# Ecology of American Martens in Coastal Northwestern California

Progress Report II

5 June 2000 - 10 December 2001

17 April 2002


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## SUMMARY

We report on the first two years of fieldwork investigating the ecology of American martens within the historical range of a recognized subspecies, *Martes americana humboldtensis*. The objectives of Phase I of this study are to determine the geographical distribution of this population, collect genetic material, collect demographic information and describe the characteristics of the locations where martens are found using a multi-scale spatial approach. The objectives of Phase II are to determine the size, habitat composition, and landscape context of marten home ranges and to describe the characteristics and spatial distribution of the resting structures they use. This information will be important for the conservation of martens and to assist in conservation planning within the redwood region. During the period from June to November of 2000-2001, 159 grid-based and 5 exploratory sample units were sampled using 2 sooted track-plate stations per unit. Martens were detected at 28 (17%) and fishers at 11 (6.7%) of the 164 sample units. Live-traps were set at 18 of the sample units where martens were detected; 9 of these resulted in the capture of 14 individuals (8 M: 6F). Although there were no recaptures in 2000, 3 individuals were recaptured at least 2 times each in 2001. Martens were detected in 2 distinctive stand types, Douglas-fir/tanoak-dominated stands in productive soils (n = 21) and western white pine-dominated stands in harsh serpentine soils (n = 7). Sixteen of the 21 Douglas-fir/Tanoak dominated stands were in the oldest successional stages (Late-mature 4, Old growth 12), while western white pine dominated stands were in a mix of early and mid seral stages. Dense shrub cover was characteristic of all stands where martens were detected (mean = 76%, SD = 24). Using 0.5 km radius circles around detection locations, serpentine locations had more area in the shrub and early-mature conifer seral stages (mean = 54%, SD = 29) while non-serpentine locations had a larger amount of area (mean = 50%, SD = 22) in the latest (late-mature and old growth) seral stages. Sufficient information exists to be concerned with the persistence of this population due to its small size, patchy distributional pattern, and limited geographic extent. To ensure the persistence of this population we recommend that: 1) efforts be made to protect all areas currently occupied by this population and 2) areas adjacent to these be surveyed for martens and evaluated for their current and future habitat suitability for martens and be managed to reflect these evaluations. The marten appears to demonstrate a higher degree of sensitivity to the loss of mature and old growth coastal forest characteristics (dense shrub layers, large diameter trees, snags, and logs) than other old forest associated species (e.g. fisher and northern spotted owl) and may be a good candidate focal species to aid in conservation planning in the redwood region. A pilot effort of Phase II began in August of 2001 with four martens (2M:2F) fitted with radio collars. These animals were monitored until mid November when snow blocked access to the study area. Monitoring resulted in the identifying of 7 rest structures, 6 stand locations, and the collection of 54 remote triangulations. Fieldwork for Phase II will begin in June of 2002, with the goal of 4-5 martens fitted with radio collars in both serpentine and non-serpentine locations (8-10 total).

# INTRODUCTION

Throughout their geographic distribution, American martens (*Martes americana*) are closely associated with late-successional mesic coniferous forests having complex physical structure at or near the ground (Bissonette et al. 1989, Buskirk and Ruggiero 1994). Recently, Zielinski et al. (2000b) documented a substantial decline in the distribution of a recognized subspecies, *M. a. humboldtensis,* endemic to the coastal forests of northwestern California (Grinnell and Dixon 1926). Currently there is only one known population occupying less than 5% of the historical range. There have been no investigations of the habitat ecology of the Humboldt marten or of *M. a. caurina* in the coastal forests of Oregon or Washington. This study will provide important new information on the ecology of martens within the historical range of the Humboldt subspecies. This information will be important for identifying management options that favor martens and for identifying the role martens can play in conservation planning (e.g. Noss et al. 1996) within the redwood region. This project has two phases: Phase I will provide information on the distribution of the population and characterize habitat selection at the stand and landscape scale and Phase II will provide fine-scale information on home ranges and resting structures.

Objectives:

Phase I:

1. Determine the geographic distribution of the marten population using track plate surveys and live traps.
2. Describe the habitat used by martens by comparing vegetation, topographic, and landscape features at sites used by martens and those available to them.
3. Collect genetic material and morphological information.
4. Estimate the minimum population size, the age structure, and the sex ratio.
5. Assess how the habitat needs of martens can be used to assist in conservation planning in the redwood region.

Phase II:

1. Estimate the home range sizes for males and females.
2. Determine the habitat composition of home ranges.
3. Determine the landscape context in which home ranges occur.
4. Determine the characteristics and spatial arrangement of rest sites.
5. Assess how the information on home range habitat composition and the number and spatial arrangement of resting structures can be used to guide habitat management or restoration efforts for martens in the redwood region.

With the end of the 2001 field season, the data collection period for Phase I has been completed. During the winter and spring of 2002 formal habitat analysis of the data collected in Phase I will begin and will be completed by the summer of 2002. Phase II began with a pilot effort in 2001 to test the field techniques necessary to achieve the objectives listed above. Phase II of this project represents a shift from investigation of population level habitat selection using systematic survey methods to an investigation of individual level selection of home range characteristics and resting structures using radio telemetry. The information from both phases is highly complementary and will provide a hierarchical understanding of marten habitat ecology within the redwood region.

## Study Area

The study area is approximately 800 $km^2$ (300 $mi^2$) and includes portions of southern Del Norte, northern Humboldt, and extreme western Siskiyou counties. The majority (80%) of the study area falls within the Smith River National Recreation Area (SMNRA) and the Orleans Ranger District (ORD) of the Six Rivers National Forest and the Ukonom Ranger District (URD) of the Klamath National Forest. The remainder of the study area is within lands owned and managed by the Simpson Timber Company (STC) (Figure 1). In 2001 the study area was extended to the northwest to include portions of Rattlesnake and Little Rattlesnake mountains on the SMNRA.

Douglas-fir (*Psuedotsuga menziesii*) and tanoak (*Lithocarpous densiflora*) associated forest types dominate the study area, with redwood (*Sequoia sempervirens*) types becoming important to the west and white fir (*Abies concolor*) types to the east and at high elevations. The presence of serpentine soils have fostered several structurally and compositionally unique forest types, which also harbor a rich diversity of plant species (Jimerson et al. 1995).

# METHODS

## PHASE I

The survey design is described in detail in Slauson et al. (2000) and consists of a 12 x 14 systematic grid with 2 km spacing (Figure 1). The grid encompasses all the locations where martens have been detected within the last four years (Zielinski et al. 2000b) and extends at least 2 km beyond them. The entire grid, excluding 5 points on the southwestern edge that fall in the Klamath river, was sampled with sooted track-plate stations (Zielinski and Kucera 1995) during the 2000 and 2001 field seasons.

### Track Plates

A track plate sample unit was established at each point on the grid and consisted of one station at the grid point and a second located 200 meters away on a random bearing, but within the same stand encompassing the grid point. Stations were baited with chicken and checked every other day for a 16-day period. A commercial trapping lure (Gusto, Minnesota Trapline Products, Pennock, Minnesota) was placed near each track plate station when established and re-applied on the $8^{th}$ day if no marten detection had occurred.

## Live Capture

We attempted to capture martens at each sample unit where they were detected using a Tomahawk live trap (Model 205, 9 x 9 x 26 inches) placed in the same location as the track-plate station. Information on trap modifications and animal immobilization and handling procedures can be found in Slauson et al. (2000) and Slauson (2000), respectively. Each trap was open for 16 consecutive days and checked at least once daily.

## Genetic Samples

Genetic samples consisting of tissue (2 x 2 mm; margin of the ear) and hair (nape and tail) were collected from each marten we captured. These samples will be used to describe the genetic heterogeneity of the population and to help determine its subspecific affiliation. Dr. Karen Stone, of Southern Oregon State University, has been conducting the genetic work using the individual variation in base pair sequences in the d-loop region of the mitochondrial DNA that codes for cytochrome-b. Martens in our study population will be compared to martens in other nearby regions and to historical museum specimens of *M. a. humboldtensis* in the Museum of Vertebrate Zoology at the University of California. Specifically we plan to compare: (1) a contemporary sample of individuals from within the historical ranges of *M. a. humboldtensis* with *M. a. sierrae* and with *M. a. caurina* and (2) a sample of historical museum specimens of *M. a. humboldtensis* and *M. a. sierrae*. The sequence data will then be interpreted in light of a more extensive North American data set for American martens (Stone 2000). This should allow us to identify the subspecies that martens in our population most resemble and therefore determine whether they are remnants of a relictual population of *M. a. humboldtensis*, or recent immigrants from elsewhere and attributable to other subspecies.

## Collection of tracks

Martens are released from traps in a manner that allows us to collect examples of their tracks (Slauson et al. 2000). These tracks will be measured and analyzed using methods described by Zielinski and Truex (1995) to develop a method to classify sexes based on track measurements.

## Habitat Analysis

The habitat analysis will consist of 3 steps. The first employs plot level sampling to gather information on the sub-stand structure around each track plate and trap location. The methodology for the plot level sampling is consistent with the statewide systematic surveys discussed in Zielinski et al. (2000a) and will allow for comparison between sites surveyed during this effort. The second step involves a multi-scale (stand, home range, and landscape) spatial analysis of compositional patterns associated with locations where martens occur. The third step involves using the knowledge gained from phase I and II to explore spatially explicit modeling of marten habitat for the study region.

### Sub-stand Structure (Plot Level Sampling)

A combination of variable-radius plot and transect methods was used to describe the vegetation composition and structure at each track plate station in each sample unit. Topographic variables included slope, slope aspect, topographic position and presence of surface water within 100m. Basal area, tree diversity, condition class, abundance and size were estimated using prism sampling. Shrub cover was visually estimated. Canopy closure was measured using a spherical densiometer and facing each cardinal direction at the track plate station and at both ends of each 25m transect centered on the station. Each site was classified according to the California Wildlife Habitat Relationships (CWHR) system to assign a habitat type, size class, and canopy cover to the area surrounding the track plate using guidelines by Mayer and Laudenslayer (1988).

### Multi-scale Spatial Analysis

For all spatial analyses, we will use the vegetation coverage developed by the Six Rivers National Forest Ecology Program (EP) during the mid 1990s (see Jimerson et al. 1996). The EP coverage describes the potential natural vegetation communities in a hierarchical manner (Allen 1987) consistent with the classification systems of other federal agencies within the United States. The EP classification system was derived from extensive ecological plot sampling of over 1200 plots and thus provides information on stand composition and structure. The EP vegetation layer was developed through a combination of air photo interpretation, polygon typing based on the classification system, and ground truthing of most polygons. Hereafter we refer to these polygons as stands, defined by the combination of their seral stage and vegetation type. There are 18 ‘seral stages’ defined within the EP coverage. These stages are quite detailed and provide information on logging history as well as the presence of large residual trees (predominants) within younger seral stages. Information on the total canopy cover and the percent contribution of coniferous and deciduous trees to the total canopy cover is also available. Each stand within the EP coverage has been field verified providing an accuracy level that is unrivaled by the other coverages. The advantages of this coverage over others that are available for the study region are discussed in Slauson et al. (2000). The EP coverage is limited, however, in that it only exists for the SRNF and a small buffer area.

Stands where martens were detected and were not detected will ultimately be characterized and compared using resource selection functions (Manly et al. 1993). The composition of stand types around detections sites will be characterized at several spatial scales and by using patch metrics such as those generated by the program FRAGSTATS (McGarigal and Marks 1995). The home range scale analysis will require using two different scales (e.g. 0.5 and 1.0 km radius circles) to reflect the observed differences in the size of male and female home ranges. Landscape scale analysis will characterize the area occupied by the current population and compare it to areas of similar size within the historical distribution of *M. a. humboldtensis*. Further discussion of the multi-scale spatial analysis can be found in Slauson (2000).

### Model Exploration and Development

Variables associated with marten locations from phase I and II will be used to build and evaluate spatially explicit models of marten habitat using the EP vegetation layer for the study region. *A priori* variable selection and model building, following the guidelines of Burnham and Anderson (1998), will be used and all models will be evaluated by their AIC values.

