Distribution and Habitat Associations of the Humboldt Marten (Martes americana humboldtensis), and Pacific Fisher (Martes pennanti pacifica) in Redwood National and State Parks: A Report to Save-the-Redwoods League

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SUMMARY

We investigated the distribution and habitat association of the Humboldt marten (*Martes americana humboldtensis*) and Pacific fisher (*M. pennanti pacifica*) within Redwood National and State Parks (RNSP) during the summer and fall of 2002. The park was systematically sampled using a six track-plate station sample unit array (SSU) arranged in a grid pattern with 5 km separating each SSU. Each grid point was the center of the SSU, with one track-plate placed there and five placed around the grid point in a pentagonal array, with 0.5 km separating adjacent track plates. Track plates at each SSU were run concurrently and checked every other day during a 16 day period. In addition to systematic sampling, a more opportunistic road-based station survey (RBS) using one track plate per station, was initiated within old growth and serpentine forest types. RBS stations were established in three areas of the park at approximately 0.5 km intervals within each area, and were checked using SSU protocols.

Twenty-three SSUs (138 track plate stations total) were surveyed from June 15 to October 18. Eight SSUs were in old growth (OG), 8 in second growth (SG), and 7 on the edge of old growth and second growth (OSG). Thirty-eight RBSs were completed between 21 October and 9 November. No martens were detected at any stations. Fishers were the most frequently detected carnivore with 7 SSUs (21 track plates total), and 14 RBSs detecting their presence. Thirteen other types of animals (11 mammals, 1 amphibian, 1 reptile) were also detected at track plate stations. Fishers were detected at SSU track plate stations in old growth (n = 4) significantly less than expected and significantly more than expected in second growth (n = 17). When summarized at the level of the sample unit, however, there was no difference between detections in old growth and second growth. The pattern of detection results for the SSU track plates suggests that fishers use second growth more than old growth redwood forest habitats.

We compared habitat variables within a 0.49 ha plot centered on each track plate station, for each stand that encompassed a station, and for 2.5 km radius circles around where fishers were and were not detected. Old growth sites where fishers were detected had twice the mean density of large (>90 cm) downed logs and large stumps than old growth sites where fishers were not detected. Within second growth redwood forests, fishers were detected at the most structurally complex micro-habitat sites and within the oldest stands. Mean basal area of conifers and snags were both higher at fisher detection sites within second growth stands. Second growth stands with fisher detections had a higher density of medium logs (30-90 cm), and both large (>90 cm dbh) and medium (30-90 cm dbh) snags and stumps than other second growth sites. Fishers were detected significantly more than expected in stands that were logged between 44 and 55 years ago and less in stands logged between 26 and 41 years ago.

Although martens were not detected during this study, they do occur on nearby federal lands, and RNSP can play a role in the conservation and restoration of martens within the redwood region. The long-term persistence of martens within the coastal forests of northwestern California will likely require the maintenance of currently occupied areas, along with the restoration and maintenance of unoccupied potential habitat and functional

landscape connectivity. Old growth redwood forest habitats within RNSP are structurally similar to habitats occupied by martens to the east of RNSP. However, restoration efforts within second growth areas of RNSP will likely be necessary and should accelerate the return of key structural elements (e.g. dense shrub cover) that will facilitate recolonization. While restoration efforts within the northern portion of RNSP may enhance recolonization by martens, alternative measures may be necessary to re-establish martens within areas of RNSP located south of the Klamath River.

INTRODUCTION

Historical records of the distribution of the Humboldt marten suggest that the subspecies was closely tied to the old-growth redwood forest from northern Sonoma County to the California-Oregon border. The Humboldt marten was historically described as occurring "within the northwest humid coastal strip, chiefly within the redwood region" (Grinnell et al. 1937). Martens had declined due to trapping for their fur as early as the 1920's and this led to the closure of the trapping season in northwestern California in 1946 (Twinning and Hensley 1947). There is currently only one known population of martens, which occupies less than 5% of the historical range of the subspecies (Zielinski et al. 2001). Redwood National and State Parks (RNSP) is in close proximity to this population (Slauson et al. 2002), and harbor some of the largest contiguous stands of old growth redwood forest. Pacific fishers have fared better than Humboldt martens within northwestern California. However, the importance of redwood forests, especially old growth and mature redwood forests, to fishers is not well understood. Studies on the habitat ecology of fishers in redwood forests have been limited to efforts on managed redwood forests (Klug 1997, Simpson Timber Company unpubl. data).

The Humboldt marten and Pacific fisher are both listed as Species of Special Concern by the California Department of Fish and Game (CDFG), Sensitive Species by the U.S. Forest Service (USFS), and the fisher was recently petitioned for federal listing as threatened or endangered. The status of these two species within RNSP is currently not well understood, as there have been no extensive systematic survey efforts for martens or fishers within the parks. While track plate and remote camera surveys throughout various portions of the park have been conducted within the last 10 years (Gellman et al. 1993, McKenzie et al. 1994, Beyer and Golightly 1995), no martens were detected during these efforts. However, park lands are <10 km of the only known extant population of martens within the historical range of the Humboldt marten. Fishers have been detected in the last few years on nearby private timberlands (Klug 1997) and on several track plate survey transects within RNSP conducted during 1994 (Beyer and Golightly 1995). However, there have been no investigations of the habitat ecology of either martens or fishers within old growth redwood forests.

Redwood National and State Parks was recently identified by the Coastal marten working group as one of the top priority areas to survey for the presence of Humboldt martens (Slauson 1998). Both martens and fishers have also been identified as 'key species for identifying habitat linkages' within the North Coast Ecoregion by The Missing Linkages Project (Missing Linkages 2000). Determining the distribution and habitat needs of marten and fisher populations within RNSP will help resource managers proceed with management activities in ways that will not harm these species, or the habitats they depend on. The Park also provides a unique opportunity to investigate how these two species use old growth and second growth redwood forest, information that will be critical for guiding park management decisions and conservation planning for the larger redwood region.

STUDY AREA

The study area is approximately 425 km^2 in size and includes all portions of Redwood National Park and Prairie Creek, Jedediah Smith, and Del Norte Coast Redwoods State Parks (Figure 1). A small portion of the Rock creek drainage (~10 km^2), on the eastern side of the new Mill Creek acquisition, were also included during road based surveys. Elevations range from sea level to about 945 meters. Extreme seasonal temperature variations are rare; annual temperatures range from an average of 7.2°C in winter to an average of 20.5°C in summer. Average rainfall is 175 cm per year. Redwood National and State Parks lie within a temperate rainforest ecosystem strongly influenced by coastal fog. The forests within RNSP are dominated by coast redwood (*Sequoia sempervirens*) and Sitka spruce (*Picea sitchensis*). Other common tree species include Douglas-fir (*Pseudotsuga menziesii*), tanoak (*Lithocarpus densiflorus*), western hemlock (*Tsuga heterophylla*), grand fir (*Abies grandis)*, and red alder (*Alnus rubra*). Upstream areas in Redwood Creek toward the southeast boundary of the park are dominated by white oak (*Quercus garryana*), black oak (*Q. kelloggii*) and Douglas-fir.

Within RNSP there are approximately 16,187 ha of old growth forest. Prior to Redwood National Park establishment, timber harvest occurred in old growth stands that are now within the park. A portion of the harvest resulted in about 7,284 ha of second growth forest 35-100 years old, with residual old growth trees and small residual old growth patches. Another 16,187 ha of old growth was mostly clearcut between 1950 and 1978 (Gutierrez and Meyer 1993, USDI and CDPR 1999). Re-growth in the clearcut stands has been variable, depending upon factors such as site condition, location within the watershed, and whether or not the harvested stands were replanted or aerial seeded. There are approximately 3,642 ha of non-forested habitats within RNSP including coastal scrub, coastal prairie, and inland prairie.

