Klug

Occurrence of Pacific Fisher (*Martes pennanti pacifica*) in the Redwood Zone of Northern California and the Habitat Attributes Associated with their Detections

by

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ABSTRACT

I conducted sooted track plate surveys in Humboldt and Del Norte Counties, California from January 1994 to July 1995 to detect the presence of Pacific fisher (*Martes pennanti pacifica*). Habitat characteristics were measured at 238 stations and the stands in which they were placed. I compared these characteristics between stations and stands at which I obtained at least one fisher detection and those stations and stands at which I did not detect fishers. Detection ratios were compared between the 3 vegetation types that occur on the study area. Predominantly Douglas-fir (*Pseudotsuga menziesii*) stands had detection ratios of 0.24, 0.38, and 0.46 in 1994, 1995, and for both years combined, respectively. Douglas-fir and redwood (*Sequoia sempervirens*) mixed stands had detection ratios of 0.25, 0.14 and 0.27 in 1994, 1995 and for both years combined. Predominantly redwood stands had detection ratios of 0.09, 0.06, and 0.13 for 1994, 1995 and both years combined. Detection ratios for the three habitat types differed significantly in 1994 (X^2 = 7.004, df = 2, $\underline{p}$ = 0.018), in 1995 (X^2 = 31.467, df = 2, $\underline{p}$ < 0.001) and for both years combined (X^2 = 24.691, df =2, $\underline{p}$ < 0.001).

Stations where fishers were detected had significantly more logs (P = 0.046), a greater volume of logs (P = 0.008), greater basal area of hardwood with dbh's between 13 and 27 cm (P < 0.001), and greater than 52 cm dbh (P = 0.006), and greater total basal area of hardwoods (P < 0.001). These stations also had

significantly less basal area of conifer between 52 and 90 cm ($P = 0.005$), more moderate slopes ($P = 0.024$), higher elevations ($P < 0.001$), and a greater distance to the coast ($P < 0.001$). Variables that were statistically different between stations with fisher detections and stations without detections ($P < 0.05$) were included in a forward stepwise logistic procedure to determine the variables that best predicted fisher occurrence. Elevation, volume of logs, basal area of conifer between 52 and 90 cm, % slope, and distance to coast were the variables chosen to predict fisher occurrence.

Stands where fishers were detected had significant differences in vegetation type ($P < 0.001$), greater % hardwood ($P = 0.001$), fewer residual redwood trees per ha ($P = 0.003$) and less basal area young growth redwood ($P < 0.001$), more residual fir trees per ha ($P = 0.010$) and greater basal area young growth fir ($P = 0.040$) than stands that did not detect fishers. Vegetation type was the only variable to be selected by the logistic procedure to predict fisher occurrence in stands. I found no relationship between fisher detections and stand age, canopy cover, or topographic position.

Fishers in my study area were detected significantly more often at higher elevations, in Douglas-fir dominated stands with greater amounts of hardwood. I found no relation to stand age or old-growth habitats. However, the amount of old-growth on the study area was very small. Although fishers were detected in redwood dominated stands, they appeared to use them much less frequently than Douglas-fir stands. The higher proportion of hardwoods in stands where fishers were detected indicated that managing for homogeneous stands of conifer should be minimized where maintaining fisher populations is a management concern.

INTRODUCTION

The fisher (*Martes pennanti*) utilizes a wide range of forest habitats across its range. These habitats include old-growth coniferous forests in California (Buck 1982, Mullis 1985, Rosenberg and Raphael 1986), and in Canada (de Vos 1952), a combination of young and old-growth forests in Idaho (Jones 1991, Roy 1991), and young mixed coniferous-deciduous forests in the eastern United States (Arthur et al. 1989). Strickland et al. (1982) suggested that fishers could inhabit any forested habitat that provided a suitable prey base. Conversely, Harris (1984) suggested that fishers are one of the most old-growth dependent species in North America. It is generally accepted, however, that fishers throughout their range utilize late successional forests (Arthur et al. 1989, Clem 1977, de Vos 1952, Thomasma et al. 1991).

In the Pacific northwest, the Pacific fisher (*M. pennanti pacifica*) has been found more often in late successional coniferous forests than in early successional forests (Buck 1982, Rosenberg and Raphael 1986, Aubry and Houston 1992). Powell and Zielinski (1994) suggested that it would be unlikely that early and mid successional forests, especially those that have resulted from timber harvest, could provide fishers with the same prey resources, rest sites, and den sites as more mature forests. Conversely, fishers in Idaho used young to medium-aged stands during certain times of the year (Jones 1991).

