles in the 1991-1992 harvest dropped by 17% in the Beaver Creek area and by 30% on the Mosquito Gulch site from the previous year. Weckwerth and Hawley (1962) demonstrated that abundance and composition of marten populations in northwest Montana was directly associated with the abundance of small mammals. Data on small mammal densities at our study sites (Kujala 1993, Coffin 1994) were too variable to determine if a decline in small mammal numbers was the cause for the decreased harvest of juveniles we observed during 1991-1992.

Male to female ratios in overall samples of live-trapped animals were $\geq$1.0 in all study sites except for the small sample from Mosquito Gulch. When samples from all years were summed, male to female ratios in harvests from all study sites were $\geq$1.0. Sex ratios from live-trapped and harvested animals in individual study areas were within ranges reported for marten harvested throughout southwest Montana from 1987 to 1992 (Aune and Schladweiler 1997).

Strickland and Douglas (1987) suggested that sex ratio can be used to evaluate harvest intensity. They based this assumption on differences in behavior between male and female marten. While sex ratios of marten at birth are about 1:1 (Yeager 1950), males are consistently found more frequently in trapped samples (Yeager 1950, de Vos 1951, Quick 1956, Archibald and Jessup 1984). Yeager (1950) felt the wide foraging habits of male increased their chances of finding sets and of being removed from the population relative to females. A preponderance of females in a harvest would suggest that a large percentage of males had been removed and that trapping intensity was high enough to take out many resident females.

Strickland and Douglas (1987) did not consider sex ratios as good an indicator of harvest intensity as the ratio of juveniles to females because sex ratios in a population may vary with food abundance as well as with harvest, but they noted a threshold ratio, $\leq$1.0 males per female, as a possible indicator of over-harvest. Assuming our study occurred during a period with a relatively stable overall food base, sex ratios in the harvest in our study sites, mostly >1.0 males per female, indicated a sustainable harvest.

Population density: Our second approach to assessing the status of populations in our study sites was use of mark-recapture models to determine pre-trapping season density. Low sample sizes precluded use of sophisticated mark-recapture models so our estimates were based on the simplest model available. For sites and years where harvest, the mechanism we relied on for recapture of marked animals, occurred, the Beaver Creek sub-unit of the West Yellowstone study area had the highest estimated density, 1.19 marten/km^2 in 1991-1992, and the Flats sub-unit had the lowest estimated population density, 0.06 marten/km^2 in 1989-1990. Densities in other studies reported by Strickland et al. (1982) varied from 0.4 to 1.9 marten per km^2, but variation in habitat type, access to trapping, seasons when estimates were made, the manner in which transients and juveniles were counted, and the models used to derive density estimates in these studies made comparisons with our study sites difficult.

The most consistent data we had for comparison with other studies were density estimates based solely on numbers of live-trapped marten. This index was available for our three primary study areas in all winters of our study. It provides conservative estimates (minimum numbers of marten per unit area) and has been commonly used to describe marten populations in other areas. Minimum marten densities (live-trapped marten/km^2) in our study areas ranged from 0.09 to 0.38 and were similar or lower than those reported elsewhere. Minimum marten densities in Yellowstone National Park during the same time frame as our study (Bissonette and Sherburne 1992) were estimated to average 0.35 per km^2 on a 10,000 ha study area, much of which was burned two years before the study. This population was not commercially trapped and occupied lodgepole pine habitats similar to the West Yellowstone Flats. Minimum densities in Yellowstone National Park most closely resembled those in the Beaver Creek study area, an area that has been trapped for > 50 years and of which only 6% was clearcut at the time of our study. In northwest Montana, Hawley and Newby (1957) reported minimum marten densities in an unharvested population in Glacier National Park of 0.72 to 1.76 per km^2 during a population high and 0.20 to 0.92 per km^2 when the population was considered low. They believed these numbers were close to estimates of total population density. Archibald and Jessup (1984) reported a minimum density of 0.60 per km^2 in the Yukon Territory, and minimum densities of 0.40 to 2.40 per km^2 were reported by Thompson and Colgan (1987) in Ontario.