OBJECTIVES

1) Determine the current distribution of martens and fishers within RNSP.

2) Determine the habitat characteristics of sites where martens and fishers are detected at several spatial scales (e.g. micro-habitat, stand, landscape).

3) Determine the association of sites where martens and fishers are detected with anthropogenic features (e.g. roads, trails) within RNSP.

RESEARCH DESIGN

Field Methods

Systematic Surveys (SSU)

The study area was systematically sampled using a grid-based approach with 5 km separating each point on the grid. This design is consistent with other efforts that have been ongoing for the past 6 years to determine the current distribution of fishers on all federal lands and several National parks (Yosemite, Sequoia, Kings Canyon) within their historical range in California (Zielinski et al. 2000). The grid for this project was aligned with this larger statewide grid and included 23 grid points to be sampled within RNSP. Each point on the grid was the center point for a 6 track-plate station sample unit, with one station in the center and five located around it in a pentagonal array. Each station was 0.5 km from any adjacent station within the sample unit. Track plate stations were run for 16 consecutive days and checked every other day. Stations were baited with chicken and a commercial lure, GUSTO (Minnesota Trapline Products**,** Pennock**,** MN), was applied in the vicinity of each station when it was established and reapplied on the 8^{th} survey day if both a marten and fisher had not yet been detected at the sample unit.

The grid was developed using a random point of origin and a GIS. Station locations were hand plotted using UTM coordinates derived from the GIS onto U.S.G.S. 7.5 minute quadrangle maps. Field personnel navigated using a combination of map and compass to each station location. Efforts to verify the exact location of each station using a Trimble™ Scout GPS unit failed due to inability of the unit to receive satellite information through the dense tree canopies. Any stations that were established in locations that differed from their planned locations were plotted on topographic field maps and subsequently digitized.

Road-based Surveys (RBS)

After completely surveying the systematic grid we initiated a second, more opportunistic, survey effort to increase the survey coverage of old growth and serpentine forest types. Martens have been detected within near-coast serpentine habitats that occur along the Rattlesnake-Red Mountain ridge complex (Slauson et al. 2002), which borders the eastern edge of the Rock Creek portion of the Mill creek unit. Three areas were selected to be surveyed, Newton B. Drury Scenic Parkway (SP), Bald Hills Road (BH), and the Rock Creek (RC) portion of the recently acquired Mill creek unit (Figure 2). Single track plate stations were established at approximately 0.5 km intervals within either old growth or serpentine forest types. Serpentine forest types occurred only within the RC drainage. Each station was run following the same protocol previously described for the systematic sample units.

Habitat Sampling

Systematic Surveys (SSU)

Microhabitat Scale

A combination of variable-radius plot and transect methods similar to those used by Zielinski et al. (2000) were used to describe the vegetation composition and structure at each track plate station in each sample unit. Topographic variables included elevation, percent slope, micro/macro aspects, topographic position and presence of surface water within 100m or less. Basal area, species diversity, condition class, abundance and size of trees were estimated using the sample of trees in a 20-factor prism sweep. The tree layer, within a 0.49 ha plot (12.5 m radius) centered on each track plate station, was further described using visual estimates of the presence of 1 or 2 distinct layers, canopy closure of each layer (total canopy closure ≤100%), and the most dominant species in each layer. Downed logs, stumps, and snags were sampled using four 25m long variable-width (5 to 10m) belt transects radiating out from each track plate station. Shrub species composition, presence of two distinct layers, and total shrub cover was also visually estimated within the 0.49 ha plot. The total tree canopy closure was measured using a spherical densiometer and facing each cardinal direction at the station and at the end 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 (Mayer and Laudenslayer 1988).

Stand and Compositional Analysis

The stand and compositional analysis habitat variables were taken from the GIS vegetation coverage provided by RNSP. Only second growth characteristics were selected for the stand scale analysis due to the lack of differentiation of structurally distinct stands types for old growth within the vegetation layer. For second growth stands the stand size (ha) and the year the stand was last cut were included. For the compositional analysis, a 2.5 km radius circle (21.25 km^2) was placed around all 23 SSUs to sample selected variables. This size was selected because it represented an area similar to that of average fisher home ranges (Buck et al. 1983, Self and Kerns 1992, Zielinski et al. Submitted (a)). Variables selected at this scale were the number of stands >3 ha, amount of riparian habitat, amount logged, amount of old growth redwood and other conifer types (e.g. Sitka spruce), and relative amount logged between 1948 to 1960 and 1961 to 1980.

Road-based Surveys (RBS)

Due to an alternative sampling protocol and the lack of a comparable vegetation coverage for the RC area, only selected micro-habitat variables (e.g. station elevation, distance to ocean, tree and shrub species rank-order dominance) were included for road-based stations where fishers were detected.

Data Analysis

Chi-squared goodness of fit tests were used to evaluate observed versus expected patterns for locations where fishers were and were not detected. Habitat characteristics were summarized using descriptive statistics (means, standard deviations, frequencies, or rank-sums) for both locations where fishers were and were not detected and for old growth and second growth locations.

RESULTS

Survey Results

During the period from June 15 to October 18, the 23 systematic sample units were completed. Eight sample units were located in old growth (OG), 8 in second growth (SG), and 7 on the edge of old growth and second growth (OSG). For each OSG sample unit, half of the stations were located in old growth and half in second growth. To achieve this, most OSG sample units had to be moved slightly from their original grid locations. Thirty-eight road-based stations, 14 in SP, 6 in BH, 17 in RC, were completed between 21 October and 9 November.

Fourteen species (12 mammals, 1 amphibian, 1 reptile) were detected at track plate stations (Table 1). No martens were detected at any stations. Fishers were the most frequently detected carnivore and were detected at 7 (30%) of the systematic sample units (SSU) and at a total of 21 of 138 (14%) SSU stations (Figures 2, 3). Fishers were detected at a total of 14 of 38 (37%) of the road-based stations (RBS), with 3 in the SP, 1 in the BH, and 10 in RC (Figures 2, 3). Mean latency to first detection for SSUs where fishers were detected was 6.8 days (SD = 4) and 10.6 days (SD= 4) for an individual track plate station. Gray foxes were the second most frequently detected carnivore and were detected at 7 (30%) of the SSUs and at a total of 11 (29%) RBSs and within all 3 RBS sample areas (Table 1).

Fisher Habitat Associations

Of the 7 SSUs where fishers were detected, 1 was in OG, 4 in SG and 2 in OSG sample units. Within the 2 OSG sample units, 5 of the 5 stations where fishers were detected were within second growth. The SSU results were not significantly different from expected ($\chi^2 = 2.67$, df = 5, P >0.25). However when all SSU stations (n = 138) were pooled into old growth (n = 69) and second growth (n = 69), fishers were detected at stations in old growth (n = 4) significantly less than expected and significantly more than expected at stations in second growth (n = 17) ($\chi^2 = 8.42$, df = 1, P <0.005).