## PHASE II

### Radio Collars

A pilot study of limited scope was conducted in the fall of 2001 during which we radio-collared and monitored a small sample of animals. A subset of martens are fitted with radio collars (Model BT, AVM Instrument Company, Ltd., Colfax, California) that transmitted 3 types of signals: 2 different activity states and mortality. We began the telemetry phase very conservatively and modified each radio collar with a 'break-away' feature so it could wear off over time (~ 6 months) or potentially be forced off if the animal became caught on an object. Typically, a collar is fastened with a nut and bolt passing through the ends of the metal collar. We modified this arrangement by removing ~60% of the threaded portion of each bolt and the nut was not used at all. We placed the shortened bolt through the holes in the collar ends and secured it by wrapping waxed dental floss, and then electrical tape, around the bolt and collar. We assumed that the tape and floss would disintegrate over time, allowing the bolt to easily become unattached from the collar releasing the collar from the animal.

### Rest Site Locations

Rest locations are sought by homing on the radio signals from animals that are inactive. An animal is considered to be inactive if several minutes of continuous inactivity pulses are received. Considerable care is taken to not disturb the animal once it is located or is nearby. When the rest structure is identified and the animal does not appear to be disturbed, a few site characteristics are noted and the site is flagged. At a later date each rest site location will be re-visited to conduct detailed vegetation sampling and reference the structure's location using a GPS unit. When a specific rest structure is not located during an outing, the observer is usually able to localize the animal to a particular vegetation polygon and this is referred to as a "stand location". Stand locations will be used primarily in home range estimation and analysis.

### Remote Triangulation

Animal locations are also determined by taking bearings on the collar's signal from a distance at known locations (referenced using GPS) using the loudest signal method (Springer 1979). Each bearing is plotted in the field to help guide decision-making at subsequent receiving locations. Error assessment will be conducted by placing radio collars in random locations throughout representative terrain used by martens. Observers whom are unaware of the locations will take bearings on these transmitters, using the same techniques used to triangulate on collared martens. Triangulation error will be calculated by measuring the distance from the estimated location to the true location of the collar. These error estimates will be used to help adjust for use of remote triangulation location in home range analysis.

### Home Range Size and Compositional Analysis

Home range sizes will be calculated using the locations of rest sites and the estimated locations from remote triangulation. We will attempt to collect at least 20 rest site locations for each marten and use remote locations in a supplementary manner as required. Home range calculation and compositional analysis will be completed using the software program LOAS version 2.04 (Ecological Software Solutions, Sacramento, CA).

### Activity Monitoring

The activity patterns of individual animals will be determined by recording whether inactive (single pulse) and active (double pulse) signals are being emitted at 30-minute intervals over 24 hr monitoring periods. To determine the nature of the signal, listening periods of 3-5 minutes will be conducted every 30 minutes to characterize the animal as active or inactive. Individual monitoring sessions will be conducted from 24 to 72 hours.

## PRELIMINARY RESULTS AND DISCUSSION

### PHASE I

During the 2000-2001 field seasons 159 of the 163 proposed sample units were sampled within the study grid (Figure 2). Five sample units were not sampled due to inaccessibility and one new sample unit was added to the grid. Five exploratory sample units were completed 5-10 km northwest of the study grid in the vicinity of Rattlesnake Mountain and Little Rattlesnake Mountain, located on the SRNRA (Figure 2). This area was of interest because it contains serpentine habitats very similar to those where martens were detected within the grid in 2000 and it is located within the same ridge network. In addition, a marten was observed moving north along a connecting ridge between these two areas in 2000. Elevations of sample units ranged from 52 to 1457 meters (170 - 4770 ft) with an average of 911 m (SD = 322; Mean = 2990 ft, SD = 1058).

### Track Plates

Eighteen species (15 mammals, 1 bird, 1 reptile, 1 amphibian) were detected at track plate stations (Table 1). American martens were detected at 26 (16.3%) of the sample units and 2 of 5 of the exploratory units (Figure 2). Mean latency to first detection at the sample units was 9.1 days (SD = 5.2; range 2 -16). Martens were detected at both stations of a sample unit at 8 of 28 sample units. Eight of the sample units where martens were detected were on the SRNRA, 3 on STC lands, 3 on the URD, and 14 on the ORD.

Detections from the 2001 effort have expanded the area known to be occupied by martens most significantly northwest to the headwaters of Rock Creek (drainage of the Smith River) in Del Norte county, further east to the headwaters of Rock Creek (drainage of the Klamath River) in Siskiyou county, and further south down the Bluff Creek drainage (Figure 2). Although all sample units completed are in Del Norte county and the southwestern edge of Siskiyou county, a radio collared female (F06) crossed into Humboldt county in November moving south along Bluff creek and spending time in the Fish Creek drainage.

Using the minimum convex polygon method, the estimated total area occupied by this population is 165 mi$^2$ (424 km$^2$). Five detections occurred on the edges (Figure 2) of the grid and additional surveys will likely detect martens in the vicinity of these grid edge locations. Fishers were detected at 11 (6.9%) sample units, 7 of which were on STC lands, 1 on the SRNRA, and 3 on the ORD (Figure 3). No fishers were detected at the exploratory units. There continues to be no clear elevational segregation between marten (Mean = 872 m, SD = 228, range 440 – 1196) and fisher (Mean = 769 m, SD = 411, range = 122 – 1308) detection sites as has been observed elsewhere in the western states (Krohn et al. 1997, Zielinski et al. 1997).

Live Capture

Live-traps were established at 18 of the 26 sample units where martens were detected. Eight sample units were not trapped due to a combination of personnel and logistical constraints. One or more martens were captured at 10 of the 18 units for a total of 14 (8M : 6F) individuals captured (Figure 4). Martens were successfully captured after a mean latency of 5.2 days (SD = 4.6). The highest latency to first capture values belong to the three martens that were the second individuals captured at their respective trap site; the latency to the first marten capture for each sample unit is 3.1 days (SD = 2.3). All traps used in 2001 were modified using the methods described in (Slauson et al. 2000) and no martens were believed to have escaped from any trap in 2001. Although no martens were recaptured in 2000, 3 animals captured in 2001 were recaptured in 2001. Two individuals with radio collars were recaptured 2 times each and an uncollared male (M07) was recaptured 6 times and left copious scat during each recapture. In 2001, a fisher was captured at a single sample unit where both a male and female marten had been trapped and radio collared and where no fisher tracks were obtained during the previous tracking period. Three western spotted skunks (*Spilogale gracilis*), two gray foxes (*Urocyon cinoreoargenteus*), one ringtail (*Bassariscus astutus*), one Douglas squirrel (*Tamaisciuris douglasii*), one chipmunk (*Tamias* sp.) and one Steller's jay (*Cyanocitta stelleri*) were also caught and released.

The mean duration of immobilization was 30.1 minutes (Table 2). All animal processing in 2001 went quite smoothly, with a mean of 10.2 minutes of extra processing time required for each individual that received a radio collar. Two of the 6 females were lactating when captured and two others showed signs of previous lactation, however not necessarily in the year they were captured (Table 3). Females weighed an average 598 grams (SD= 39) and males 889 grams (SD=100) (Table 3). M08, caught in mid October

2001, had molted into winter pelage, with dense fur around the pads of the feet, noticeably bright reddish brown overall coloration and particularly dense under-fur. All animals appeared in good health with the most serious injury discovered being several broken, but apparently healed, tail vertebrae on M03 in 2000. Ticks were the only ectoparasites detected and were only on two individuals in 2000.

A total of 103 scats were collected from live traps, during animal processing, or at rest sites. In general, most scats contained fruits of one of the following shrub species: California red huckleberry (*Vaccinium parviflora* var. *californica*), evergreen huckleberry (*Vaccinium ovatum*), and salal (*Gaultheria shalon*). In 2001, most of the berries in the scats were from salal. Manzanita (*Artostaphylos* sp.) berries were identified from at least one scat. During 2000-2001, berries were found in fresh scats from mid June until late November and were likely available slightly earlier and later than these dates, depending on location. Multiple scats contained hair, bone, or claws from mammals as well as s few with feathers. Formal scat analysis is planned to begin at the conclusion of Phase II.

Genetic Samples

Tissue and hair samples were successfully collected from all 14 individuals that were captured. In 2001, contemporary samples were collected from 3 individuals of *M. a. sierrae* from Lassen National Park to augment the sample of *M. a. sierrae* currently in our possession. Dr. Stone has analyzed the samples collected from 8 individuals we captured in 2000, 3 road killed animals from the range of *M. a. caurina* in coastal Oregon, and 2 animals from the range of *M. a. caurina* from the southern Cascades of Oregon. The preliminary groupings of these animals, including 2 out-groups from northern British Columbia and southeastern Alaska, are presented in a phylogenetic tree in Figure 5. We have no new information yet to help determine the subspecific affiliation of the martens in our study population. The data suggest, however, that the majority of animals from our study population (n = 5) share the same haplotype and that the remainder (n = 3) differ from the majority by either 1 or 3 base pairs. Two of these 3 sequences share the same haplotype as 3 individuals from coastal Oregon; whereas one animal (75-7) has a unique haplotype (Figure 5). A single base pair difference (e.g. between Klamath county, Oregon and Coastal Oregon) may suggest recent (thousands of years) divergence, whereas a 5 base pair difference (e.g. California 75-7 compared to California 75-1) may suggest divergence during the last period of glaciation (K. Stone pers. comm.). Caution must be taken in drawing any conclusions from this information because the addition of new samples to this analysis will probably influence the interpretation of the current results.

Two samples from *M. a. sierrae* individuals have had their DNA extracted and await analysis. Dr. Stone has recently acquired samples from museum specimens of *M. a. humboldtensis* and *M. a. sierrae* that await sequencing and analysis. We expect to have the preliminary analysis of all of these samples completed by the spring of 2002.

Habitat Analysis: Martens

Sample units where martens were detected fall into two distinct groups, those with serpentine soils (7 units) and those without (21 units (Figure 6). Because of low levels of essential nutrients and high concentrations of detrimental elements, serpentine soils offer a harsh growing environment for plants (Jenny 1980). As a result, forest stands growing on serpentine soils are typically open and rocky with stunted trees (Jimerson et al. 1995). Seral stages assigned by tree size class alone can be a misleading surrogate for stand age. For example, stunted, small diameter (< 12 cm) lodgepole pine (*Pinus contorta*) trees are often >100 years old in these sites (Jimerson et al. 1995). The development of dense, and often decadent, shrub layers in serpentine habitats is also likely to be comparatively slow. The non-serpentine sites grow in much more productive soil types, tend to have closed canopies, larger diameter trees, and have comparably little surface rock (Jimerson et al. 1996). Because of the significant differences between the serpentine and non-serpentine sites, their use by martens was summarized separately.

Microhabitat Analysis

Serpentine

The tree canopy closure at serpentine stations was sparse to almost absent (mean = 25%, SD = 16), with the two units with the lowest tree canopy closure (5%) being classified as 'montane chaparral' using the CWHR system (Table 5). The dominant tree species, in declining rank order were: western white pine (*Pinus monticola*), Douglas-fir, and lodgepole pine. Percent shrub cover was high across all serpentine stations (mean = 86%, SD = 9) (Table 5). The 3 most dominant shrub species at serpentine sites were huckleberry oak (*Quercus vaccinifolia*), dwarf tanbark (*Lithocarpous densiflora var. echinoides*), and white-leaf manzanita (*A. viscida*). Although not yet quantified, serpentine sites detecting martens had a conspicuous abundance of groups of boulder-sized surface rocks, many of which created interstitial spaces that could be used by martens and their prey for cover.

Non-Serpentine

Tree canopy closure at non-serpentine stations was fairly high (mean = 78%, SD = 13), with the lowest value belonging to a station located in the earliest seral stage that had been pre-commercially thinned (Table 4). Douglas-fir was the dominant overstory tree species at 21 of the 28 stations with ≥2 tree layers, and tanoak, chinquapin (*Castanopsis chrysophylla*), and bigleaf maple (*Acer macrophyllum* ) were the most dominant understory species in declining rank order. Similar to the serpentine sites, the cover of shrubs was very high (mean cover = 74%, SD = 27; Table 4, 5) but the dominant species of shrubs were different (i.e., salal, evergreen huckleberry, Oregon grape [*Berberis nervosa*], and rhododendron [*Rhododendron macrophyllum*]).

## Multi-scale Spatial Analysis

### Stand scale

At the stand scale, total canopy closure was similar to that of the plot level estimates for both serpentine (mean = 30%, SD = 27) and non-serpentine stands (mean = 88%; SD = 9) where martens were detected (Table 6,7). Both non-serpentine and serpentine stands have large conifer components in the tree layer, with the latter sites lacking hardwood canopy cover all-together. The seral stages of stands where martens were detected differed sharply between serpentine and non-serpentine locations. Serpentine stands were in a mix of shrub, early-mature, and mid-mature conifer seral stages while non-serpentine stands were mostly in the latter seral stages (Tables 6, 7). Sixteen of 21 non-serpentine sites were in the late-mature (4) or old-growth (12) stages while one additional stand was mid-mature with residual late-mature or old-growth trees (predominants) (Table 6).