In 1990, environmental groups petitioned the U.S. Fish and Wildlife Service to list the Pacific fisher as an endangered species in the western U.S.

under provisions of the Endangered Species Act. In January of 1991, the Service reported insufficient evidence to warrant listing (Federal Register 56[8]:1159-1161). In 1994, the Service was again petitioned to list the fisher as threatened in the western U.S. (Biodiversity Legal Foundation 1994). Although this petition was also denied, there continues to be concern over the species long-term survival in several western states, including California. This concern is primarily due to the rapid harvest of mature and old-growth Douglas-fir (*Pseudotsuga menziesii*) forests (Rosenberg and Raphael 1986) resulting in habitat loss and alteration. Powell and Zielinski (1994) suggested that habitat fragmentation from timber harvest or other human activities may be inhibiting the growth of fisher populations.

The majority of published research on fishers has been conducted in the upper midwest and northeastern United States and in southern Canada (Clem 1977, Kelly 1977, Raine 1983, Arthur et al. 1989, Arthur et al. 1993, Powell 1994a, Kilpatrick and Rego 1994). In California, Pacific fishers have been studied in interior forests and have been shown to use areas of young forest less often than mature old-growth forests (Buck 1982, Mullis 1985, Buck et al. 1994). To date, only one other study (Beyer and Golightly 1996) has been conducted in coastal forests that are often dominated by redwood (*Sequoia sempervirens*). A pilot study conducted in 1993 in Humboldt and Del Norte Counties, California, indicated that fishers could be detected in large contiguous areas of predominantly second growth forests and in a variety of coastal habitat types (Klug unpub. report, Simpson Timber Co. Korbel, CA. 95550).

The vegetative makeup of northern coastal California is different than elsewhere in the range of the Pacific fisher. The wet, mild climate produces ideal conditions for the growth of thick rainforests dominated by redwood and Douglas-fir. These forests are highly productive, fast growing, and often obtain characteristics of mature forests at a relatively early age. Many of these lands are privately owned and are managed for commercial timber production. Conversely much of the non-coastal forest in northern California is publicly owned. Within the coastal zone, as elevation and the distance from the coast increase, Douglas-fir replaces redwood as the dominant overstory tree species.

Appropriate mitigation to offset potential negative effects from anthropogenic land disturbance is difficult for fishers in northern California due to a lack of knowledge about fisher habitat. In one scenario, suitable fisher habitat is presumed to be present and mitigation should be considered appropriate. In an opposite scenario, some people presume that there is no suitable fisher habitat present, thus fishers are probably not present, therefore there should be no need for concern or mitigation. Unfortunately, there is little scientific data to support either of these presumptions. Without knowing the critical attributes of fisher habitat, protection or mitigation measures are likely to be inappropriate.

I studied fishers on intensively managed young growth forests in northern California. Most of my work took place in the coastal redwood region.

The objectives of my study were to determine the distribution of fishers in three different forest vegetation types and to gain insight into the habitat attributes, both coarse and fine scale, that were important to fishers in northwestern California. Variables were chosen to facilitate comparisons to other studies of fishers, and to compare my results with a previous study (Folliard 1993) on Northern Spotted Owls (*Strix occidentalis*) that was conducted on the same study area. A Habitat Conservation Plan (Simpson Timber Co. 1992) was implemented for spotted owls based on the results of Folliard (1993). The results of my study have the potential to be used to modify practices used in managing for spotted owls such that suitable habitat for fishers is also created. Conversely, if the results differed then additional measures may be needed to provide fisher habitat.

STUDY AREA

I conducted the study in Humboldt and Del Norte Counties of northern California on lands owned primarily by Simpson Timber Company (STC), as well as on smaller areas owned by Louisiana Pacific Corporation and Sierra Pacific Industries land (Figure 1). These lands were comprised of scattered tracts ranging in size from 16 to 20,000 ha and totaling approximately 150,000 ha. Most of this land was within 30 km of the Pacific Ocean. Elevation on the study area ranged from five to 1400 m. The topography of the area was characterized by steep slopes with highly dissected drainages.