Micro-habitat Scale

At the micro-habitat scale, fishers were detected more frequently at stations in second growth sites that were less than 100m from surface water (9 of 16) and showed disproportionate use of sites less than 100m from water relative to their availability (56% used versus 26% available, Table 2). Second growth sites where fishers were detected also had lower mean slopes (24.0%) than second growth sites where they were not detected (35.8%; Table 3). Mean basal area of conifers (242 m^2/ha, SD = 135) and mean basal area of snags (23 m^2/ha, SD = 28) were both higher at second growth sites where fishers were detected than where they were not (144 m^2/ha, SD = 88, 12 m^2/ha, SD = 18, respectively; Table 3). Mean basal area of hardwoods (43 m^2/ha, SD = 64) was lower at second growth sites where fishers were detected than where they were not (77 m^2/ha, SD = 74; Table 3). Mean tree canopy cover for the overstory at old growth sites where fishers were detected was lower (27.8%, SD = 25) than at old growth sites where they were not detected (47.0%, SD = 17; Table 3).

Fishers were detected at second growth sites characterized by redwood as being both the rank-order dominant overstory species and rank-order dominant conifer species in the understory (Table 4). Second growth sites where fishers were not detected were characterized by Douglas-fir being both the rank-order dominant overstory species and rank-order dominant conifer species in the understory (Table 4). Mean shrub cover was higher at second growth sites where fishers were detected (58.1%, SD = 27) than in second growth sites where they were not (41.2%, SD = 29; Table 3). Shrub species rank-order dominance and species composition remained consistent across all sites (Table 4).

Sites where fishers were detected in old growth had twice the mean density of large (>90 cm) downed logs (55 logs/ha, SD = 57) and more large (>90 cm dbh) stumps (7.5 stumps/ha, SD 15) than old growth sites where they were not detected (26 logs/ha, SD 25; 0.1 stumps/ha, SD = 1; Table 5). Second growth sites where fishers were detected had a higher density of medium (30-90 cm) logs (90 logs/ha, SD = 65), large snags (4.3 snags/ha, SD = 8), medium snags (6.2 snags/ha, SD = 9), large stumps (31 stumps/ha, SD = 24), and medium stumps (8.7 stumps/ha, SD = 13) than second growth sites where fishers were not detected (55 logs/ ha, SD = 51; 1.7 snags/ha, SD = 4; 3.1 snags/ha, SD = 5; 22 stumps/ha, SD = 19; 4.2 stumps/ha, SD = 6; respectively; Table 5). Fishers were detected <100m from roads and trails more than expected and >100m significantly less than expected ($\chi^2 = 4.61$, df = 1, prob. of $\chi^2 > 4.61 = p < 0.04$). The mean elevation for all stations (SSU and RBS) where fishers were detected (mean = 305m, SD = 194, range = 39 – 617) did not differ significantly from that for all stations where fishers were not detected (mean = 291m, SD = 194, range 23 – 784). CWHR results are presented in Table 6.

Stand Scale

Forty-one unique second growth stands were included within the SSU areas sampled, twelve of which had 2 stations within them and 2 which had 3 stations. A stand was considered used if a fisher was detected at ≥1 station within it. Fishers were detected significantly more than expected in stands that were logged between 44 and 55 years ago and less in stands logged between 26 and 41 years ago ($\chi^2 = 8.47$, df = 1, prob. of $\chi^2 > 8.47 = p < 0.005$). Second growth stands where fishers were detected had larger mean areas (262.3 ha, SD 282) than second growth stands where they were not detected (183.9 ha, SD = 247).

Compositional Analysis

Sample units where fishers were detected had on average fewer total number of stands ≥3 ha (37, SD = 24) within a 2.5 km radius than sample units where fishers were not detected (48, SD = 30; Table 7). This is due to the fact that average stand sizes were larger where fishers were detected than where fishers were not detected. Sample units where fishers were detected had only a slightly lower percent composition of old growth redwood (32%, SD = 24) than sample units that did not detect fishers (43%, SD = 26). Sample units where fishers were detected had a higher mean relative percent of area logged between 1948-1960 (70%, SD = 22) than sample units that did not detect fishers (40%, SD = 31).

DISCUSSION

Current Distribution of Martens and Fishers in RNSP

Martens were not detected at any stations within our survey. Although track plate surveys can confirm the presence of a species, they cannot confirm the absence of a species from an area. However our methods, both the systematic sampling design and the 16-day survey duration should have been adequate to detect martens at the locations that were sampled if in fact they had occurred there. The mean latency to first detection at track plate stations for martens within the population located to the east of the park was 9.1 days (SD = 5.2, range 2 to 16 days; Slauson et al 2002). We believe the survey coverage was sufficient to conclude that a significant marten population does not currently occur within RNSP. Our survey coverage was not thorough enough however, to rule out the potential that one or more individuals may occupy areas that we did not survey. The closest marten detection to any portion of RNSP occurred in 2002 within approximately 1 km of the eastern boundary of the Mill Creek acquisition on the Smith River National Recreation Area (SRNRA) in the headwaters of Rock creek (Figure 5; Slauson et al. 2002). Potentially suitable, but unsurveyed serpentine habitat for martens occurs on the SRNRA along much of the border with the Mill creek acquisition. However further south on the SRNRA, in the Red Mountain vicinity, the pattern of marten detections and the preliminary results of radio tracking several individual martens suggests that they do not occur within extensively logged areas and rarely venture into them even when their home ranges are in close proximity (Slauson et al. 2002, Slauson in review, Slauson unpubl. data). Despite their proximity, martens will not likely use areas within the Mill creek acquisition until suitable habitat conditions are restored (e.g., dense shrub cover, suitable resting structures).

Fishers are distributed from north to south within RNSP, occurring from the southern and southwestern portions of Jedediah Smith State park to the southern tip of RNP in the headwaters of Devil's creek (Figures 2,3). Fishers were detected within <1 km of the ocean in both Squashan creek and south of Aldercamp road and >13 km inland in Rock and Devil's creeks. Detection results for sites surveyed in near coast (<5 km) locations between the mouth of the Klamath River and Orick were similar to those of Beyer and Golightly (1995). The largest areas where fishers were not detected occurred in the vicinity of the Mill creek campground, Damnation creek trail and SSUs in the lower Redwood creek and the Orick vicinity. These results are similar to those of Gellman et al. (1993) and McKenzie et al. (1994) for the Mill creek/Damnation creek vicinity and of Beyer and Golightly (1995) for the lower Redwood creek and Orick vicinity.

Habitat Characteristics Associated with Fisher Detections

We assume that fishers visit track plate stations while foraging and that the habitat characteristics associated with these sites represent the types of areas used for foraging. We do not know whether these sites also provide for other key life history needs (e.g. suitable resting structures). We also do not know the effect that the presence of small baits and an olfactory lure may have on the decision of a fisher to use the sites where track plate stations were located. However, track plates can help answer the question: 'What are the characteristics of sites that fishers are willing to visit?' Other methods for investigating foraging locations are either not possible in RNSP (i.e., direct observation or snow-tracking) or less accurate (i.e., radio telemetry). Fishers select forested habitats that provide adequate overhead cover and the structural elements for resting/denning and as habitat for prey (Buskirk and Powell 1994). Overhead cover is provided in the form of dense tree canopies and tall shrubs. Of the 138 SSU stations, no station had less than 75% total (tree and tall shrub) overhead cover, thus differences between sites where fishers were and were not detected should reflect associations with either preferred prey populations or with structural elements important for resting and denning.