Serpentine stands tended to be located on or near ridge tops and showed no trend in stand aspect. However 66% of the non-serpentine stands were in the most mesic aspects (northwest to northeast, 280 to 70 degrees) and 5 of 7 of those with xeric positions (southeast to southwest, 130 to 250 degrees) had surface water available at the time they were sampled. Only one of the serpentine stands had been previously logged. Two of the non-serpentine stands were in the pole stage and had been previously logged, however both had dense shrub layers and were adjacent to either old growth or late-mature stage stands. Serpentine stands where martens were detected were at higher elevations (mean = 1091 m, SD = 106) than non-serpentine stands (mean = 848 m, SD = 261) (Table 7). All serpentine stands where the vegetation series is known are in the western white pine series (Table 7). This series is unique among all serpentine series types having the highest amount of surface rock (mean = 46%), the second highest amount of shrub cover (mean = 76%), and is only found in cool sites in close proximity to the ocean (Jimerson et al. 1995).

### Home range scale

Serpentine and non-serpentine sites show different seral stage compositions using 0.5 km radius circles centered on each detection location (Tables 8, 9). Serpentine locations had more area in the shrub and early-mature seral stages (mean = 54%, SD = 29) while non-serpentine locations had a larger amount of area (mean = 50%, SD = 22) in the latest (late-mature and old growth) seral stages (Table 8, 9). The results for the serpentine locations might be expected, however, if martens are using for resting and denning the interstitial spaces created by surface rocks rather than large woody structures (e.g. snags and downed logs) that are typically used by martens elsewhere. This also may reflect the importance of the rocky substrate and dense shrub cover at these sites; characteristics which may not vary with seral stage in serpentine habitats. In 2002 we will investigate the importance of surface rocks in phase II by determining the resting locations and structures for several martens that are found in serpentine habitats. We will also be employing quantitative means to characterize and compare the structure and distribution of these rocky features in these habitats. Three serpentine sites (59, 74, 303) also had significant (39-44%) late-mature/old growth components while 2 non-serpentine sites (118, 119) had significant shrub (natural) components within 0.5 km circles. These 5 sites lie on transitional soils, where serpentine and more productive types mix and may demonstrate the importance of the juxtaposition of these forest types for martens. Using the 1.0 km radius scale of assessment, patterns of association with particular seral stages were very similar to those for the 0.5-km analysis for non-serpentine locations (Table 10). However, the relative percentages of shrub and early-mature conifer declined for serpentine sites (Table 11). Two of the sites where both male and female martens were captured had the highest (80.7%) and third highest (57.2%) composition of late-mature and old growth seral stages using the 1 km radius scale of assessment.

Of particular interest is the use by martens of serpentine habitats. The serpentine ridge system within the study area, and one location approximately 75 km to the north on the Siskiyou National Forest, are the only locations where martens have been found in this type of habitat. The overall importance of these habitats from a population perspective is unknown, but 1 of the 4 individuals captured at the serpentine sites was a lactating female. These locations also harbor a conspicuous abundance of golden-mantled ground-squirrels (*Spermophilus lateralis*) (K. Slauson pers. obs.) that are sparsely distributed elsewhere in the study area and known to be an important prey item for martens elsewhere in California (Zielinski et al. 1983). Although the unconventional serpentine forest types may be considered an addition to the definition of "marten habitat," it is important to consider this from a landscape perspective. Martens are known to use habitats that are structurally similar to the serpentine sites (e.g., natural shrub habitats [Buskirk and Ruggiero 1994, Zielinski unpub. data] and talus fields [Grinnell et al. 1937, Streeter and Braun 1968]), but in each situation these other habitats are closely associated with late-successional coniferous forest at a larger spatial scale. Serpentine habitats within northwestern California are also very patchy and are imbedded largely in a dense-forest matrix (Figure 6), so it is very likely forest composition at the larger spatial scales plays an important role in whether these habitats are used. Four of 7 of the serpentine sites had between 16 and 40% (mean = 30% SD = 11) late-mature and old growth seral stages within 1 km radius circles. Use of serpentine habitats has been confirmed as late as mid November, but not yet during winter when snow is present in these locations. The systematic surveys described in Zielinski et al. (2000a) included many other serpentine sites on the Six Rivers and Siskiyou National Forest where martens were not detected.

Marten Management and Conservation Planning in The Redwood Region

The Humboldt marten was historically a "fairly numerous" (Grinnell et al. 1937) species within redwood and coastal coniferous forests of northwestern California. Today, the population of focus in this study is the only known remnant population within the historical range of *M. a. humboldtensis*, which represents an area equivalent to about 5% of its historical distribution. A combination of intense historical trapping for their fur and habitat destruction through extensive loss of mature and old growth forests throughout their historical range are likely the two factors most responsible for this decline (Zielinski and Golightly 1996). During the last century redwood forests have undergone a 93-95%

conversion from mature and old growth stands to stands of 80 years of less (Thornburg et al. 2000). Adjacent near-coast coniferous forest types, such as those dominated by Douglas-fir, have undergone a similar pattern of loss of mature and old growth stands. The USFS portion of the study area includes the largest contiguous areas of low-elevation, near-coast late-successional forest (Figure 7) within the historical distribution of the Humboldt marten and lies directly on the transition zone between redwood dominated and redwood associated forests. Although we have just begun to learn about the ecology of martens within coastal forests, and thus should proceed cautiously, we face 2 challenges related to the restoration of the coastal California marten population: 1) the longer that a population remains small, the greater the chance that it will lose genetic variation (Nei et al. 1975) or that it will be eliminated due to stochastic events, and 2) restoration of forest habitats with the structural characteristics necessary to be suitable for martens may take many decades.

Population Recovery

Information from this study suggests that the population is patchily distributed, which may likely reflect the limited availability of suitable habitat within the study region (Figure 7). All of the serpentine sites where martens were detected occur on the Red mountain-Rattlesnake mountain ridge complex. This ridge system sits along the eastern edge of the distribution of redwood-dominated forest types. This system also runs north to the Little Bald Hills portion of Redwood National and State Parks (RNSP) and is connected to the portions of Rock and Mill creek recently purchased by Save-The-Redwoods League. The non-serpentine sites where martens were detected occur more patchily throughout the study area and are largely associated with areas composed of mesic late-mature and old growth stands of coniferous forest. The detections along the edges of the study grid, and the 2 detections resulting from the exploratory efforts in 2001, suggest that the geographic distribution of this population may be slightly larger than currently understood and future surveys should focus on sampling all peripheral areas with similar habitat to where martens were detected. Habitat models that will be developed from the data presented here will help plan these efforts. Areas immediately to the south and east of the study area with suitable habitat are likely to be few and be extremely restricted to mesic aspects or near riparian areas (e.g. Bluff creek and adjacent major tributaries) as the forest structure and composition changes (e.g. dense shrub layers under the tree canopy are absent) with increasing distance from the coast. It is important to note that due to the orientation of the major watersheds within the study area, fog often penetrates well inland during the summer and is likely an important factor in supporting the dense vegetation associated with areas used by martens.

Areas immediately to the north and especially to the northwest of the study area may have the greatest potential to support additional suitable habitat. However much of this area, with exception of the core middle and northern portions of the Siskiyou Wilderness, was surveyed using a 10 km grid and 6 track plate station sample units in 1997 without any marten detections (Zielinski et al. 2000a). Although the unsurveyed northern portion of the Siskiyou Wilderness may seem like a logical area to harbor martens, only three martens were detected in the 28 sample units located in the southern portion of this wilderness area and no detections of martens have occurred in the high elevation true fir forest types (white and red fir) within the study region which are also common forest types in the wilderness. High elevation surveys in 2001 along the north edge of the Siskiyou Wilderness and within the nearby Red Buttes wilderness also did not detect any martens (Slauson and Zielinski in prep.). No martens were detected in regenerating redwood forest on STC lands and only 3 martens (2 in unlogged serpentine stands, and 1 in a regenerating mixed hardwood conifer stand) were detected on lands owned by the STC; these were immediately adjacent (<200 m) to USFS lands.

To date, live-trapping has identified 14 individual martens within the study population. We can generate a very crude population estimate by assuming that the number of martens that would be captured at *all* sample units with a detection would be similar to the number captured (n=14) at the 10 sample units that were trapped (i.e., 1.4 per sample unit). Thus, if each of the 28 sample units with a detection would capture 1.4 animals if they had been trapped, we would have identified 39 animals in the population. Although crude, this method of estimation is a first approximation using the only information currently available.

To ensure the persistence of this population we suggest that: 1) efforts be made to protect the areas currently occupied and 2) areas adjacent to the study area be surveyed for martens and evaluated for their current and future suitability for martens and managed to reflect these evaluations. The analyses of the information from phase I and II should provide a detailed and hierarchical understanding of what constitutes "suitable" marten habitat for this population. Many of the locations on USFS lands where martens are currently found lie within Late-Successional Reserves or the Siskiyou Wilderness. However at least 9 locations do not lie within these protected areas and are in "matrix" lands that do not currently afford martens or suitable habitat for martens specific protection. Connectivity will need to be evaluated to assure full recovery to currently unoccupied regions of the range. Opportunities to reestablish martens in nearby, currently unoccupied areas of apparently suitable habitat currently exist within RNSP. Martens are not likely to occur in RNSP (Zielinski and Golightly 1996), however a new complete survey of the park lands will be conducted in 2002 (see Future Plans).

The results of the complete genetic analysis will have important contributions to the development of population recovery objectives, especially for large scale conservation planning. If it is determined that this population is the only remnant population of the distinct subspecies, *M. a. humboldtensis*, then it should probably be managed for connectivity only within its historical range. If the results of the genetic analyses suggest that the population is more closely related to populations either to the north in the Oregon Coast Range or from areas to the east in the Marble or Trinity mountains, then a much larger area will need to be targeted for the maintenance of connectivity. In either case, a second phase of genetic analyses focusing on nuclear DNA will probably be necessary for large scale and long term conservation planning.

Conservation Planning: Marten as a Focal Species for the Redwood Region

Noss et al. (2000) outline a conservation planning strategy for the redwood region that specifies the need for information on the needs of *highly imperiled* populations of native species and to base reserve and connectivity designs on the needs of the species most sensitive to fragmentation. The dramatic decline of the marten throughout much of its historical distribution within the redwood region clearly warrants its consideration as a *highly imperiled taxon* within this region. Martens have been shown to be highly sensitive to the loss and fragmentation of mature forest in several different forested regions of North America (Bissonette et al. 1997, Potvin et al. 1999). An explicit investigation of the effects of mature forest fragmentation on martens in the redwood region is likely impossible given the current condition of the region, most of which has far surpassed the 30-35% threshold of mature forest loss beyond which Bissonette et al. (1997) found that marten populations could no longer persist. However the future analysis of the data from phase I and II will provide additional information on the effects of fragmentation and loss of mature forest on habitat selection. Information from this study, at this stage of analysis, suggests that martens may be more sensitive to the loss of mature and old growth coastal forest characteristics (dense shrub layers, large diameter trees, snags, and logs) than other old forest associated species such as the fisher and spotted owl (*Strix occidentalis*). These species are still found in some extensively logged areas of coastal forests, but the marten is not. The marten appears to exhibit a strong association with mature and old growth coastal forest characteristics that make it well suited to serve as a focal species for conservation planning in the redwood region.

PHASE II:

A pilot effort of phase II began in August of 2001 with the goal of testing the techniques necessary to achieve the new objectives. This included attaching modified 'break-away' radio collars, attempting to locate rest structures by homing ('walking-in') on signals in difficult terrain, and collecting remote triangulation information. Overall the radio telemetry techniques worked well and much was learned about how the radio signals are affected by the diverse topography in the study area. We also realized that the steep and remote terrain will probably slow the pace of data collection on rest sites locations.

Radio Collars

Four martens (2M:2F) were fitted with radio collars in August and September 2001. As a precaution, the first collar was attached with a generous amount of extra space to avoid the negative effects that a snug collar could have as the animal gained weight or put on a thicker winter coat of fur. However, this female slipped her collar within 24 hours. It was recovered in a cavity approximately 0.5 m below the surface, created by rocks under a downed log. Subsequent collars were attached with less additional space and no other collar was slipped. Animals were monitored until 18 November after which snow blocked access to the study area. Attempts will be made to monitor the animals by airplane with the assistance of the CDFG during the winter and spring of 2002.