Trapping effort and efficiency: Marten are considered highly vulnerable to trapping (Photo 4.2) due to their curiosity, aggressiveness, and high rate of movement through relatively large home ranges (Strickland et al. 1982). This introduces the possibility of tracking population density through harvest or effort required to trap marten (Douglas and Strickland 1987). Because trapping goals may influence the relationship between marten population density and trapping success, we analyzed our live-trapping efforts separately from trapping efforts devoted to harvest.

The amount of effort we put into capturing marten was related to our desire to capture a minimum number of marten in each study area for radio telemetry. This resulted in a high number of trap-nights in areas where we had difficulties in capturing marten. We tended to cease or reduce trapping effort at a study site when our goal for radios was reached and concentrated our efforts on other study sites. Trappers interested in harvesting marten concentrated their efforts in areas where they believed marten densities were highest. This resulted in a strong positive relationship between harvest trap-nights and total marten harvested per km^2.

Over the study, we live-trapped 92 individual marten in 10,844 trap-nights or 118 trap-nights per marten. We were able to document 102 marten harvested in our study sites with an investment of approximately 17,194 trap-nights, 169 trap-nights per harvested marten, during the same period. Our average efficiency with live-traps was much lower than the average for the most efficient live-trapping effort we found in the literature, 58 trap-nights per marten (not including recaptures) for an unexploited population in Glacier National Park (Weckwerth and Hawley 1962) but was less than the average for trappers using foothold traps in our study sites.

The relationships between population density and indices of trapping effort or efficiency can be complex. We found that our live-trapping efficiency varied based on individual experience and tended to become better as our experience increased. Efficiency in harvest was also related to skill, some trappers were more knowledgeable than others, but other factors played a role. The trappers who traditionally set out trap-lines in our Big Hole study site felt that their success rate in 1989-1990 indicated a declining marten population and decided that, with increasing fuel prices and decreasing fur prices, it was no longer worth their time to trap in the area. Trappers in the West Yellowstone Flats sub-unit evidently looked on trapping as another way to enjoy recreation on snow machines and did not respond to fur prices or fuel prices.

Live-captures per km^2 and harvest per km^2 were similar in the Big Hole study area and the Flats sub-unit of the West Yellowstone study area. They differed markedly in the Beaver Creek sub-unit. Over the study, we decreased our effort in this sub-unit because of safety issues related to avalanches while trappers increased their effort and their efficiency. In the Mosquito Gulch sub-unit during 1991-1992, we were able to trap marten very efficiently, but we were only able to spend a limited amount of time in the area and captured only three marten. A trapper was active in this drainage for the entire 1991-1992 trapping season and was able to harvest 27 marten The variation in total captures and captures per km^2 among years and study sites that could be explained by factors unrelated to population density suggests that harvest per km^2 should only be used as an index of population change if motivation for trapping is understood.

Track transects: Thompson et al. (1989) found significant correlations between population estimates based on live-trapping and relative densities calculated from track counts. We established transects in 1989 at three study sites and, because they were accessible to snow machines, we were able to replicate them easily and efficiently. Means from the three winters of our study indicated the highest track densities were in the Beaver Creek drainage, followed by the Big Hole study area and the West Yellowstone Flats sub-unit. Unfortunately, the 1 km transects recommended by Thompson et al. (1989) produced highly variable results within each study area.

Snow conditions were responsible for some of the variability. On the West Yellowstone Flats sub-unit, we were hampered by almost daily snow storms during 1989-1990 and infrequent snowfall during 1991-1992. Another source of variability was the short length of our transects. Our radio-telemetry data indicated that a 1 km transect could fall within the home range of only one individual and might simply reflect the presence or absence of that individual. Our experience with tracking radio-collared marten also indicates that a single marten is capable of multiple road crossings in one activity period and that marten tend to use specific travel routes so that the same animal could cross a transect two or more times per day or several times in consecutive days in the same general area. We attempted to handle this problem by counting multiple tracks within 500 m as a single marten detection, but we were unable to assess how accurate this rule was.