The pattern of detection results for the SSUs and pooled SSU stations suggest that fishers use second growth forest habitats within RNSP more than old growth redwood habitats. The lack of significance for the chi-squared test for the SSU results was more likely due to the small sample sizes in each category rather than lack of a strong observed pattern. Fishers were historically not known to be common within old growth redwood forests and most early trapping records occur distinctly interior from the coast and occur near the redwood-Douglas-fir transition zone (Grinnell et al. 1937). These early records cannot be attributed to a lack of trapping effort within the redwood region as trappers were active in this region and commonly taking martens while trapping in old growth redwood forests (Grinnell et al. 1937). The results of this study are consistent with those of other contemporary studies, and suggest that fishers are fairly widely distributed within the northern redwood region (Beyer and Golightly 1995, Klug 1997). Since the early 1900s, 93-95% of old growth redwood forest have been logged and most of these logged redwood forest are currently managed on short rotations (e.g., 60 years) to produce wood products (Thornburg et al. 2000). It is possible that fishers have expanded their distribution within the redwood region as a result of the conversion from old growth redwood to predominantly younger aged redwood forests. This may be due in part to structural changes (e.g. reduction of dense shrub cover) or changes in prey species composition and availability (e.g. woodrats; Hamm et al. 1996) in younger aged redwood stands. Weir and Harestad (2003) found that fishers selected against stands with dense (>80%) low shrub cover and hypothesized that an overly complex forest floor may reduce the likelihood of fishers capturing prey. Old growth sites included in this study had nearly double the amount of shrub cover as second growth sites (Table 3). And, fishers were rarely detected within the area occupied by the marten population to the east of RNSP, a landscape with a large composition of near-coast, late-successional conifer forest with dense shrub cover (Slauson et al. 2002, Slauson and Zielinski unpubl. data). Dense shrub cover appears to play important, but potentially alternative, roles for both martens and fishers and should be given more consideration in the management and restoration of coastal forests. Although the sample unit and station level detection patterns suggest fishers use second growth redwoods more than old growth redwood habitats in RNSP, the 2.5 km compositional analysis showed that on average 1/3 of the area around sample units where fishers were detected contained old growth redwood habitat. The four old growth sites where fishers were detected contained twice the density of potential resting structures, large (>90 cm) downed logs and large diameter (>90 cm dbh) stumps, than old growth sites where fishers were not detected. Although fishers were mostly detected in second growth stands, many of these were adjacent to or in close proximity to old growth redwood patches. Further investigation will be necessary to clarify the importance of old growth redwood patches to fishers at this spatial scale.

Within second growth redwood forests in RNSP, fishers were detected within the oldest age stands and at the most structurally complex micro-habitat sites. Most elements of physical structure (e.g. higher basal area) and species composition (e.g. declining alder dominance) at the micro-habitat scale were consistent with older stand age. Our findings with respect to stand age and lower basal area of hardwoods are contrary to those of Klug (1997) who found no significant relationship between stand age and a positive relationship with higher basal area of hardwoods and fisher occurrence. At the micro-habitat scale, sites where fishers were detected had much higher densities of medium and large deadwood structures, including snags, stumps, and downed logs. High structural diversity is known to be associated with an increase in prey species richness and abundance and deadwood structures are positively associated with several potential prey species (e.g. red-backed voles *Clethrionomys californicus***,** Hayes and Cross 1987). Structural complexity near the ground may also affect the vulnerability of prey species to capture by fishers (Buskirk and Powell 1994). Fishers are considered dietary generalists and tend to focus foraging activities in areas where prey are both abundant and vulnerable to capture (Powell 1993). Large snags and logs are used by fishers for resting and denning (e.g. Gilbert et al. 1997, Zielinski et al. submitted (b)). Our findings that fishers were detected at sites with higher amounts of downed logs were consistent with those of Klug (1997).

Shrub cover was higher, but species composition of shrubs remained the same between micro-sites where fishers were and were not detected. Shrub species provide food for fishers in the form of fruits (e.g. evergreen huckleberries (*Vaccinium ovatum*), salal (*Gautheria shallon*) berries; Slauson unpubl. data) and for prey species in the form of fruits and vegetative material. While sites where fishers were detected had higher shrub cover than sites where they were not detected, most sites overall had a moderate level of shrub cover (40-60%). These results are consistent with those of Weir and Harestad (2003) who found that fishers selected stands and patches within stands with moderate levels of structural complexity near the forest floor. Redwood was the most dominant overstory and understory species where fishers were detected; Douglas-fir was dominant at sites where they were not. This finding is contrary to the results of Klug (1997) who found that fisher detections were more common in Douglas-fir dominated stands. However his study areas included much more of the redwood-Douglas-fir transition zone, while our study area was confined to near coast forests dominated by redwood.

At the stand scale, stand size was larger where fishers were detected which is also consistent with the results of the 2.5 km compositional analysis. For the compositional analysis, sample units where fishers were detected had a higher relative percentage of total area of older second growth (logged from 1948-1960) than where fishers were not detected. This suggests that fishers may be responding to patch characteristics of suitable habitat when determining areas to use within RNSP. Further investigation will be necessary to evaluate this relationship.

Of all 21 SSU stations where fishers were detected, 18 were <100m from low-use unpaved road types (13) and foot trails (5). Only one SSU station where a fisher was detected was <100m from a paved road. The presence of low-use secondary roads and trails likely poses little direct threat to fishers. Dark (1997) found that low-use secondary forest service roads were positively associated with fisher occurrences. RBSs were biased near roads but provide us with additional information that fishers also occur near (<100 m) paved, high-use roads (Newton B. Drury Scenic Byway and Bald Hills Road) within RNSP. These roads are relatively narrow, have no physical barriers (e.g. center dividers), and fishers can likely cross these roads but may be susceptible to auto-collisions, especially in high-use, high-speed areas. In this regard, it is important that fishers were not detected at sample units with both high human use and in close proximity to highway 101 (e.g. Mill Cr. Campground, Damnation Cr. trail, Orick vicinity SSUs) and that these results are consistent with surveys conducted in these same areas 8-11 years previously (Gellman et al. 1993, McKenzie et al. 1994, Beyer and Golightly 1995). We cannot determine the influence of these two factors on the occurrence of fishers based on our results. However, we believe that the highway 101 corridor is likely one of the most significant barriers to the movement of mesocarnivores in the region. The development or enhancement of natural undercrossings and created crossing structures (e.g. large culverts) could aid in mitigating the negative effects of highway 101 on forest carnivore movements.

Conservation and Management Considerations of Martens and Fishers in RNSP

In the western United States, the distribution of the fishers has dramatically declined from its historical distribution (Giblisco 1994, Aubry and Houston 1992, Aubry and Lewis in press), prompting several recent petitions for listing under the Endangered Species Act (e.g. Biodiversity Legal Foundation 1994). In contrast the marten has remained fairly well distributed relative to its historical distribution in the western United States (Giblisco 1994). Paradoxically in northwestern California, the opposite pattern currently exists, where fishers remain well distributed within most of their historical distribution (Zielinski et al. 1995, Zielinski et al. 2000) while the marten has undergone a dramatic decline in their distribution (Zielinski et al. 2001). Historically the marten was 'fairly numerous' in the redwood belt, while fisher occurrences were rare and more common in interior forest types (Grinnell et al. 1937). Currently there is only one population of martens remaining in an area equivalent to <5% of the historical range of the Humboldt marten (Slauson et al. 2002). The fisher appears to have increased its distribution into redwood forest types over the last century and is currently distributed throughout much of the intensively managed timberlands in the northern redwood region. The marten does not occur in extensively logged redwood forests and currently only occurs in conifer-dominated, late-mature and old-growth forests with dense shrub cover or near-coast serpentine communities with dense shrub cover (Slauson in review). It has been hypothesized that high fisher populations can limit marten populations and that deep snowfall can limit fisher populations (Krohn et al. 1995, Krohn et al. 1997). Most of the redwood region remains snow free year-round, with only the higher interior ridges receiving infrequent and ephemeral snowfall. Due to the absence of snow to limit the historical distribution of fishers in the old growth forests of the redwood region, other factors, such as dense shrub cover or the associated prey availability, may have historically limited fisher populations. Within the last century most of the old growth redwood forests have been logged and currently exist as structurally dissimilar early-seral forests. Fishers are now widely distributed in these forests. Although high fisher populations in second growth and intensively managed redwood forests may limit martens from occupying these areas, restoration of old growth redwood forest characteristics, such as dense shrub cover, may in turn limit fishers from occupying these areas thereby facilitating recolonization by martens.