Coniferous forests, with a predominant overstory of coastal redwood and Douglas-fir, comprised 86% of STC's lands. Redwood was found mostly in the coastal areas and at lower elevations along major watercourses. As elevation and distance from the coast increased, redwood was replaced by Douglas-fir. Hardwood forests made up 8% of STC's land with predominantly red alder (*Almus rubra*) in cool mesic sites, and tanoak (*Lithocarpus densiflorus*) and madrone (*Arbutus manziesii*) at higher more xeric sites. The remaining land consisted of non-forested areas including natural grassland, rock outcrops, and gravel river beds.

Most of STC's land has been logged and less than 1% of the coniferous forest remaining is old-growth. The remainder was second and third growth forest ranging in age from recently cut to 120 years. The primary silvicultural practice has been clearcutting with some selection harvest. Some

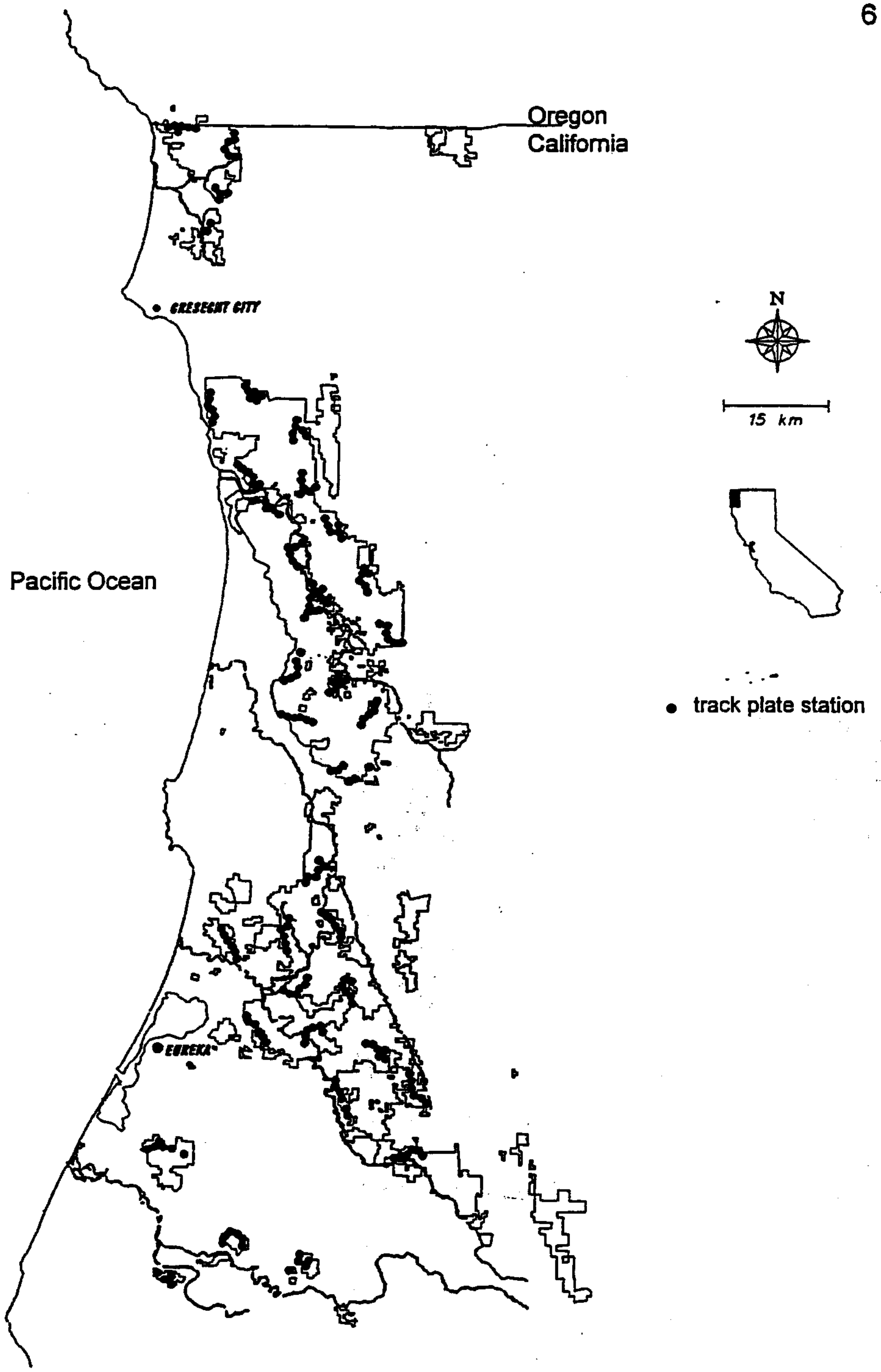

Figure 1. Location of Track Plate Stations on Managed Timberlands in Humboldt and Del Norte Counties, California. Polygons indicate areas of STC ownership

areas contain a significant older residual component in the second growth stands resulting from "sloppy" clearcutting in the past.