Utility of indices versus density: Although we had no absolute values for marten population sizes in any study area, we were able to compare different techniques using a small set of site, by year, combinations in which all techniques were represented. We assumed that our estimates of density, population density calculated from a Lincoln-Petersen estimator and minimum density based on live-captures, were the techniques most likely to approximate real population parameters. When we compared both estimates of density to indices of abundance based on trapping efficiency, trapping effort, and track counts, we found few strong associations, and the strong associations we did find were often counter-intuitive. Population density was positively associated with the number of marten harvested indicating that more marten were harvested in areas with higher marten densities. To harvest marten in relatively high density populations, trappers evidently put in more trap-nights and had reduced efficiency (higher numbers of trap-nights per harvested marten) compared to areas with lower marten densities. Indices developed from live-trapping efficiency and effort more often reflected our desire to trap a minimum number of marten than marten density. Counts of tracks on transects were not strongly associated with any other indices.

Population status: Estimates of relative marten density among study areas varied substantially depending upon the index used, but most of the indices indicated highest marten densities in the Beaver Creek study site. The single year of data from Mosquito Gulch indicated it also had a relatively high marten density. The Big Hole study area and the West Yellowstone Flats sub-unit generally had lower index values than Beaver Creek, but the relative relationship between the two areas varied depending on methodology. After considering results from all our indices, we concluded that marten populations in our study areas were relatively secure despite high apparent harvest rates in the West Yellowstone study area. Numbers and population structure varied over the three winters, and densities were low compared to some other areas in North America, but each of our areas had sustained trapping pressure for at least 50 years without elimination of marten. The West Yellowstone Flats sub-unit was probably a population sink that depended on immigration from Yellowstone National Park and was likely to support fewer marten than it would have without logging and associated access, but the population did survive despite heavy trapping pressure, major habitat modification, and a dense road/trail network. The Beaver Creek, Big Hole, and Mosquito Gulch sites were less heavily impacted by logging and roads but were accessible to trappers.

The ability of marten populations in our study sites to persist despite apparent heavy harvest was probably facilitated by adjacent protected areas. Each of the study sites abutted on unroaded areas protected as national parks or wilderness areas. Immigration from unroaded areas and decreases in trapping effort when established trappers perceived declines in marten numbers tended to produce an informal negative feedback system that allowed populations to recover.

Societal attitudes towards trapping, costs of trapping, and fur price variability have had and will continue to have unpredictable impacts on this feedback system. Costs of trapping versus fur prices are likely to be a larger consideration for trappers that expect to derive part of their yearly income from furs than for recreational trappers. Therefore, as recreational trapping increases, there should be less feedback between profit and effort. Fur prices are driven by a complicated interaction between fashion, social mores, international treaties, and availability of fur farm-reared animals. We doubt that fur price fluctuations in the normal range are likely to be closely related in a positive or negative sense to marten population densities in Montana although extremely high prices would be expected to spur interest in trapping no matter what populations levels might be.

Monitoring marten in southwest Montana: Live-trapping, fur harvests, and track transects all provide information useful in assessing the "health" of marten populations. Each method has different advantages and disadvantages. Raphael (1994) provides a good review of methods for monitoring populations of marten, and Zielinski and Kucera (1995) describe in detail non-intrusive methods for the detection of marten and other forest carnivores.