Slauson et al. (2002) proposed that the marten be considered a 'highly imperiled taxon' within the redwood region. Following the conservation planning guidelines of Noss et al. (2000) for the redwood region, the needs of highly imperiled populations, especially potential 'umbrella' species like carnivores, should be used as a basis for reserve and connectivity designs. RNSP contains both the largest remnant patches and the largest total amount of old growth redwood forests. The long-term persistence of martens within the coastal forests of northwestern California will likely require both the maintenance of areas currently occupied by martens and the expansion of their distribution through the combined effects of the restoration of suitable habitat and functional landscape connectivity to enable recolonization of suitable, but currently unoccupied habitat. Although we have just begun to learn about the ecology of martens in the coastal forests of the redwood region, and thus should proceed cautiously, we face 2 challenges related to the restoration of the coastal California marten population: 1) the longer 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 demographic or environmental events, and 2) the restoration of forest habitats with the structural characteristics necessary to be suitable for martens may take decades.

RNSP can play a major role in the conservation and restoration of martens within the redwood region. Based on the survey results of this study, martens are likely absent from RNSP. Old growth redwood forest habitats within RNSP are structurally similar to the old growth Douglas-fir habitats occupied by martens to the east of RNSP on adjacent lands of the SRNRA. They are conifer dominated, have large live trees, large snags, large downed logs, and dense shrub layers composed of mast producing species (e.g. evergreen huckleberry, salal). However the old growth within RNSP represents only approximately 40% of the total forested area, while second growth comprises 60%. Furthermore, the old growth forest habitat within the RNSP is patchily distributed within a matrix of second growth forest that is structurally dissimilar to both old growth redwood forests in RNSP and old growth habitats used by martens.

Second growth sites that we surveyed within RNSP had less shrub cover, fewer large live conifers, fewer large snags, fewer large logs than both old growth sites in RNSP and sites used by martens east of RNSP. These features are likely to return to the second growth forests within RNSP over time, but management alternatives can be considered that may accelerate the restoration of old growth forest conditions. Thinning can accelerate the development of individual trees and a multi-layered tree canopy and also increase the productivity of the shrub layer through increased solar exposure (Tappeiner et al. 2001). The increased productivity of the shrub layer may have particular importance for martens by increasing the total shrub cover and by increasing the mast production which is food for martens and their prey. To maximize the benefits of thinning, we recommend that they be spatially located to: 1) increase the patch sizes of suitable habitat by treating stands adjacent to existing old growth, 2) create or increase connectivity between old growth patches, and 3) create connectivity between SRNRA lands currently occupied by martens and old growth in RNSP. While restoration efforts within the northern portion of RNSP may facilitate its recolonization by martens, alternative measures (e.g., reintroduction) may be necessary to re-establish martens within areas of RNSP located south of the Klamath River. Large areas of early-seral industrial forest, the Klamath river, and the Highway 101 corridor likely represent three significant barriers that martens would have to cross in order to reach this region of the park.

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Figure 1. Redwood National and State Parks, northwest California.

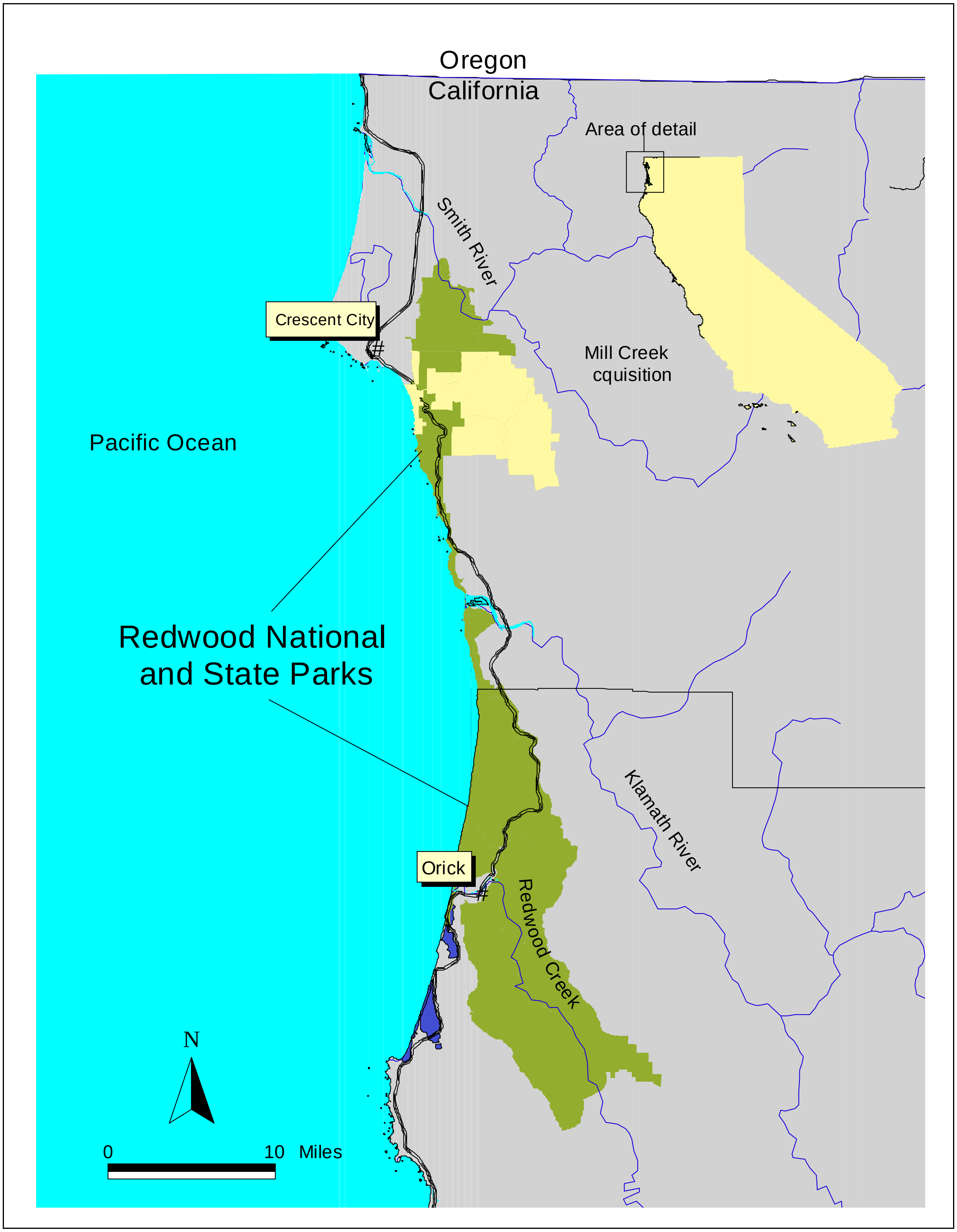

Figure 2. 2002 track plate survey station locations and detection results for fishers for the NORTHERN HALF of Redwood National and State Parks.