The climate on the study area was generally considered maritime. The mean summer and winter temperatures along the coast are 15° C and 8° C respectively (Zinke 1988). Coastal and valley low clouds and fog are characteristic of the area during much of the year. Most of the annual precipitation occurs during the winter. Significant snowfalls can occur at elevations above 500 m with persistent accumulations above 1000 m. Temperatures become less moderate with more seasonal variation as elevation and distance from the coast increases.

METHODS

A sooted track-plate survey of the study area was conducted to compare presence of fishers among the three forest vegetation types. Habitat attributes were measured at each track-plate station and compared between stations that received fisher detections and those that did not. The vegetation types sampled were characterized by the predominant overstory vegetation of 1) redwood, 2) redwood-Douglas-fir mix, and 3) Douglas-fir. These vegetation types represent a clinal transition from coastal, low elevation forests to inland, and high elevation forests.

Fisher Detections

I used sooted track plates (Fowler and Golightly 1994) to assess differences in fisher occurrence among the three different vegetation types and to associate habitat attributes at locations where fishers were and were not detected. I placed six sooted track plates (stations) at 1-km intervals in alternating 5-km segments of a survey route (Figure 2). A survey route consisted of three to five adjacent segments . Each station represented an individual sampling unit. Based on 1994 data, I found the 1-km separation was sufficient to insure independence among stations of the same segment (Klug et al. in prep). The 5-km segments were used to provide total coverage of the