Live-trapping has low potential as a general monitoring technique for southwest Montana. It is costly and labor intensive, and the skill of the trapper can have major impacts on live-trapping success. Traps must be checked at least once each day, and large numbers of traps would be required to produce reliable results on a regional scale. Live-trapping can provide accurate information on sex ratios if experienced trappers are employed. Accurate age information is difficult to obtain for live martens without extracting a tooth for radiography and/or cementum analysis. Palpating to determine sagittal crest development and/or determining age on canine wear is a subjective measure and will not permit accurate differentiation between juveniles and animals ≤ 2.5 years old.

Monitoring harvest and/or harvest per unit effort provides information on marten populations without the investment of time and personnel associated with live-trapping. If resource managers can monitor individual trappers or require trappers to turn in marten carcasses, biologists can secure data on sex, age, and fecundity that are also valuable in assessing the status of a marten population. Managers should be aware, however, that harvests do not always reflect true population size (Strickland 1994). Trapping intensity in our study areas was dictated by the accessibility of each area. Trappers can use virtually any trail available and may set traps at substantial distances from marked trails, but most trappers tend to make sets near roads and are less likely to trap areas requiring long off-trail hikes. These tendencies produce heavy trapping pressure in areas with well developed road and snowmobile trail systems and lower pressure in unroaded areas, especially areas that do not allow access by snow machine (i.e. wilderness areas). Fur prices, expenses associated with trapping, and perceptions in the trapping community about the status of marten populations in different areas also may play a role in the amount of effort expended to trap marten.

Track transects potentially allow managers to estimate the relative abundance of marten populations without the need for trapping (Strickland and Douglas 1987, Thompson et al. 1989) or introducing biases associated with baiting animals to trap sets (Raphael 1994).
Track transects also have disadvantages. Results from track transects are very dependent on snow conditions and transect length and sensitive to multiple crossings of a transect by a single animal. Marten densities in our study areas were low compared to densities encountered by Thompson et al. (1989). They recommended 1 km transects, but a transect of 1 km would likely intersect the home range of only one marten in our study areas. We know of no objective means of separating multiple sets of tracks made by a single individual from single track sets made by multiple individuals.

In southwest Montana, an area with low to moderate marten density and a landscape fragmented by natural processes (non-forested valleys separating mountain ranges and extensive forest fires) and human activities (logging), we believe that a combination of replicated track transects, with lengths long enough to encompass several marten home ranges, and mandatory reports from trappers is the best general monitoring system. MFWP has now instituted a monitoring program that incorporates both techniques.

Furbearer snow track surveys have been conducted annually by MFWP personnel on permanently established transects, or routes, in representative marten habitat since 1990. By 2001, routes were distributed throughout marten habitat in Montana (approximately 34,000 mi^2) at an average density of one route per 1,000 mi^2 (1 per 2,590 km^2) of coniferous forest habitat. Survey protocol calls for each route to be replicated three times per winter (3-4 weeks apart) with each replicate completed two to three days following fresh snow. Route lengths are not standardized and vary from 14 to 54 km. Track detection results are calculated as an indices based on the number of tracks/100 miles traveled.Multiple track trails within a 30 meter section are counted as a single track detection. The same survey routes are run each year. Replication has been a problem in some years due to variable weather conditions and time constraints on biologists, but a substantial database on species distribution, relative abundance, and population trend has been developed (B. Giddings, pers. comm.).

MFWP requires trappers to have marten pelts tagged. This has produced a reliable estimate of statewide harvest for more than 40 years. In 1978, MFWP began requiring trappers to register their harvest which includes reporting locations of harvest (drainage) and the gender of harvested animals. For the past 10 years, trappers have been required to turn in skulls of harvested marten for tooth extraction. Age of these individuals is determined by pulp cavity measurements or tooth cementum annuli counts. These data allow MFWP managers to track total harvest, age structure of harvested animals, and sex ratios of harvested animals by drainage, mountain range, or administrative area. Since 1993, MFWP's annual trapper harvest survey has included marten and other registered species. This data provides trapper effort and catch rate which are used to predict population trend based on trapper effort and success.