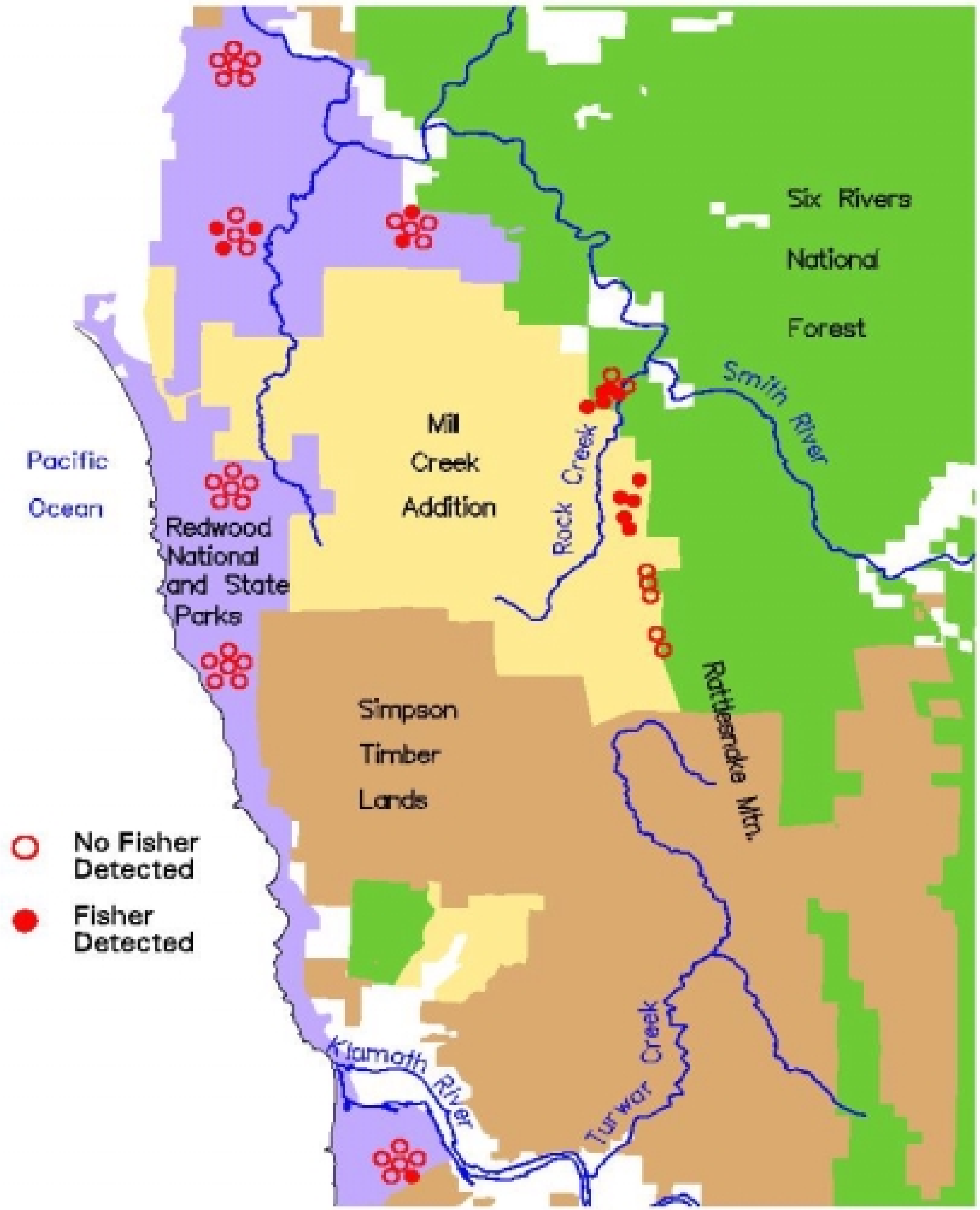

Figure 3. 2002 track plate survey station locations and detection results for fishers for the SOUTHERN HALF of Redwood National and State Parks.

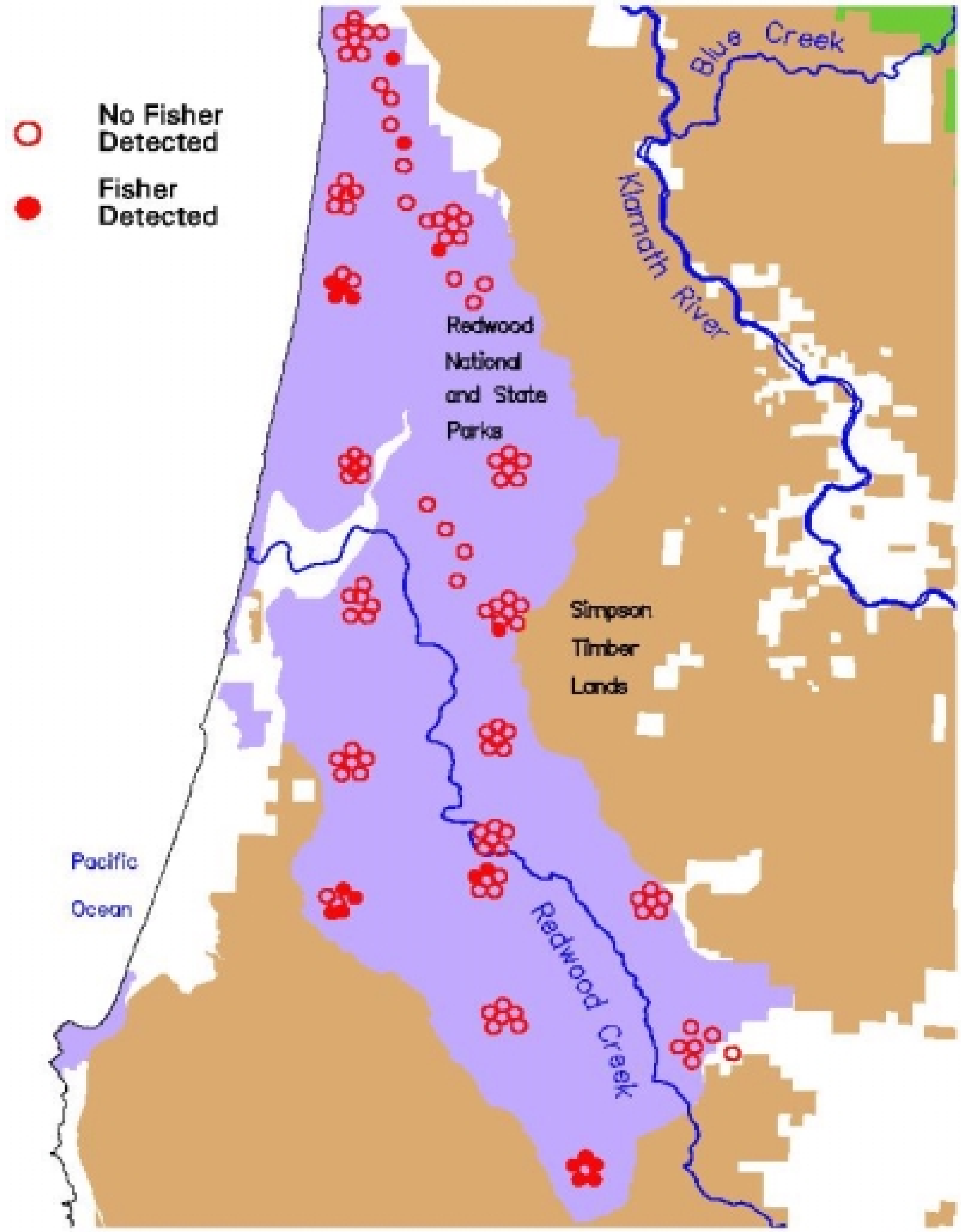

Figure 4. Distribution of all contemporary marten detections (solid blue dots = marten detection location; 1996-2002) relative to Redwood National and State Parks lands.