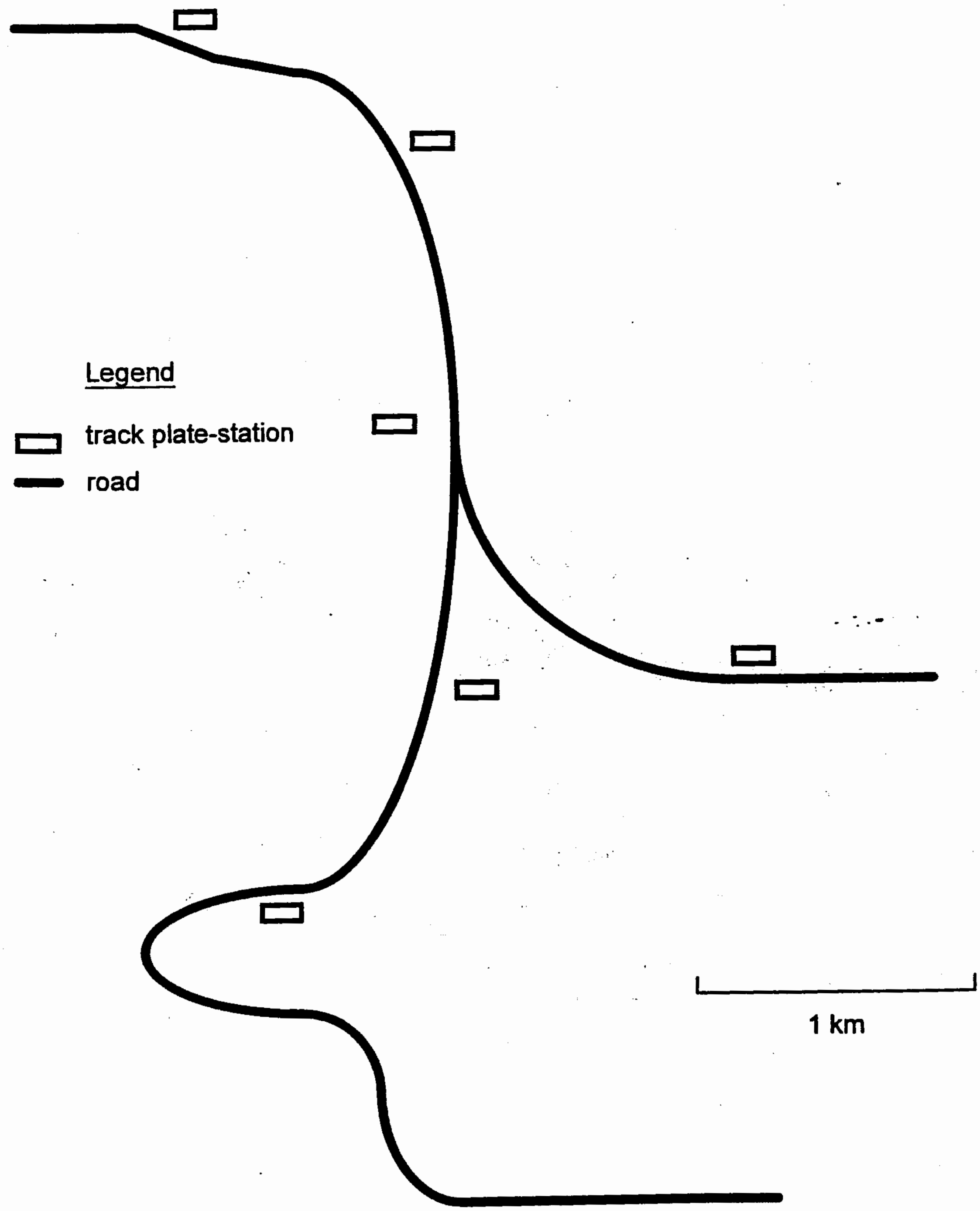

Figure 2. Diagram of a 6 Station Segment in the Sampling Design of the Sooted Track Plate Survey in Humboldt and Del Norte Counties, California. Each Station is Separated by 1km. Each Segment Was Separated by 5 km from Adjacent Segments.

study area in one field season and to provide an additional large scale sampling unit.

Survey routes were selected by identifying all potential routes in the study area and choosing routes that insured complete north-south and east-west coverage across the study area. Accessibility was an important factor in the selection of survey routes and timing of the surveys. Side roads were used where possible to increase the number of segments on a survey route and to insure sampling variation in vegetation and landscape. Each segment was separated by at least 5-km from other sample segments on the same and other survey routes, except when separated by a major barrier to fisher movement such as the Klamath River (Kelly 1977). When two or more potential survey routes were available through the same area, one was randomly selected to be the survey route.

I placed stations in the most suitable habitat within 100 m of each 1-km interval. If unsuitable fisher habitat (e.g., prairie, young clearcut <3 years old) occurred at the 1 km interval, I moved the station to the nearest available appropriate habitat in alternating directions from the previous station. Adjacent stations were separated by at least 0.6 km even when unsuitable habitat forced adjustments in the placement of the stations.

Each station was baited with half of a chicken wing. Track plates were re-sooted and re-baited every other day for 22 consecutive days. A sample consisted of one station maintained for 22 consecutive days at the same location. Fowler and Golightly (1994) found that a 22 day sampling period was long enough to be 95% certain that martens could be detected given that a track plate was placed within an individual's home range. I was only attempting to obtain a representative sample of the habitats fishers used and was not concerned with being certain that I detected all fishers. Given the larger average home ranges of fishers compared to martens (Powell 1994b) I decided that 22 days was an appropriate minimum survey length. Two complete surveys of the 40 segments were conducted, once each from 15 January to 16 June 1994 and again in 1995 (primary surveys). I sampled five to nine segments simultaneously over this period until all segments were sampled.

When a track was present on the track plate, the contact paper was labeled with the date and the station number. It was then removed and placed in a clear acetate document folder for cataloging. At the end of each day all detections were recorded on a separate data sheet and entered into a database.

To investigate consistency and independence of results through time, I resampled a subset of eight segments each year between 1 July and 15 August (repeated surveys). The repeated segments were chosen at random out of a subset of segments that were logistically feasible to resample. The same subset of eight segments was used each year. Detection ratios (Fowler and Golightly 1994) of the primary and repeated surveys were analyzed separately and then compared.