## Rest Sites

Seven rest structures were located from 24 Aug – 18 Nov 2001; 4 were snags and 3 were downed logs. The actual resting location was determined in 4 of the rest structures. One woodpecker hole and two natural platforms created by trunk breakage and decay were used in snags. One of these platforms was atop a 7 m broken snag where F06 was observed sleeping for over 2 hours in the late morning sun during mid October. A chamber created by a decaying log on top of bowling-ball sized boulders was used by F05. Also of note was the presence of multiple other large snags or logs in the immediate vicinity of each of the rest structures found in 2001. Detailed vegetation sampling at all rest sites is planned for 2002. One additional rest site was located in the vicinity of another site and was marked with several scats at its entrance. This structure was a downed log and the entrance was an enlarged woodpecker hole. A downed log in the immediate vicinity of these 2 rest structures was monitored for approximately 4 weeks using a remotely-triggered camera system (Trailmaster 1500, Goodson & Associates, INC, Lenexa, Kansas). The camera documented a marten visiting the area on one occasion during the daytime and a fisher on 2 separate occasions. Six attempts to locate martens at rest sites failed and resulted instead in the more general 'stand' locations.

## Remote Triangulation

A total of 54 locations via remote triangulation were collected in 2001 (18 for M05, 18 for M06, 18 for F06). Approximately 10% of remote triangulation attempts resulted in a set of bearings that were not useful to estimate the location of the animal. This process helped us learn which locations receive erroneous signals that are reflected or 'bounced'. Formal accuracy assessment for remote triangulations will begin during the 2002 field season.

## Home Range

Home range analysis will begin after the 2002 field season.

## Activity Patterns

Activity patterns for two martens (M05, F06) were remotely monitored during 7, 3-day sessions from 29 August - 19 November, 2001 as part of an independent project (J. Pennycook pers. comm.) The two martens were most active during the crepuscular (1.5 hours before and after sunrise and sunset) period, followed by the diurnal period. Martens were least active during the nocturnal period. By comparing the 95% confidence intervals of the differences, using two-sample t-test comparisons of the periods, the two martens were 17-28% more active during the diurnal compared to the nocturnal period ($Z = 8.04$, $P < 0.001$) and 9-21% more active during the crepuscular compared to the diurnal period ($Z = -13.77$, $P < 0.001$). Logistic regression was used to investigate the influence of temperature ($^oC$), cloud cover (%), and the presence of rain (Y/N), while taking time of day into account. Both the temperature ($\beta$ = -0.024, Z = -2.53, P = 0.012) and rain ($\beta$ = -0.699, Z = -3.77, P = <0.001) variables had significant negative effects on activity such that as the temperature increased or it rained, each marten was less likely to be active. Cloud cover ($\beta$ = 0.132, Z = 1.05, P = 0.29) had no significant relationship to activity.

## FUTURE PLANS

Formal habitat analysis will begin in February 2002 with hopes of completion by May 2002. The results of this work will be available in K. Slauson's Master's thesis, which should be completed by late summer. We will also be working with Dr. Stone to evaluate the results of the preliminary genetic analysis and whether we have sufficient information to make any conclusions about the marten subspecies question. These results will either lead to a publication of the findings or suggest that additional analysis will be needed in order to confirm the subspecific identity of the study population. Fieldwork on phase II will resume in June 2002 with the goal of radio-collaring 8-10 martens, half from the eastern and half from the serpentine-rich western portion of the study area. We hope to be able to monitor and collect rest site information on these martens into the winter of 2002. However, we are currently seeking additional funds to support this effort during the winter months. Also, in June 2002 we will be starting a new study with Redwood National and State Parks to determine the distribution of martens and fishers on park lands. This will provide the opportunity to determine whether martens still persist in the largest remnant patches of old growth redwood forest.

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* Available at http://www.rsl.psw.fs.fed.us/pubs/WILD90S.html

## ACKNOWLEDGEMENTS

We must first thank the individuals and organizations who provided financial and logistical support to get the project started: Quentin Youngblood, Brenda Devlin, Kristin Schmidt, Tony Hacking and the Six Rivers National Forest; Ruskin Hartley and Save-The-Redwoods League; Esther Burkett and the California Department of Fish and Game; Amedee Brickey and the Arcata Field Office of the U. S. Fish and Wildlife Service; Redwood Sciences Lab, Pacific Southwest Research Station, U.S Forest Service; and the Department of Forest Science, Oregon State University. We wish to thank also the Simpson Timber Company and Keith Hamm, Lowell Diller, and Chris Howard for providing access and assistance. Rick Truex, Chet Ogan, and especially Ric Schlexer provided critical logistical support throughout the year. We also thank Jan Werren for producing a variety of GIS maps and products that were essential for conducting this work. Finally and most importantly, we would like to acknowledge the members of the field crew who endured the ruggedness of the study area and made many personal sacrifices to make phase I a success: Lisa Cross, Jessica Flayer, Jesse Grossman, Heather Lessig, Brit O'Brien, Julian Mangas, Giovanni Manghi, Jody Pennycook, David Prins, Nick Polato, Jonothan Storm, Noel Soucy and especially Ben Marckmann.

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Figure 1.  Study area with sample unit grid and all American marten detections within the historical range of *M. a. humboldtensis*: 1996-1998.

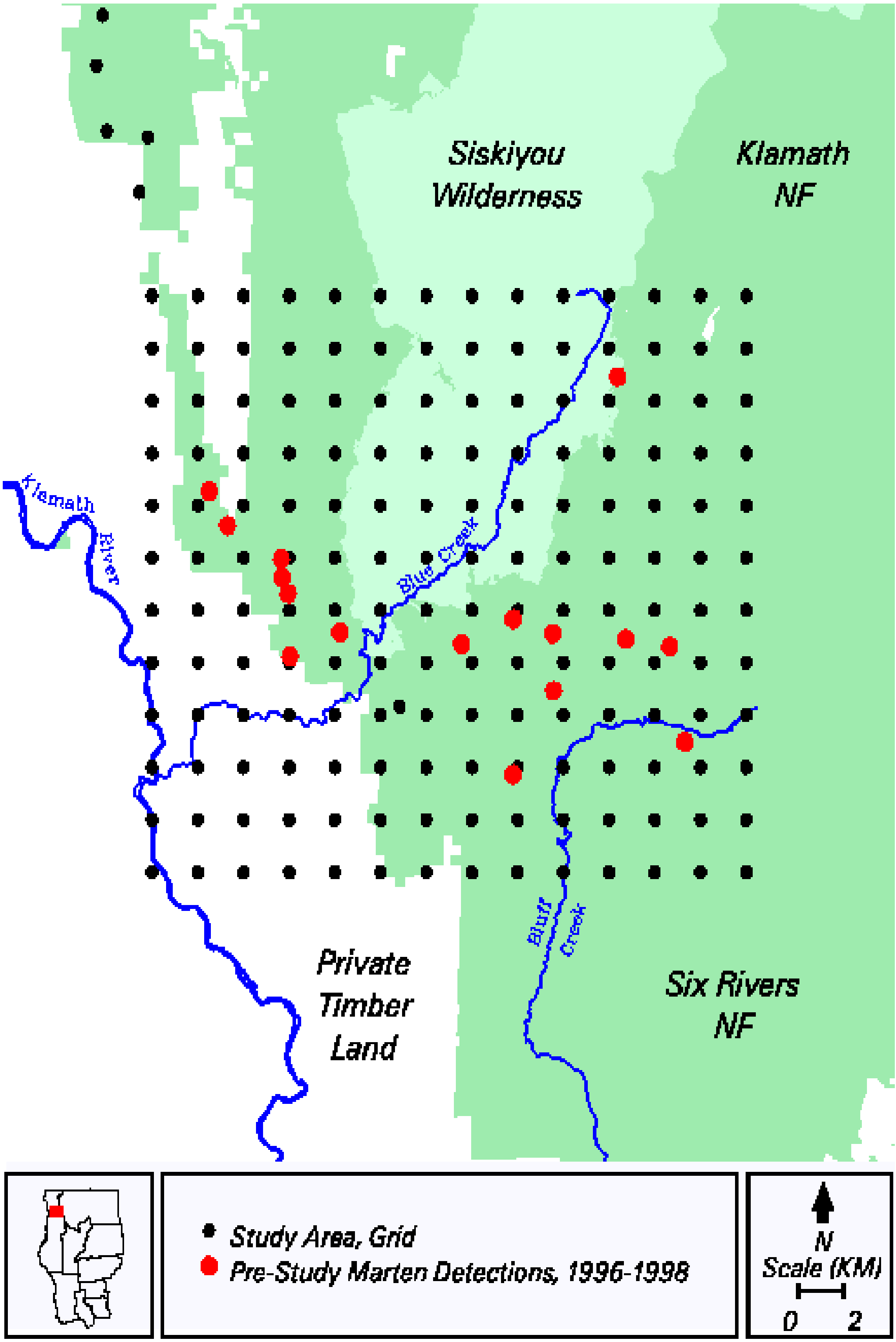


Figure 2. Sample units completed, location of exploratory units, and marten detections: 2000-2001.

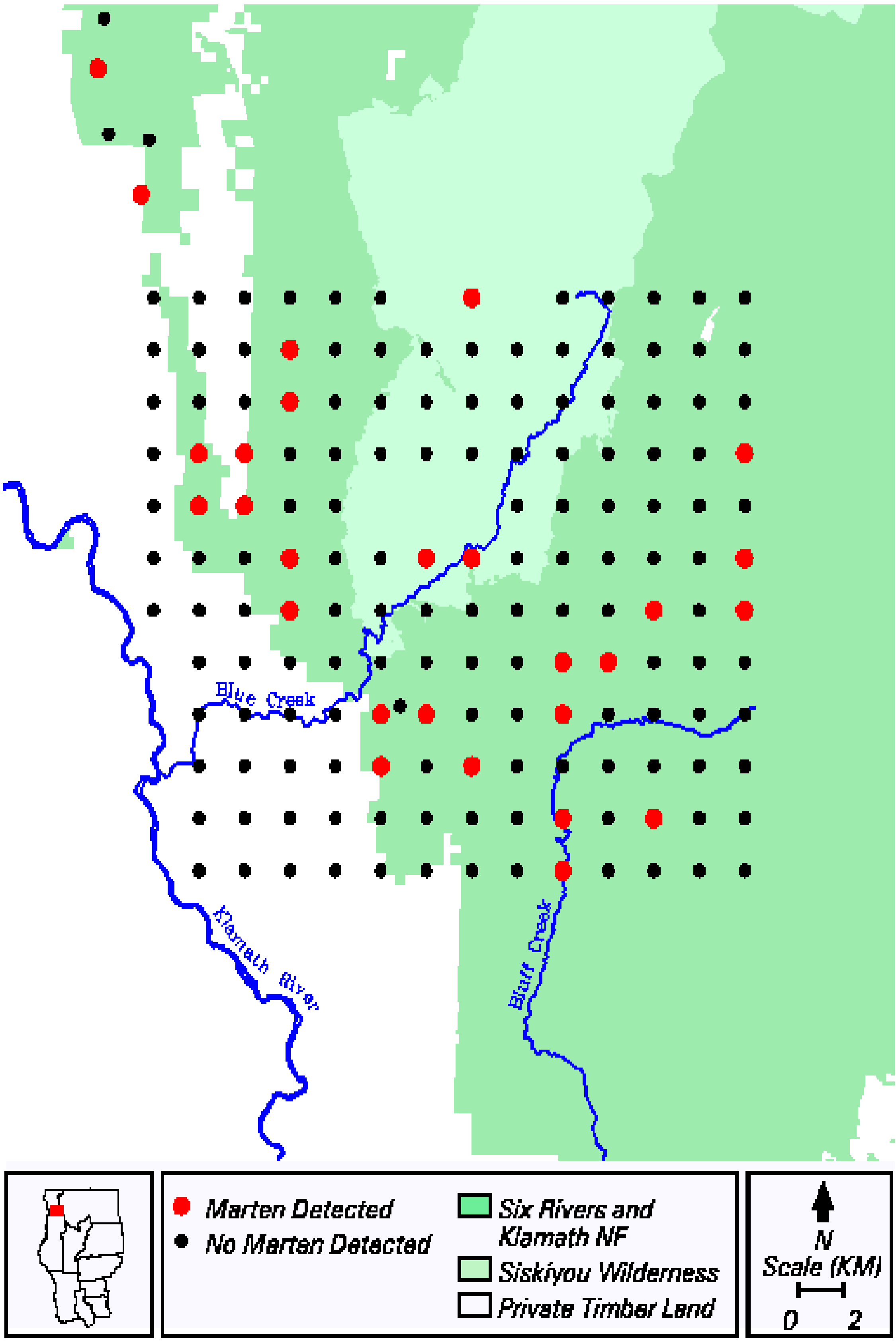


Figure 3. Sample units detecting American martens and fishers at track-plate stations: 2000-2001.