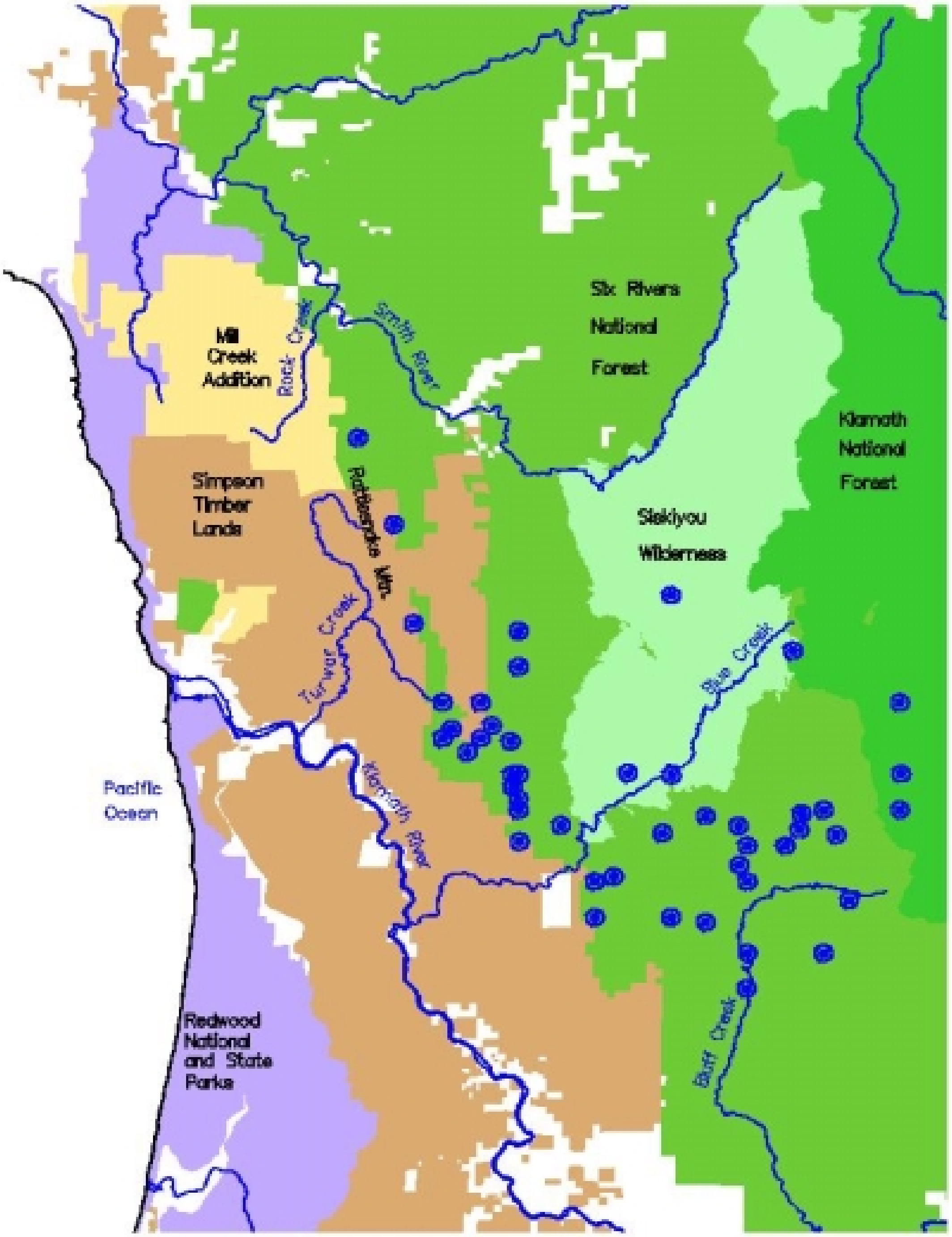

Table 1. Species detected using sooted track plates in Redwood National and State Parks in 2002.

Species	Systematic Sample Units (n=23) OG (n=8)	SG (n=8)	OSG (n=7)	Road-based Stations (n=38) SP (n=14)	BH (n=6)	RC (n=17)
Fisher	1	4	2	3	1	10
Gray Fox	0	4	3	1	6	4
Western spotted Skunk	0	2	1	0	0	6
Ringtail	0	0	0	0	0	9
Weasel Sp.	1	0	1	1	0	0
American Black Bear	0	3	2	0	0	1
Raccoon	0	0	0	5	0	0
American Opossum	0	0	0	1	0	1
Northern Flying Squirrel	1	1	1	0	0	0
Dusky-footed Woodrat	0	2	1	0	0	0
Chipmunk Sp.	0	2	1	0	0	2
Mice Sp.	6	7	6	9	4	9
Northern Red-legged Frog	2	0	3	0	0	0
Lizard Sp.	0	1	0	0	0	0

Key: OG = Old Growth, SG = Second Growth, OSG = Half Old Growth and Half Second Growth, SP = Scenic Parkway, BH = Bald Hills, RC = Rock Creek.

Table 2. Micro-habitat characteristics sampled at each track plate station. All stations are pooled for fisher detection and for non-detections as well as by old growth and second growth.

Variable	Fisher Detections		Fishers Not Detected		All Stations	
	Old Growth (n = 4)	Second Growth (n = 17)	Old Growth (n = 65)	Second Growth (n = 52)	Old Growth (n = 69)	Second Growth (n = 69)
Distance To Water						
>100m	1	7	54	43	46	51
<100m	3	9	11	9	23	18
Micro Slope Position						
Ridge Top	-	2	2	3	2	5
Convex Slope	2	3	11	6	13	10
Mid Slope	1	8	39	33	40	41
Concave Slope	-	-	3	6	3	6
Draw Bottom	1	-	5	-	6	-
Macro-Aspect						
NE (017 – 107^{o})	1	3	8	10	9	13
SE (108 – 197^{o})	-	4	24	13	24	17
SW (198 – 287^{o})	-	2	19	13	19	15
NW (288 - 016^{o})	2	4	11	12	13	16
Distance to Road						
0-50m	10		43		53	
50-100m	8		31		39	
>100m	2		38		40	

*Note: Columns with totals that do not equal sample sizes include sites with missing data values.

Table 3. Micro-habitat characteristics sampled at each track plate station. All stations are pooled for fisher detection and for non-detections as well as by old growth and second growth. Numbers in parenthesis indicate standard deviations.