Habitat Attributes

Data were collected on two different scales; the microsite characteristics of the station and the vegetative characteristics of the stand in which the station was located. Aerial photographs (1994, 1:12,000, Cascade Aerial Maps and Surveys, Inc., Eugene, Oregon) were used to measure straight line distance from the station to the closest forest opening greater than 2.0 ha, the relative number of residual large trees within a 0.5 km radius of the station in stands less than 30 years old, and the topographic position of the station. To avoid an age related bias, I did not attempt to measure the relative number of residual large trees in stands older than 30 years because as the stands become older these trees are more difficult to see from aerial photographs. Simpson Timber Company's Forest Resource Inventory System (FRIS) database was used to determine the vegetation type, stand age, stand size, basal area of young growth conifer, and the number of residual conifer trees per acre in stands with stations (Table 1). This database was designed to inventory merchantable conifer species. In some instances, stands comprised of mostly hardwoods were designated as the conifer species that would most likely occur at that location. All data in the database were collected in English units and were converted to metric units prior to analysis (see Appendix A for a more complete description of the FRIS database). Stand ages from stations on Louisiana Pacific property were obtained from their geographic information system database.

Table 1. Habitat Variables Measured at Track Plate Stations or Their Associated Stands in Humboldt and Del Norte Counties, CA, Measured from 1:12,000 Aerial Photographs, USGS 7.5 and 15 Minute Quadrangle Maps, or Simpson Timber Co. FRIS Database.

Variable	Measurement Protocol
d to coast	Map distance (km) of station from closest coastal location.
d to gap	Distance (m) from station to nearest non-forest opening greater than 2 ha, measured from aerial photos.
slope position	Relative position of station in relation to major topographic features; upslope, midslope, and downslope.
vegetation type	Dominant (> 70% basal area) conifer vegetation of the track plate stand: Redwood, Douglas-fir, or mix.
stand size	Size (ha^2) of the contiguous stand (same age and vegetation type) that surrounds the station.
stand age	Age of the stand that surrounds the station. Old-growth arbitrarily designated 250 years.
percentage hardwood	% hardwood (basal area) within the stand.
basal area young growth redwood	Basal area (m^2/ha) of young growth redwood within the stand.
basal area young growth fir	Basal area (m^2/ha) of young growth Douglas-fir within the stand.
basal area young growth other conifer	Basal area (m^2 /ha) of young growth hemlock, spruce, and grand fir within the stand.
residual	Subjective determination of the relative amount of noticeably larger remnant trees left from a previous harvest within a 0.5 km buffer around track plate station, determined from 1:12,000 aerial photographs; assigned values of 0 = none, 1 = few, 2 = some, 3 = many.
residual trees per hectare redwood	Number of stems per ha residual redwood within the stand.
residual trees per hectare Douglas-fir	Number of stems per ha residual Douglas-fir within the stand.
residual trees per hectare other conifer	Number of stems per ha residual hemlock, spruce, and grand fir within the stand.

To assess microsite characteristics, a fixed 0.04 ha circular plot centered at the station was sampled (Table 2). Variables measured were chosen to assess the extent of late seral characteristics at the station. Canopy closure was measured using a spherical densiometer at 5 locations within the plot, at the center and 11.3 m from the center in each of the 4 cardinal directions. Percent slope was measured from the upper most point of the plot to the lowest point using a clinometer. Slope aspect was measured along this same line using a compass and placed into one of 8 aspect categories, N (337° - 22°), NE (23° - 67°), E (68° - 112°), SE (113° - 157°), S (158° - 202°), SW (203° - 247°), W (248° - 292°) and NW (293° - 336°). Quantity of large wood was calculated by adding the volume of each log within the plot. The volume of each log was calculated using a mean diameter and length of the log within the plot (Robinson and Bescheta 1990). Large wood was defined as any dead and down wood greater than 25 cm diameter at the smallest end. Trees were sampled using a variable radius plot with a glass prism (20 and 30 basal area factors) centered at the station. Each tree within the variable radius plot was identified to species and put into one of four size classes. The size classes represented four growth stages of trees; small pole timber (13-27 cm), large pole timber (28-52 cm), small sawtimber (53-90 cm), and mature-large sawtimber (>90 cm). The location of each station was found and plotted on 1:12,000 aerial photographs. Because the stations were close to roads (an exact reference point) these locations were

Table 2. Habitat Variables Measured at Fisher Track Plate Stations in Humboldt and Del Norte Counties, CA, Using 0.04 ha Circular and Variable Radius Plots Centered at the Track Plate.