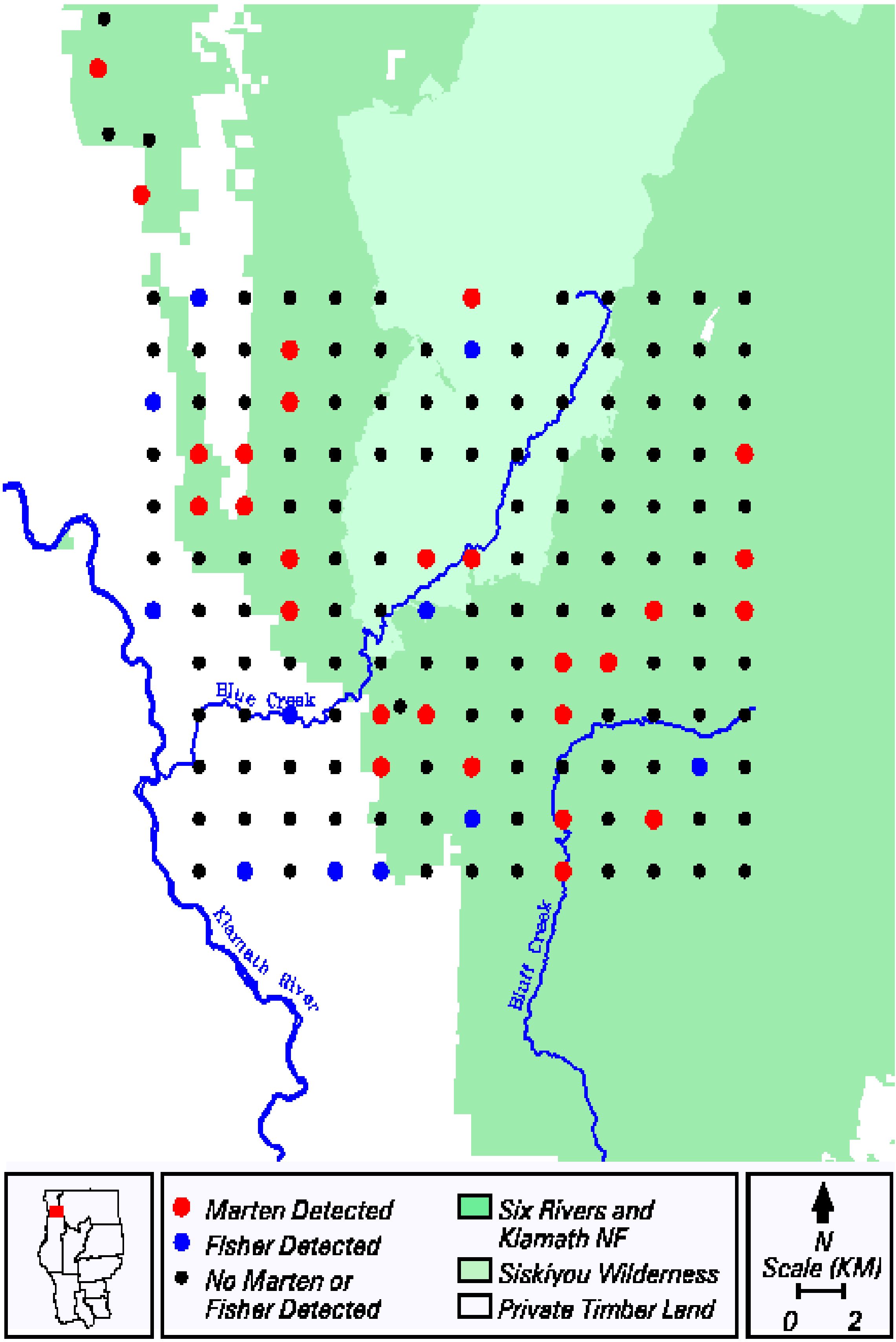
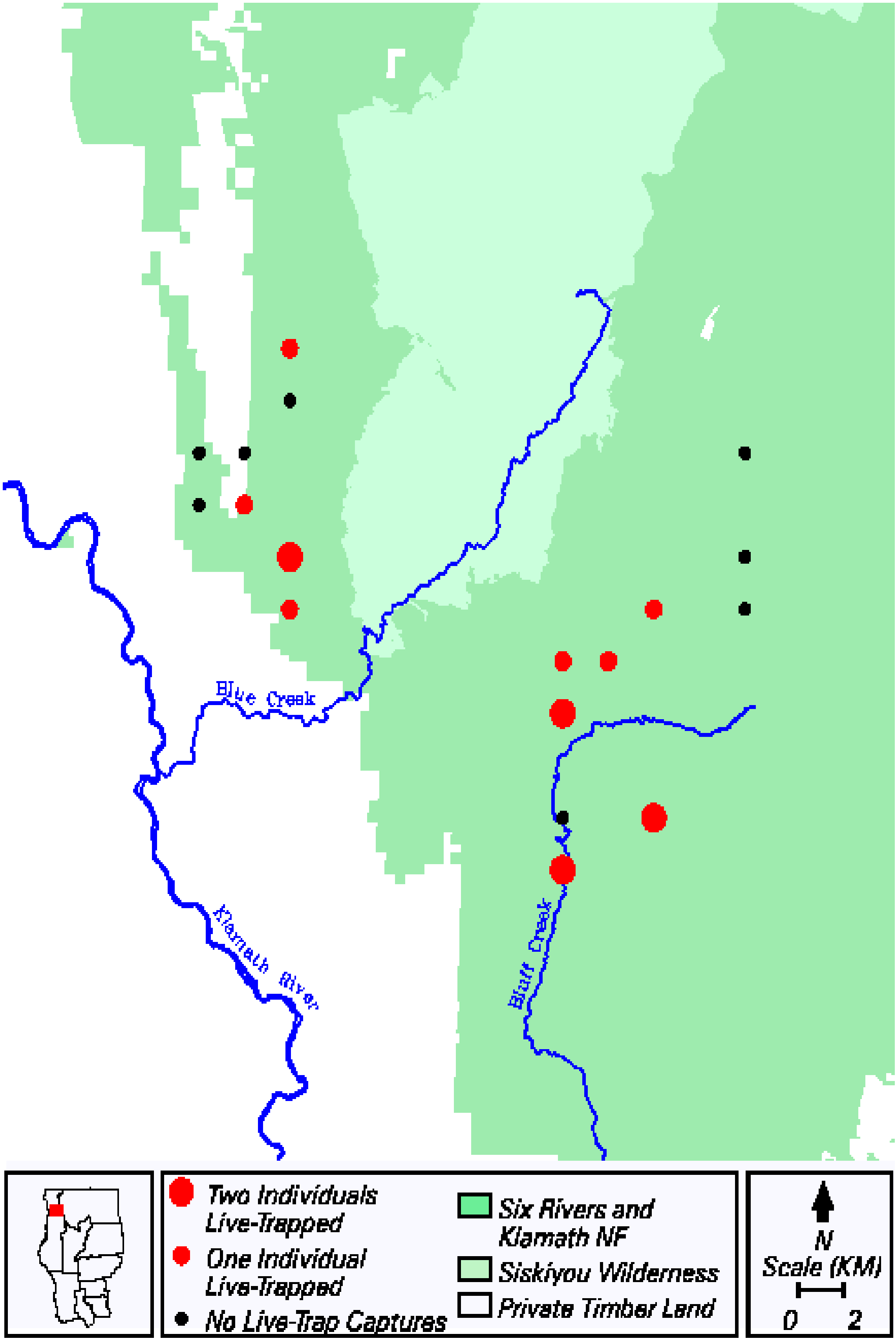


Figure 4. American marten live-trapping results: 2000-2001.



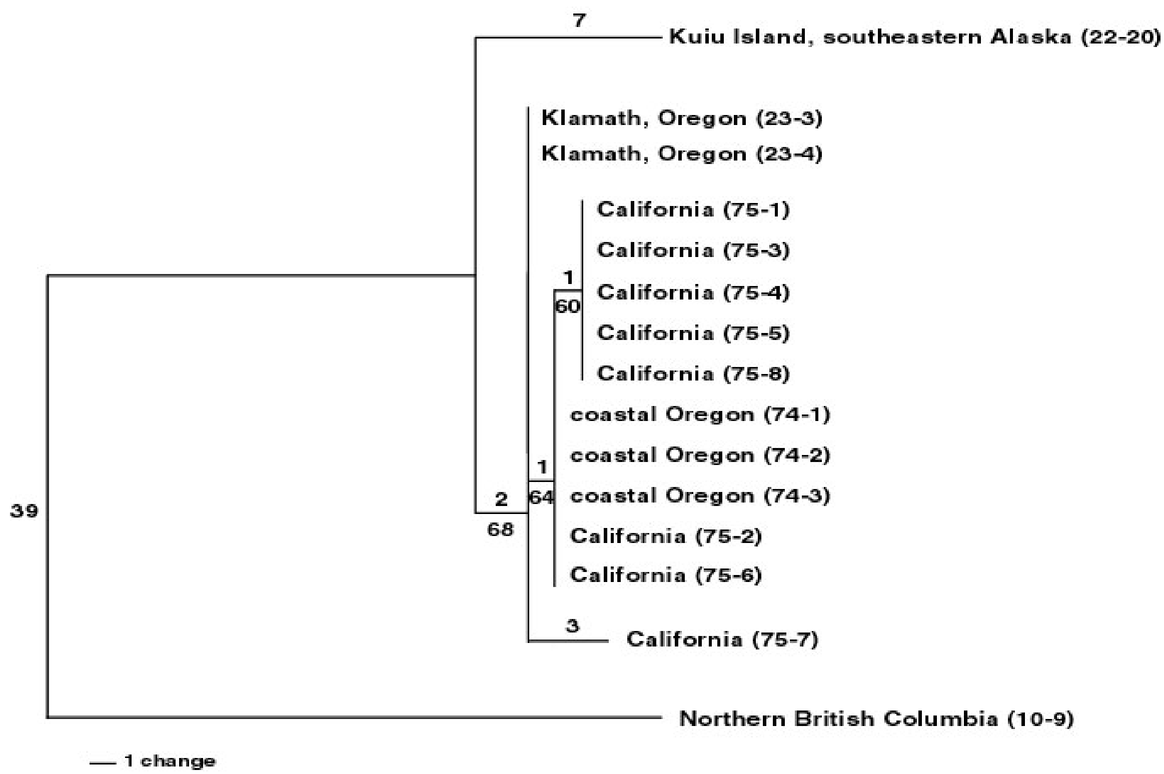



Figure 5. Phylogenetic tree showing relationships among *Martes americana* individuals. This tree was generated using cytochrome b and control region sequences (1428 base pairs). Numbers above branches represent branch lengths, or the number of base pair differences out of 1428, and numbers below branches are bootstrap values, which show support for the branching pattern. Numbers in parentheses are identification numbers.

Key: California= samples from the study population in NW CA; coastal Oregon= samples from 3 roadkills collected in the vicinity of the Oregon Dunes NRA and Siuslaw N.F.; Klamath, Oregon= samples from southern cascades, Klamath county, Oregon.