Absolute values for track densities, harvest numbers, and harvest structure are unlikely to provide much useful information for management. Track counts and trapper returns alone are too vulnerable to perturbations by factors unrelated to marten density, to be totally reliable in all years. As the data set expands, however, managers will be able to pick up deviations from the "normal" variations, that could signal changes in marten population trend. When deviations indicate a downward trend and probable causes are apparent, biologists can recommend actions to correct problems such as restricting harvest levels temporarily. When reasons for trends are unknown, more intensive monitoring can be applied to the local population in question.

CHAPTER 5

CONCLUSIONS

Marten have a reputation of being vulnerable to over-harvest and to the removal of mature forest habitat. We investigated marten populations in two study areas in southwest Montana to determine population characteristics and habitat use patterns in areas experiencing habitat changes due to logging and fire combined with harvest under trapping regulations that did not limit the number of trappers or the number of animals harvested by each trapper (Photo 5.1). Home range sizes, based on movements of radio-collared marten, varied among our study sites with the largest home ranges associated with the highly disturbed, xeric lodgepole pine forests in the Flats sub-unit of the West Yellowstone study area. Home ranges in this study site were larger than most reported in the literature, suggesting that the Flats sub-unit was relatively poor habitat. Large home ranges in an area with a high density of roads and snow machine trails increased the probability that resident marten would encounter traps, which is consistent with the high harvest rate we calculated from harvest of marked animals. The large home ranges also allowed resident marten to exploit an area with abundant clearcuts by moving between patches of uncut timber. The maximum dispersal distance we recorded of 34 km indicates that marten in southwest Montana are capable of moving long distances, and actively recolonize suitable habitat in which marten populations have been reduced or extirpated.

Locations of radio-collared marten in our study areas indicated a preference for mature coniferous forest with high canopy coverage, abundant herbaceous vegetation in the understory, and abundant deadfall during periods of the year with snow cover. Where these conditions were common, selection was less pronounced than where they were rare. Marten probably developed their reputation as a "climax" species because large trees, high canopy coverage, abundant deadfall, and ground cover that supports small mammals are characteristic of climax conditions in many coniferous forests; however, these conditions may also be found in mid-seral stages of many forest communities in the Rocky Mountains. Landscapes with extensive clearcuts, shelterwood cuts, or seed tree cuts and areas impacted by extensive crown fires are seldom used by marten in winter, although marten movements indicated they will still traverse these sites to move into suitable habitat.

When maintenance of marten populations is an objective in a USFS forest plan, we recommend that timber cutting units be spaced (temporally and spatially) so that marten have access to large, mid-seral to climax blocks of forest. We did not investigate the effects of patch size and spacing on habitat use, so we cannot offer concrete guidelines for spacing cutting units. However, distances between consecutive locations at weekly intervals for most radio-collared marten were < 2 km, therefore 1.6 km (1 mi) might serve as a first approximation of the maximum allowable distance between blocks of mature forest. Appropriate temporal spacing, the interval between successive timber harvests in the same cutting unit, is more easily estimated. In southwest Montana, high quality marten habitat that is logged will probably not return to moderate quality for martens for 75-100 years following timber harvest but could be used as a reasonably safe travel corridor within 25 years (assuming reasonable growth rates for seral species such as lodgepole pine).

Marten habitat in managed forests could also benefit from consideration of cutting unit shape and post-cutting site preparation. Care should be taken to minimize narrow forest corridors between cuts and long stringers of riparian forest with cuts on slopes on either side of the drainage. Marten tend to use linear bands of timber to move between patches. Trappers recognize this and can turn what is designed to be a corridor connecting patches into a mortality sink. Post-harvest site preparation should emphasize techniques that promote ground coverage of herbaceous vegetation and that will retain moderate to large diameter deadfall (>5 cm). The deadfall left during harvest will not be useful to marten in winter until a forest canopy returns, but large diameter deadfall, jackpot piles, and snags that will become deadfall may persist long enough to make seral stands with well developed canopy coverage suitable as marten winter habitat.