Variable	Fisher Detections: Old Growth (n = 4)	Fisher Detections: Second Growth (n = 17)	Fishers Not Detected: Old Growth (n = 65)	Fishers Not Detected: Second Growth (n = 52)	All Stations: Old Growth (n = 69)	All Stations: Second Growth (n = 69)
% Canopy Cover						
Overstory	27.8 (25)	54.6 (25)	47.0 (17)	51.2 (32)	46.9 (16)	63.8 (43)
Understory	31.2 (19)	45.0 (12)	28.8 (22)	39.2 (31)	28.9 (21)	43.6 (30)
Basal Area (m^2/ha)						
All	330 (140)	286 (140)	347 (135)	221 (67)	346 (134)	299 (93)
Conifers	330 (140)	242 (135)	336 (134)	144 (88)	335 (133)	212 (109)
Hardwoods	0	43 (64)	17 (38)	77 (74)	16 (37)	87 (72)
Snags	60 (69)	23 (28)	50 (52)	12 (18)	51 (53)	18 (21)
% Total Shrub Cover	86.2 (10)	58.1 (27)	89.0 (16)	41.2 (29)	86.3 (15)	46.5 (29)
Shrub over	36.2 (7)	28.3 (19)	42.9 (23)	21.3 (20)	41.3 (22)	24.7 (26)
Shrub under	61.2 (28)	38.2 (29)	50.1 (26)	21.9 (25)	49.3 (26)	23.2 (19)
% Slope	31.2 (10)	24.0 (14)	33.1 (18)	35.8 (19)	33.0 (18)	35.6 (18)
% Ground Cover						
Litter	62.5 (27)	84.0 (16)	74.4 (19)	81.7 (16)	71.5 (20)	82.3 (16)
Herb	36.2 (27)	18.2 (16)	18.9 (16)	15.1 (21)	19.4 (17)	15.3 (20)
Rock	1.2 (0)	---	1.5 (8)	0.9 (12)	1.4 (8)	0.7 (12)
Soil	---	---	0.3 (2)	0.1 (0)	0.2 (2)	---

Table 4. Plant species rank-order for each vegetation structure layer sampled at each track plate station. All stations are pooled for fisher detections and for non-detections as well as by old growth and second growth. Road-based stations in old growth are included here. Numbers in parenthesis are sum of the ranks.

	Fisher Detections		Fishers Not Detected		All Stations	
Variable	Old Growth (n = 18)	Second Growth (n = 17)	Old Growth (n = 76)	Second Growth (n = 52)	Old Growth (n = 90)	Second Growth (n = 69)
Tree Overstory	SESE2 (24)	SESE2 (35)	SESE2 (223)	PSME (86)	SESE2 (257)	PSME (112)
	PSME (16)	PSME (26)	PSME (80)	SESE2 (72)	PSME (96)	SESE2 (97)
	CHLA (5)	TSHE (6)	PISI (27)	ALOR (36)	PISI (29)	ALOR (36)
Tree Understory	TSHE (18)	LIDE2 (29)	SESE2 (149)	LIDE2 (84)	SESE2 (153)	LIDE2 (113)
	LIDE2 (17)	SESE2 (18)	TSHE (106)	PSME (40)	TSHE (124)	SESE2 (57)
	SESE2 (12)	ALOR (13)	LIDE2 (85)	SESE2 (18)	LIDE2 (102)	PSME (48)
Dominant Shrubs	POMU1 (24)	VAOV (37)	POMU1 (165)	VAOV (83)	POMU1 (189)	VAOV (120)
	VAOV (14)	POMU1 (22)	VAOV (129)	POMU1 (75)	VAOV (143)	POMU1 (97)
	RHMA (7)	RHMA (12)	RHMA (60)	RHMA (30)	RHMA (69)	RHMA (42)
Shrub Overstory	VAOV (17)	VAOV (37)	VAOV (158)	VAOV (65)	VAOV (175)	VAOV (88)
	RHMA (11)	RHMA (20)	RHMA (85)	RHMA (41)	RHMA (96)	RHMA (61)
	RUSP2 (11)	RUSP2 (5)	VAPA (76)	POMU1 (27)	VAPA (86)	POMU1 (29)
Shrub Understory	POMU1 (28)	POMU1 (27)	POMU1 (199)	POMU1 (64)	POMU1 (227)	POMU1 (91)
	GASH (13)	VAOV (20)	GASH (72)	VAOV (32)	VAOV (31)	VAOV (52)
	BLSP (11)	GASH (8)	BLSP (48)	GASH (26)	GASH (85)	GASH (34)

Species Codes: SESE2: Redwood, PSME: Douglas-fir, CHLA: Port-Orford cedar, TSHE: Western hemlock, PISI: Sitka spruce, ALOR: Red alder, LIDE2: Tanoak, VAOV: Evergreen huckleberry, RHMA: Rhododendron, RUSP2: Salmonberry, VAPA: California red huckleberry, POMU1: Sword fern, GASH: salal, BLSP: Deer fern.

Table 5. Micro-habitat characteristics from belt-transects centered on each track plates station. All stations are pooled for fisher detection and non-detections as well as by old growth and second growth. Numbers in parenthesis indicate standard deviations.

Variable	Fisher Detections		Fishers Not Detected		All Stations	
	Old Growth (n = 4)	Second Growth (n = 17)	Old Growth (n = 65)	Second Growth (n = 52)	Old Growth (n = 69)	Second Growth (n = 69)
Density of Logs (#/Ha)						
Large (>90cm)	55 (57)	12 (13)	26 (25)	17 (20)	28 (28)	16 (19)
Medium (30-90cm)	53 (34)	90 (65)	53 (43)	55 (51)	53 (43)	63 (56)
Density of Snags (#/Ha)						
Large (>90cm)	11 (13)	4.3 (8)	9.1 (10)	1.7 (4)	9.2 (10)	2.3 (5)
Medium (30-90cm)	5.0 (5)	6.2 (9)	4.3 (8)	3.1 (5)	4.3 (8)	3.8 (7)
Density of Stumps (#/Ha)						
Large (>90cm)	7.5 (15)	31 (24)	0.1 (1)	22 (19)	0.5 (3)	25 (20)
Medium (30-90cm)	0 (0)	8.7 (13)	0.07 (6)	4.2 (6)	0.07 (0.6)	5.2 (8)

Table 6. CWHR micro-habitat characteristics for each track plate station. All stations are pooled for fisher detection and non-detections as well as by old growth and second growth.

Variable	Fisher Detections		Fishers Not Detected		All Stations	
	Old Growth (n = 4)	Second Growth (n = 17)	Old Growth (n = 65)	Second Growth (n = 52)	Old Growth (n = 69)	Second Growth (n = 69)
CWHR Habitat Type						
Redwood	4	8	59	14	63	22
Douglas-fir	-	5	1	13	1	18
Montane-hardwood Conifer	-	2	2	11	2	13
Montane Riparian	-	-	3	1	3	1
Klamath Mixed Conifer	-	1	-	2	-	3
Montane Hardwood	-	-	-	2	-	2
CWHR Size Class						
6**	4	-	56	4	60	4
5 (>60.9cm)	-	-	7	4	7	4
4 (27.9-60.9 cm)	-	10	2	20	2	30
3 (15.2-27.9 cm)	-	4	-	18	-	22
2 (2.5-15.2 cm)	-	2	-	5	-	7
CWHR Canopy Cover						
D (>60%)	4	16	64	50	68	66
M (40-59%)	-	-	1	-	1	-

*Note: Columns with total that do not equal sample sizes include sites with missing data values.
**Size class 5 trees over a distinct layer of size class 4 or 3 trees, total tree canopy exceeds 60% closure.

Table 7. Compositional variables for 2.5 km radius (1960 ha) circles centered on each sample unit.

Variable	Fisher Detected (n = 7)	Fisher Not Detected (n = 16)
# of Stands >3 ha	37 (24)	48 (30)
Riparian (ha)	1.5 (3)	37 (84)
% Logged	60% (29)	51% (29)
% Old Growth Redwood	32% (24)	43% (26)
% Old Growth Conifer (e.g. Sitka spruce)	7% (15)	4% (8)
Amount Logged (ha) 1948-1960	369 (243)	248 (270)
Amount Logged (ha) 1961-1980	256 (292)	484 (385)
Amount Logged (ha) Unknown Year	151 (187)	92 (140)
Relative % Logged (ha) 1948-1960	70% (22)	40% (31)
Relative % Logged (ha) 1961-1980	30% (22)	60% (31)