Figure 6. American marten detections and distribution of serpentine and non- serpentine habitats within the study area: 2000-2001

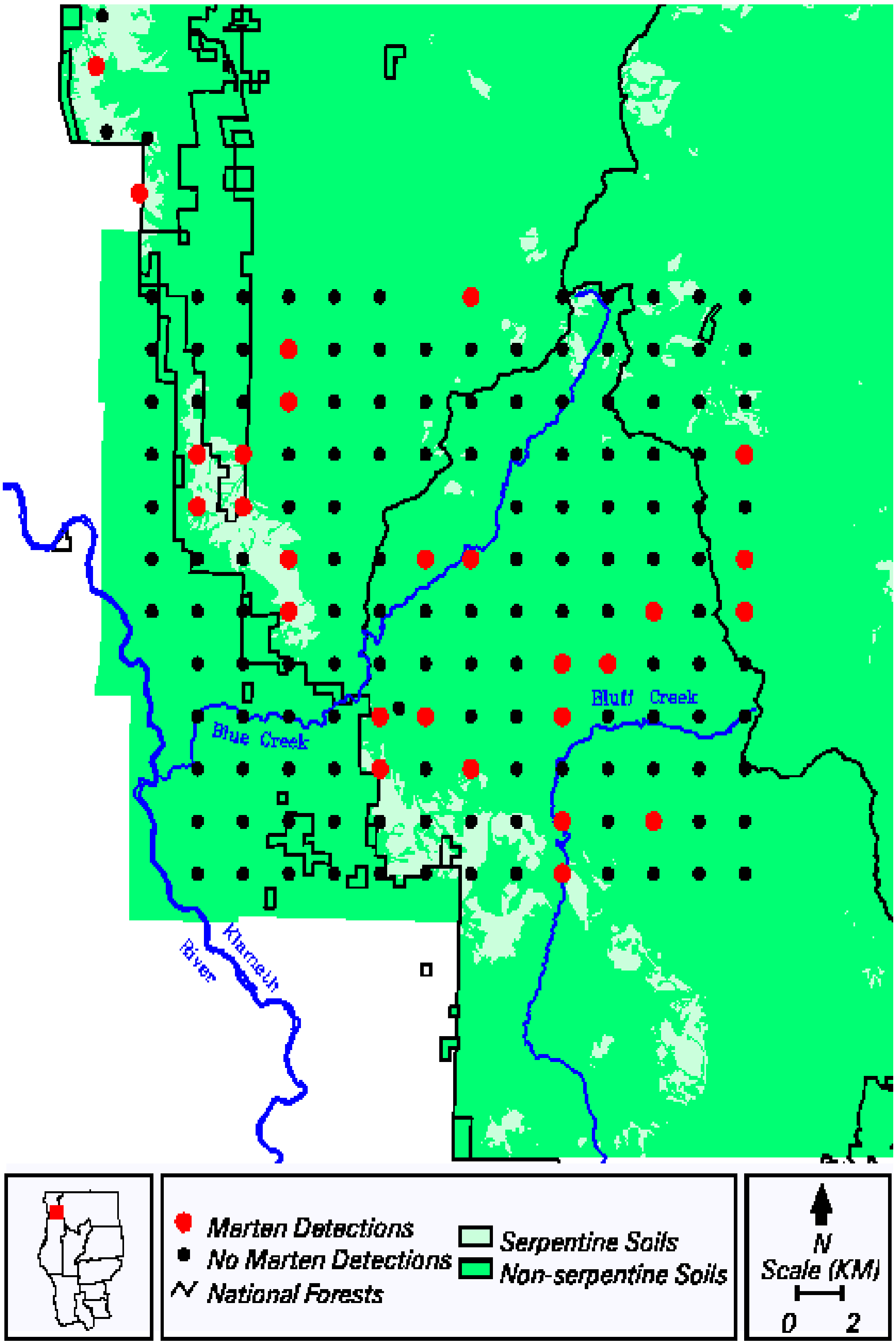


Figure 7. American marten detections and seral stage distribution for the study area: 2000-2001.

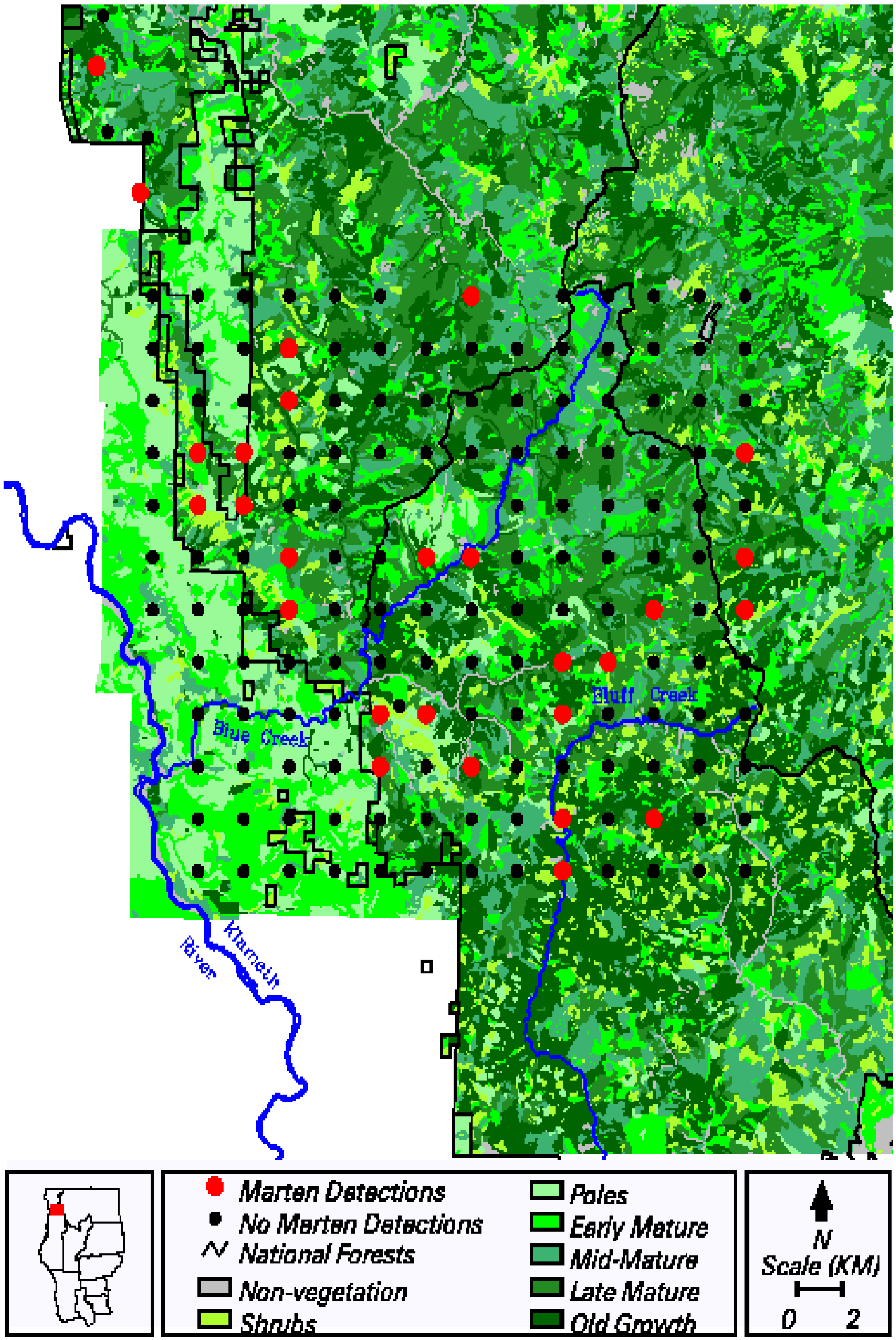


Table 1. Species detected at track-plate stations in 2000-2001.

| Species | Sample Units (n=159) Number | Sample Units (n=159) Percent | Stations (n=318) Number | Stations (n=318) Percent |
|---|---|---|---|---|
| American marten | 26 | 16.4 | 34 | 10.7 |
| Fisher | 11 | 6.9 | 16 | 9.3 |
| Spotted skunk | 34 | 21.4 | 50 | 29.1 |
| Weasel sp. | 3 | 1.9 | 3 | 1.7 |
| Ringtail | 8 | 5.0 | 10 | 5.8 |
| Gray fox | 5 | 3.1 | 6 | 3.5 |
| American Black bear | 33 | 20.8 | 37 | 21.5 |
| Porcupine | 1 | 0.6 | 1 | 0.6 |
| Dusky-footed woodrat | 8 | 5.0 | 9 | 5.2 |
| Golden-mantled ground squirrel | 2 | 1.3 | 2 | 1.2 |
| California ground squirrel | 4 | 2.5 | 4 | 2.3 |
| Northern flying squirrel | 7 | 4.4 | 7 | 4.1 |
| Douglas squirrel | 3 | 1.9 | 3 | 1.7 |
| Chipmunk sp. | 42 | 26.4 | 51 | 29.7 |
| Small mammal species* | 117 | 73.6 | 167 | 97.1 |
| Pacific giant salamander | 6 | 3.8 | 6 | 3.5 |
| Western fence lizard | 8 | 5.0 | 8 | 4.7 |

*Includes rodents smaller than chipmunks whose tracks are not currently distinguishable.

**Species totals in this table do not include species detected at the 5 exploratory sample units located to the northwest of the study grid. Exploratory Unit Results (# det/Sample Units, # det/Stations): American marten (2/5, 2/10), Spotted skunk (3/5, 5/10), Small mammal species (4/5, 6/10).

Table 2. Immobilization summary for each American marten captured during 2000-2001.

| Individual # | Date of Capture | Injection # | Dose (mL) | Minutes Immobilized | Initial Body Temp (ºF) | Final Body Temp (ºF) |
|---|---|---|---|---|---|---|
| F01 | 06-JULY-2000 | 1/2 | 0.10/0.04 | 23 | 102.5 | 101.7 |
| F02 | 11-JULY-2000 | 1 | 0.15 | 30 | 105.4 | 104.3 |
| F03 | 19-SEPT-2000 | 1/2 | 0.13/0.10 | 30 | 104.2 | 102.8 |
| F04 | 20-SEPT-2000 | 1 | 0.14 | 26 | 103.1 | 102.6 |
| F05 | 20-AUG-2001 | 1/2/3 | 0.12/0.07/0.05 | 50 | 103.8 | 100.6 |
| F06 | 22-AUG-2001 | 1/2/3 | 0.12/0.08/0.05 | 32 | 103.0 | 99.6 |
| M01 | 08-JULY-2000 | 1 | 0.15 | 19 | 104.7 | 103.5 |
| M02 | 19-JULY-2000 | 1 | 0.15 | 20 | 102.5 | 102.8 |
| M03 | 21-JULY-2000 | 1/2 | 0.14/0.10 | 30 | 102.2 | 101.0 |
| M04 | 30-SEPT-2000 | 1 | 0.15 | 28 | 102.7 | 100.8 |
| M05 | 22-AUG-2001 | 1/2/3 | 0.15/0.09/0.10 | 38 | 102.8 | 99.6 |
| M06 | 04-SEPT-2001 | 1/2/3 | 0.15/0.15/0.10 | 41 | 102.7 | 103.2 |
| M07 | 18-SEPT-2001 | 1/2 | 0.15/0.09 | 25 | 103.6 | 102.8 |
| M08 | 17-OCT-2001 | 1 | 0.15 | 30 | 102.8 | 101.0 |

Table 3. Morphological and demographic features of American martens live-trapped during 2000-2001.

| Individual # | Date of Initial Capture | Total Length (mm) | Tail Length (mm) | Weight (g) | Reproductive Status (Females only) | *Estimated Age Temp (ºF) |
|---|---|---|---|---|---|---|
| F01 | 06-JULY-2000 | 535 | 170 | 600 | LACTATING | ADULT |
| F02 | 11-JULY-2000 | 508 | 157 | - | LACTATING | ADULT |
| F03 | 19-SEPT-2000 | 535 | 190 | 630 | UNDEV TEATS | JUV (<2) |
| F04 | 20-SEPT-2000 | 530 | 170 | 630 | DEVEL TEATS | ADULT |
| F05 | 20-AUG-2001 | 495 | 182 | 534 | DEVEL TEATS | ADULT |
| F06 | 22-AUG-2001 | 570 | 175 | 600 | UNDEV TEATS | JUV (<2) |
| M01 | 08-JULY-2000 | 645 | 187 | 950 | - | ADULT |
| M02 | 19-JULY-2000 | 555 | 176 | 850 | - | Y-ADULT |
| M03 | 21-JULY-2000 | 560 | 164 | 1080 | - | ADULT |
| M04 | 30-SEPT-2000 | 567 | 170 | 915 | - | ADULT |
| M05 | 22-AUG-2001 | 620 | 195 | 740 | - | Y-ADULT |
| M06 | 04-SEPT-2001 | 595 | 173 | 903 | - | ADULT |
| M07 | 18-SEPT-2001 | 597 | 180 | 815 | - | ADULT |
| M08 | 17-OCT-2001 | 562 | 202 | 860 | - | Y-ADULT |

*Ages are estimated using the combination of reproductive characteristics, tooth wear, and overall condition.