Density and population structure in the marten populations we studied varied among years and study areas, but none of the populations we monitored appeared likely to disappear under the trapping pressure and land disturbance rates we observed during the period of our research. Marten densities tended to be higher in study sites with less disturbance from logging and fire, but marten were able to occupy heavily logged and roaded areas such as the West Yellowstone Flats sub-unit. We found some evidence of short-term over-harvest at some sites, but all of the study sites were easily accessible to trappers and had been open to trapping with minimal restrictions for more than 50 years, evidently without eliminating marten populations.

In our study areas, marten populations survived despite minimal restrictions on trapping (i.e.only restricted season length) and habitat changes due to logging or fire partially because of the way in which marten trappers operate in southwest Montana . We observed a wide range of attitudes towards marten harvest among trappers. Most trappers had traditional areas where they set traps, and they tended to actively or passively separate their traplines from other trappers. Several trappers in our study areas consciously regulated the number of animals they harvested to avoid eliminating marten in the local areas they trapped. A few individuals either did not trap or ended trapping early in the season when they perceived low populations or diminishing returns for the effort and expenses required to run a trapline. Still other trappers maintained trap-lines during the entire season in some areas, despite the likelihood that harvesting a marten was low, such as the West Yellowstone Flats sub-unit.

The trappers that were active in the Big Hole study area in 1989-1990 indicated that economic returns from trapping were important to them. Trapping that occurred in the West Yellowstone study area appeared to be a recreational activity. While most of the trappers sold marten pelts, none of these individuals relied on the harvest of marten alone, or in combination with other furbearers, as a major source of income. In both study areas, the variability in pelt prices and active immigration of young animals from adjacent undisturbed habitats apparently buffered the effects of any short-term over-harvest that occurred by these trappers.

All of our study sites had road and trail systems (any Forest Service trail or road serves as an entry point for trappers) with active timber harvest, but all were closely connected to substantial roadless areas (Wilderness Areas and Yellowstone National Park). The over-harvest of marten in one year was compensated by the immigration of young animals. While managers can usually rely on these "source" populations to supplement populations of marten subject to harvest, they should not be complacent about the status of marten in these areas adjacent to the source populations. Changes occurring in habitats due to succession, fire, logging, or residential development will likely precipitate major changes in population densities or in the species susceptibility to harvest. Unpleasant surprises regarding dramatic changes in species status can be avoided by routine monitoring of harvest levels and marten distribution.

In isolated blocks of habitat and areas where timber harvest, residential development (which breaks up forest canopy, modifies populations of small mammals, eliminates deadfall, introduces domestic predators, and increases opportunities for accidental mortality), or crown fires have affected large portions of the landscape, immigration may not adequately restore populations that have declined or disappeared due to over-harvest or habitat degradation. The persistence of marten populations in the smaller isolated mountain ranges of southwest Montana, where logging and marten harvest have occurred for decades, indicates that marten populations are not as vulnerable to extirpation as authors such as Gibilisco (1994) suggest, although a lack of nearby sources of immigrants could preclude or delay recolonization if resident marten disappear. Monitoring distribution, population trend, and harvest levels in isolated blocks of habitat would be desirable to identify declines before marten numbers reach a critical level.

MFWP now requires trappers to identify location, number, and gender of all harvested marten and to turn in skulls to the State Wildlife Laboratory for age determination. Biologists in MFWP have established representative track surveys in marten habitat across Montana that are conducted utilizing snow machines to annually monitor relative density and distribution. These management efforts should provide the information necessary to identify problems that may arise in marten populations to predict impacts from development before declines occur. This study found marten are prolific, mobile, and capable of using a wide variety of habitats. With reasonable restraint in human land use and maintaining harvest season length restictions, marten can continue to offer both consumptive and non-consumptive recreational opportunities across the landscape while persisting as a valuable member of our forest communities.

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