Table 4. Plot level characteristics for stations in non-serpentine soils where American martens were detected in 2000-2001.

| Sample Unit | Station | Serpentine Soils (No/Yes) | WHR Type | WHR Size | WHR %CC | Total %CC | Overstory %CC | Understory %CC | Shrub %Cover |
|---|---|---|---|---|---|---|---|---|---|
| 8 | B | N | DFR | 6 | D | 95 | 70 | 25 | 60 |
| 18 | A | N | MHC | 5 | D | 65 | 30 | 35 | 85 |
| 18 | B | N | MHC | 5 | D | 70 | 40 | 30 | 100 |
| 32 | A | N | MRI | 4 | D | 75 | 5 | 70 | 30 |
| 45 | A | N | MHC | 2 | D | 60 | 60 | 0 | 85 |
| 56 | A | N | MRI | 3 | D | 85 | 85 | 0 | 10 |
| 77 | A | N | DFR | 5 | D | 75 | 45 | 30 | 90 |
| 77 | B | N | MHC | 4 | D | 75 | 20 | 55 | 90 |
| 78 | A | N | MHC | 4 | D | 100 | 40 | 60 | 30 |
| 78 | B | N | MHC | 4 | D | 90 | 40 | 50 | 70 |
| 84 | A | N | MHC | 5 | D | 95 | 50 | 45 | 90 |
| 96 | A | N | MHC | 6 | D | 75 | 55 | 20 | 75 |
| 98 | A | N | MHC | 4 | D | 85 | 10 | 75 | 100 |
| 108 | A | N | DFR | 5 | D | 80 | 60 | 20 | 70 |
| 109 | A | N | DFR | 3 | D | 70 | 70 | 0 | 80 |
| 109 | B | N | MHC | 3 | M | 40 | 40 | 0 | 100 |
| 118 | B | N | MHW | 3 | D | 75 | 15 | 60 | 75 |
| 119 | A | N | MHW | 3 | D | 75 | 15 | 60 | 100 |
| 122 | A | N | MHC | 6 | D | 80 | 20 | 60 | 50 |
| 122 | B | N | DFR | 5 | D | 90 | 60 | 30 | 100 |
| 132 | A | N | MHC | 4 | D | 90 | 20 | 60 | 100 |
| 132 | B | N | MHC | 3 | D | 85 | 10 | 75 | 100 |
| 134 | A | N | DFR | 5 | D | 60 | 20 | 40 | 80 |
| 150 | A | N | DFR | 6 | D | 90 | 50 | 40 | 65 |
| 152 | A | N | DFR | 4 | D | 60 | 45 | 15 | 95 |
| 152 | B | N | DFR | 5 | D | 80 | 70 | 10 | 90 |
| 164 | A | N | DFR | 4 | D | 95 | 20 | 75 | 35 |
| 995 | A | N | MHC | 6 | D | 90 | 20 | 70 | 20 |
| Mean: Non- Serpentine | | | | | | 78.8 | 38.8 | 39.6 | 74.1 |
| St. Deviation | | | | | | 13.6 | 22.1 | 25.2 | 27.1 |

* All percentage estimates in this table represent ocular estimations of the respective plot variable.

<u>WHR KEY</u>: Montane hardwood-conifer (MHC), Douglas-fir (DFR), western white pine (WPN),Montane riparian (MRI), Montane Hardwood (MHW); Tree sizes: sapling 1-6" DBH(2), Pole 6-11" DBH (3), small 11-24" DBH (4), medium/large >24" DBH (5), multi-layed size class 5 trees over a distinct layer of size 3 or 4 trees (6); Cover: 10-24% (S), 25-39% (O), 40-59% (M), 60-100% (D).

Table 5. Plot level characteristics for stations in serpentine soils where American martens were detected in 2000-2001*.

| Sample Unit | Station | Serpentine Soils (No/Yes) | WHR Type | WHR Size | WHR %CC | Total %CC | Overstory %CC | Understory %CC | Shrub %Cover |
|---|---|---|---|---|---|---|---|---|---|
| 44 | A | Y | WPN** | 2 | S | 20 | 20 | 0 | 85 |
| 58 | B | Y | MCP | 3 | D | 5 | 5 | 0 | 90 |
| 59 | A | Y | WPN** | 3 | M | 55 | 50 | 5 | 70 |
| 74 | A | Y | WPN** | 3 | P | 30 | 20 | 10 | 80 |
| 74 | B | Y | WPN** | 3 | P | 35 | 15 | 20 | 80 |
| 88 | B | Y | MCP | 3 | D | 5 | 5 | 0 | 95 |
| 300*** | B | Y | LPN | 3 | P | 25 | 25 | 0 | 95 |
| 303*** | B | Y | DFR | 4 | P | 30 | 20 | 10 | 95 |
| Mean: Serpentine | | | | | | 25.6 | 20.0 | 5.6 | 86.3 |
| St. Deviation | | | | | | 16.4 | 14.1 | 7.3 | 9.2 |
| Mean: Non- Serpentine | | | | | | 78.8 | 38.8 | 39.6 | 74.1 |
| St. Deviation | | | | | | 13.6 | 22.1 | 25.2 | 27.1 |
| Mean: Total | | | | | | 66.9 | 34.6 | 32.1 | 76.8 |
| St. Deviation | | | | | | 26.4 | 21.9 | 26.5 | 24.7 |

* All percentage estimates in this table represent ocular estimations of the respective plot variable.

**Denotes sites where CWHR key failed to identify the forest type. In each of these cases the site was dominated by Western white pine and a type was created (WPN) for use in this table.

***These are exploratory sites located in the Little Rattlesnake Mtn. Vicinity sampled in 2001.

WHR KEY: Douglas-fir (DFR), western white pine (WPN),Montane chaparral (MCP) Lodgepole pine (LPN); Tree sizes: sapling 1-6" DBH(2), Pole 6-11" DBH (3), small 11-24" DBH (4), medium/large >24" DBH (5), multi-layed size class 5 trees over a distinct layer of size 3 or 4 trees (6); Shrub sizes: mature shrub (3); Cover: 10-24% (S), 25-39% (O), 40-59% (M), 60-100% (D).

Table 6. Stand characteristics for sample units in non-serpentine soils where American martens were detected in 2000-2001*

| Sample Unit | Serp. Soils (No/Yes) | Series-Sub-series | Seral Stage | Total Canopy Closure (%) | Conifer Canopy Closure (%) | Hardwood Canopy Closure (%) | Elevation (m) |
|---|---|---|---|---|---|---|---|
| 8 | N | Douglas-Fir-Chinquapin | Late-mature | 85 | 80 | 10 | 1077 |
| 18 | N | Tanoak/Evergreen Huckleberry | Late-mature | 90 | 70 | 45 | 703 |
| 32 | N | Tanoak-P-O-Cedar-W. Hemlock | Old-growth | 90 | 35 | 75 | 628 |
| 45 | N | Tanoak/Salal | Pole-harvest | 85 | 35 | 50 | 936 |
| 56 | N | Tanoak-Canyon Live Oak | Old-growth | 90 | 60 | 50 | 1475 |
| 77 | N | Tanoak/Dry shrub | Old-growth | 95 | 50 | 80 | 465 |
| 78 | N | Tanoak-Evergreen Huckleberry | Old-growth | 90 | 80 | 25 | 519 |
| 84 | N | Tanoak-Chinquapin | Old-growth | 90 | 70 | 50 | 884 |
| 96 | N | Douglas-Fir-Chinquapin | Mid-mature w Predoms | 65 | 60 | 10 | 1153 |
| 98 | N | Tanoak-Chinquapin | Old-growth | 80 | 60 | 30 | 901 |
| 108 | N | Tanoak/Evergreen Huckleberry | Old-growth | 95 | 65 | 60 | 704 |
| 109 | N | Douglas-Fir-Chinquapin | Pole-harvest | 80 | 70 | 10 | 1166 |
| 118 | N | Tanoak/Evergreen Huckleberry | Shrub-natural | 80 | 75 | 15 | 440 |
| 119 | N | Tanoak/Salal | Late-mature | 65 | 60 | 10 | 605 |
| 122 | N | Tanoak-Maple | Late-mature | 65 | 40 | 30 | 828 |
| 132 | N | Douglas-Fir/Huckleberry Oak | Old-growth | 70 | 70 | 5 | 756 |
| 134 | N | Tanoak-Chinquapin | Old-growth | 90 | 80 | 20 | 881 |
| 150 | N | Tanoak-Canyon Live Oak | Old-growth | 90 | 55 | 65 | 1055 |
| 152 | N | Douglas-Fir-Chinquapin | Old-growth | 85 | 75 | 15 | 889 |
| 164 | N | Tanoak-Chinquapin | Old-growth | 90 | 70 | 35 | 662 |
| 995 | N | Douglas-Fir-Chinquapin | Mid-mature | 90 | 90 | 5 | 1088 |
| Mean: Non-serpentine | | | | 88.0 | 67.5 | 34.8 | 848.3 |
| St. Deviation | | | | 9.7 | 14.9 | 23.8 | 261.6 |

*All stand information came from the Ecology Program coverage; percent estimates are for the entire stand, methods of estimation can be found in Jimerson et al. (1995) and Jimerson et al. (1996).
**Conifer and Hardwood percent cover can exceed 100% to include overlapping cover not included in the total canopy closure estimation.

Table 7. Stand characteristics for sample units in serpentine soils where American martens were detected in 2000-2001*

| Sample Unit | Serpentine Soils (No/Yes) | Series-Sub-series/Association | Seral Stage | Total Canopy Closure (%) | Conifer Canopy Closure (%) | Hardwood Canopy Closure (%) | Elevation (m) |
|---|---|---|---|---|---|---|---|
| 44 | Y | W. White Pine-Lodgepole Pine/Huckleberry Oak-Dwarf Tanoak | Shrub-natural | 5 | 5 | 0 | 1112 |
| 58 | Y | W. White Pine-Lodgepole Pine/Huckleberry Oak-Dwarf Tanoak | Shrub-natural | 5 | 5 | 0 | 1173 |
| 59 | Y | W. White Pine-Lodgepole Pine/Huckleberry Oak-Dwarf Tanoak | Mid-mature | 55 | 55 | 0 | 1196 |
| 74 | Y | W. White Pine-Lodgepole Pine/Huckleberry Oak-Dwarf Tanoak | Early-mature | 55 | 55 | 0 | 1033 |
| 88 | Y | W. White Pine-Douglas-fir/Huckleberry Oak-Dwarf Tanoak | Shrub-harvest | 5 | 5 | 0 | 1124 |
| 300*** | Y | NA | NA | NA | NA | NA | 1077 |
| 303*** | Y | W. White Pine-Lodgepole Pine/Huckleberry Oak-Dwarf Tanoak | Early-mature | 55 | 55 | 0 | 908 |
| Mean: Serpentine | | | | 30.0 | 30.0 | 0.0 | 1091.0 |
| St. Deviation | | | | 27.4 | 27.4 | 0.0 | 106.0 |
| Mean: Non-serpentine | | | | 88.0 | 64.5 | 37.0 | 848.3 |
| St. Deviation | | | | 9.7 | 19.0 | 25.9 | 261.6 |
| Mean: Total | | | | 69.3 | 52.5 | 26.4 | 908.5 |
| St. Deviation | | | | 27.1 | 24.5 | 27.2 | 253.1 |

*All stand information came from the Ecology Program coverage; percent estimates are for the entire stand, methods of estimation can be found in Jimerson et al. (1995) and Jimerson et al.(1996).
**Conifer and Hardwood percent cover can exceed 100% to include overlapping cover not included in the total canopy closure estimation.

Table 8. Summary of the composition of seral stages within 0.5 km circles centered on sample units with non-serpentine soils where American martens were detected in 2000-2001.

| Sample unit | Serpentine Soils (No/Yes) | % Shrub | % Pole | %Early-Mature | % Mid-Mature | % Late-Mature | % Old Growth | % Non-forest |
|---|---|---|---|---|---|---|---|---|
| 8 | N | 0.00 | 0.92 | 9.86 | 76.24 | 12.98 | 0.00 | 0.00 |
| 18 | N | 24.6 | 19.7 | 0.0 | 0.0 | 35.4 | 20.3 | 0.0 |
| 32 | N | 24.7 | 19.6 | 0.2 | 0.8 | 19.2 | 35.5 | 0.9 |
| 45 | N | 9.7 | 67.2 | 0.4 | 6.0 | 9.8 | 6.9 | 0.0 |
| 56 | N | 11.7 | 0.0 | 36.7 | 22.2 | 0.0 | 29.4 | 0.0 |
| 77 | N | 0.0 | 24.4 | 39.1 | 0.0 | 0.8 | 35.7 | 0.0 |
| 78 | N | 0.0 | 6.3 | 26.0 | 9.8 | 1.8 | 47.4 | 6.8 |
| 84 | N | 7.5 | 0.0 | 5.2 | 1.7 | 39.8 | 45.8 | 0.0 |
| 96 | N | 7.3 | 0.7 | 7.2 | 15.2 | 38.1 | 31.5 | 0.0 |
| 98 | N | 17.6 | 0.0 | 11.9 | 7.6 | 0.0 | 62.9 | 0.0 |
| 108 | N | 3.1 | 0.0 | 0.6 | 17.2 | 27.7 | 50.3 | 0.9 |
| 109 | N | 3.7 | 29.8 | 18.8 | 8.7 | 27.7 | 11.2 | 0.0 |
| 118 | N | 48.6 | 12.5 | 3.9 | 17.6 | 11.2 | 0.0 | 4.6 |
| 119 | N | 40.6 | 25.9 | 0.0 | 17.3 | 3.0 | 13.1 | 0.0 |
| 122 | N | 0.0 | 42.6 | 1.0 | 0.0 | 21.5 | 34.9 | 0.0 |
| 132 | N | 5.1 | 14.0 | 0.0 | 8.9 | 40.5 | 20.2 | 0.3 |
| 134 | N | 0.0 | 5.3 | 2.2 | 27.7 | 12.8 | 47.1 | 3.8 |
| 150 | N | 32.2 | 10.1 | 10.1 | 1.5 | 0.0 | 45.6 | 0.4 |
| 152 | N | 5.8 | 0.0 | 12.8 | 0.5 | 0.0 | 80.8 | 0.0 |
| 164 | N | 9.9 | 5.0 | 17.2 | 8.6 | 3.2 | 54.1 | 1.5 |
| 995 | N | 0.0 | 0.0 | 0.0 | 25.0 | 47.4 | 26.9 | 0.0 |
| Mean: Non-serpentine | | 12.0 | 13.5 | 9.7 | 13.0 | 16.8 | 33.3 | 0.9 |
| St. Deviation | | 14.3 | 17.3 | 11.9 | 16.9 | 16.1 | 20.9 | 1.8 |
| Mean Non-detection (N=101)** | | 7.75 | 9.26 | 16.57 | 21.72 | 20.57 | 19.79 | NA |
| St. Deviation | | 12.32 | 17.44 | 17.67 | 21.63 | 20.18 | 20.02 | NA |

*This category lumps all forms of logging (e.g. clear cut, selective)

** 21 additional sample units were completed on Simpson Timber Company lands which are not represented here.
The addition of the data from these locations will increase the overall percentages in the early seral stage classes and decrease the percentage in the latter seral stages for the non-detection means.

Table 9. Summary of the composition of seral stages within 0.5 km circles centered on sample units with serpentine soils where American martens were detected in 2000-2001.

| Sample unit | Serpentine Soils (No/Yes) | % Shrub | % Pole | %Early-Mature | % Mid-Mature | % Late-Mature | % Old Growth | % Non-forest |
|---|---|---|---|---|---|---|---|---|
| 44 | Y | 20.2 | 4.3 | 51.5 | 22.3 | 0.2 | 1.1 | 0.3 |
| 58 | Y | 77.4 | 18.9 | 3.0 | 0.7 | 0.0 | 0.0 | 0.0 |
| 59 | Y | 2.5 | 25.6 | 16.3 | 14.0 | 10.4 | 31.1 | 0.0 |
| 74 | Y | 0.0 | 15.2 | 32.2 | 13.4 | 39.2 | 0.0 | 0.0 |
| 88 | Y | 57.1 | 3.3 | 32.5 | 0.0 | 4.0 | 3.1 | 0.0 |
| 300 | Y | NA | NA | NA | NA | NA | NA | NA |
| 303 | Y | 2.1 | 0.0 | 31.0 | 17.7 | 7.6 | 36.5 | 5.0 |
| Mean: Serpentine | | 26.5 | 11.2 | 27.8 | 11.4 | 10.2 | 12.0 | 0.9 |
| St. Deviation | | 33.0 | 10.2 | 16.5 | 9.1 | 14.8 | 17.0 | 2.0 |
| Mean: Non-serpentine | | 12.0 | 13.5 | 9.7 | 13.0 | 16.8 | 33.3 | 0.9 |
| St. Deviation | | 14.3 | 17.3 | 11.9 | 16.9 | 16.1 | 20.9 | 1.8 |
| Mean: Total | | 15.7 | 13.5 | 13.0 | 12.4 | 15.6 | 28.3 | 0.7 |
| St. Deviation | | 20.3 | 15.9 | 14.7 | 15.6 | 16.0 | 22.2 | 1.7 |
| Mean Non-detection (N=101)** | | 7.75 | 9.26 | 16.57 | 21.72 | 20.57 | 19.79 | NA |
| St. Deviation | | 12.32 | 17.44 | 17.67 | 21.63 | 20.18 | 20.02 | NA |

*This category lumps all forms of logging (e.g. clear cut, selective)

** 21 additional sample units were completed on Simpson Timber Company lands which are not represented here.
The addition of the data from these locations will increase the overall percentages in the early seral stage classes and decrease the percentage in the latter seral stages for the non-detection means.

Table 10. Summary of the composition of seral stages within 1.0 km circles centered on sample units in non-serpemtime soils where American martens were detected in 2000-2001.

| Sample unit | Serpentine Soils (No/Yes) | % Shrub | % Pole | %Early-Mature | % Mid-Mature | % Late-Mature | % Old Growth | % Non-forest | % Logged |
|---|---|---|---|---|---|---|---|---|---|
| 8 | N | 0.0 | 0.0 | 9.9 | 16.7 | 58.3 | 15.1 | 0.1 | 0.0 |
| 18 | N | 21.5 | 26.2 | 9.6 | 1.3 | 23.7 | 17.7 | 0.0 | 48.6 |
| 32 | N | 26.4 | 11.7 | 3.3 | 3.4 | 32.1 | 23.2 | 0.0 | 41.8 |
| 45 | N | 0.0 | 52.6 | 12.7 | 4.2 | 22.1 | 8.4 | 0.0 | 52.2 |
| 56 | N | 14.8 | 0.3 | 17.0 | 33.3 | 1.4 | 33.1 | 0.0 | 13.5 |
| 77 | N | 0.0 | 36.6 | 24.9 | 0.2 | 14.1 | 23.7 | 0.5 | 0.0 |
| 78 | N | 0.1 | 12.4 | 23.8 | 14.0 | 12.0 | 32.7 | 5.0 | 0.1 |
| 84 | N | 5.4 | 2.9 | 11.5 | 11.6 | 24.5 | 44.2 | 0.0 | 8.9 |
| 96 | N | 7.3 | 0.5 | 16.1 | 18.6 | 41.1 | 16.4 | 0.0 | 9.8 |
| 98 | N | 23.0 | 7.8 | 9.7 | 2.7 | 7.0 | 42.9 | 0.0 | 34.4 |
| 108 | N | 3.7 | 0.2 | 8.4 | 13.8 | 27.1 | 46.0 | 0.8 | 4.0 |
| 109 | N | 10.2 | 14.9 | 19.0 | 6.9 | 36.8 | 12.2 | 0.0 | 24.8 |
| 118 | N | 38.0 | 6.9 | 13.9 | 16.1 | 8.6 | 13.6 | 2.9 | 4.6 |
| 119 | N | 44.1 | 14.6 | 21.9 | 3.7 | 8.7 | 6.8 | 0.2 | 21.9 |
| 122 | N | 7.2 | 24.0 | 15.7 | 4.8 | 21.3 | 27.0 | 0.0 | 29.6 |
| 132 | N | 9.9 | 16.8 | 12.4 | 15.1 | 26.0 | 18.6 | 1.2 | 0.0 |
| 134 | N | 3.2 | 8.0 | 8.3 | 18.9 | 29.4 | 28.9 | 3.5 | 0.0 |
| 150 | N | 27.5 | 5.7 | 9.2 | 6.4 | 0.6 | 45.2 | 4.4 | 34.8 |
| 152 | N | 8.9 | 0.0 | 16.4 | 8.3 | 0.8 | 65.6 | 0.0 | 8.9 |
| 164 | N | 17.7 | 2.8 | 9.3 | 11.2 | 0.8 | 55.8 | 2.8 | 18.2 |
| 995 | N | 0.0 | 5.5 | 1.1 | 21.6 | 50.0 | 21.3 | 0.6 | 2.9 |
| Mean Serpentine | | 14.1 | 13.2 | 14.4 | 12.3 | 23.5 | 31.5 | 1.2 | 18.9 |
| St. Deviation | | 13.0 | 13.5 | 6.2 | 8.2 | 16.4 | 16.1 | 1.6 | 17.1 |

* Total area for 1 km circles is approximately 313 hectares.

** Seral stage listed above represent the following collapsed categories, not all of which are present for each sample unit: SHRUB: shrub-nautral, shrub-harvest, shrub salvage; POLE: pole-natural, pole-harvest, pole-salvage; EARLY: early-mature, early-mature with predoms, early-harvest, early-harvest with predoms, MID: mid-mature, mid-mature with predoms, mid-harvest, mid-harvest with predoms; LATE: Late-mature, late-harvest; OLD GROWTH: old growth, old-harvest.

*** The % logged column includes all forms of logging (e.g. clear-cut, selective harvest)

Table 11. Summary of the composition of seral stages within 1.0 km circles centered on sample units in serpemtime soils where American martens were detected in 2000-2001.

| Sample unit | Serpentine Soils (No/Yes) | % Shrub | % Pole | %Early-Mature | % Mid-Mature | % Late-Mature | % Old Growth | % Non-forest | % Logged |
|---|---|---|---|---|---|---|---|---|---|
| 44 | Y | 18.4 | 8.6 | 38.7 | 12.9 | 15.8 | 5.0 | 0.5 | 11.2 |
| 58 | Y | 48.2 | 23.2 | 12.6 | 6.5 | 7.0 | 1.7 | 0.8 | 1.6 |
| 59 | Y | 11.2 | 28.5 | 12.0 | 6.9 | 15.4 | 25.5 | 0.5 | 4.7 |
| 74 | Y | 3.1 | 10.2 | 23.9 | 30.1 | 32.6 | 0.0 | 0.0 | 0.0 |
| 88 | Y | 28.0 | 8.6 | 40.3 | 5.2 | 9.8 | 6.7 | 1.4 | 23.7 |
| 300**** | Y | NA | NA | NA | NA | NA | NA | NA | NA |
| 303**** | Y | 1.4 | 4.0 | 24.5 | 29.6 | 6.4 | 34.2 | 0.0 | 0.0 |
| Mean Serpentine | | 15.8 | 11.9 | 21.7 | 13.0 | 12.4 | 10.4 | 0.5 | 5.9 |
| St. Deviation | | 17.6 | 9.7 | 12.2 | 11.7 | 9.7 | 14.1 | 0.5 | 9.3 |
| Mean Non-serpentine | | 14.1 | 13.2 | 14.4 | 12.3 | 23.5 | 31.5 | 1.2 | 18.9 |
| St. Deviation | | 13.0 | 13.5 | 6.2 | 8.2 | 16.4 | 16.1 | 1.6 | 17.1 |
| Mean Total | | 21.8 | 15.8 | 25.5 | 12.3 | 16.1 | 7.8 | 0.6 | 8.2 |
| St. Deviation | | 17.4 | 9.4 | 13.7 | 10.4 | 9.9 | 10.2 | 0.5 | 9.6 |

* Total area for 1 km circles is approximately 313 hectares.

** Seral stage listed above repesent the following collapsed categories, not all of which are present for each sample unit: SHRUB: shrub-nautral, shrub-harvest, shrub salvage; POLE: pole-natural, pole-harvest, pole-salvage; EARLY: early-mature, early-mature with predoms, early-harvest, early-harvest with predoms, MID: mid-mature, mid-mature with predoms, mid-harvest, mid-harvest with predoms; LATE: Late-mature, late-harvest; OLD GROWTH: old growth, old-harvest.

*** The % logged column includes all forms of logging (e.g. clear-cut, selective harvest)