Variable	Measurement Protocol
% canopy	Measured with a spherical densiometer at 5 locations within the circular plot (mean of the 5 measurements).
# logs	Count of all logs and log portions within the circular plot greater than 25.4 cm at the smallest end.
volume of logs	Volume (m^3) of logs, volume determined using a mean diameter and total length.
% slope	Measured using a clinometer from the highest point on the plot to the lowest.
aspect	Directional azimuth of the line that was used to measure % slope.
# snags	Number of snags counted in the variable radius plot.
basal area conifer	Basal area of conifer trees within the variable radius plot. Each tree placed into 1 of 4 size classes: diameter at breast height (dbh) 13-27cm, 28-51 cm, 52-90 cm, and greater than 90 cm.
total conifer basal area	Combined basal area of all conifer trees within the variable radius plot with dbh's greater than 13 cm.
basal area hardwood	Basal area of hardwood trees within the variable radius plot. Each tree placed into 1 of 3 size classes: dbh's between 13-27 cm, 28-51 cm, and greater than 52 cm.
total hardwood basal area	Combined basal area of all hardwood trees within the variable radius plot with dbh's greater than 13 cm.
total basal area	Combined basal area of all trees within the variable radius plot with dbh's greater than 13 cm.

accurate to within 10 m. Locations were then transferred to 1:12,000 FRIS generated maps and entered into the FRIS database.

Analyses

I analyzed each survey (1994 and 1995, primary and repeated) separately. Two pooled analyses were also conducted. The first was done on the primary surveys for 1994 and 1995 combined and the second was done on the repeated surveys for 1994 and 1995 combined. I calculated detection ratios (Fowler and Golightly 1994) for each habitat type by dividing the number of stations at which I obtained a fisher detection in a vegetation type by the total number of stations in that vegetation type. A station contributed only once to the detection ratio regardless of the number of repeat detections that I obtained at it. Detection ratios were used to represent the relative difference in fisher use among the three vegetation types. Chi-square contingency table analysis (Zar 1984) was used to test for differences in the detection ratios among the habitat types and between years. I used a Chi-square Goodness-of-Fit test (Zar 1984) to compare use of vegetation types to availability. A Bonferroni *Z*-statistic and 95% confidence intervals (Neu et al. 1974, Byers et al. 1984) were used to test whether observed use of vegetation types was significantly less than or greater than expected. If fisher detections occurred randomly across all three vegetation types, then the detections would be proportional to the available stations in each habitat type. To calculate the expected number of detections for each habitat type I multiplied the actual number of stations in a habitat type by the actual proportion of all stations that had one or more fisher detection. All statistical analyses were performed using NCSS statistical software, version 6.0.20 (Hintze 1995).

All variables except aspect were compared using two-sample t-tests to test for differences in mean values of stations with at least one fisher detection to stations with no fisher detections. If the data were non-normal or heteroscedastic, I used the Mann-Whitney U test or an Aspin-Welch unequal variance test. Aspect was compared using a Chi-square Goodness-of-Fit test. To examine which variables best predicted fisher occurrence I used a forward stepwise logistic regression. Only variables that differed significantly between stations with fisher detections and stations with no detections were included in the analyses. Separate logistic procedures were conducted for the station and stand level variables. I included all variables that were selected by the logistic procedure ($P < 0.15$) in an all variable logistic regression for final model determination (Bigg pers. comm.). Due to partial coverage of STC's GIS database (mainly those stands over 30 years of age) and to 34 stations being off STC property, only 170 stations were included in the stand level logistic regression. Stand level univariate analyses were conducted on all stations where stand data was available for each survey year.

RESULTS

Fisher Detections

I sampled 238 stations distributed among 40 segments (2 segments contained only 5 stations). A total of 238 stations were sampled in 1994, of which, 233 were re-sampled in 1995. Three stations included in the overall detection ratio calculation for the 1994 survey were removed from the habitat analysis because the habitat at the station was removed or significantly altered before it could be measured (they were not used in the vegetation-type detection ratio calculations). I obtained at least one fisher detection at 71 different stations during the two primary surveys. There were twenty-three stations at which I obtained fisher detections both years. There were two stations at which I obtained fisher detections during all 4 surveys. The mean detection ratio of the 4 surveys was 0.198.

Primary Surveys

The detection ratio was 0.18 (n=238) in 1994 and 0.21 (n=233) in 1995 (Table 3). The mean detection ratio of the primary surveys from both years was 0.195 (n=2 years). There was no significant difference in detection ratios of the primary survey between years (X^2 = 0.658, df = 1, P = 0.417). Fishers were detected on 26 of the 40 (65%) segments during both primary surveys combined. Fishers were the third most frequently detected mammalian species. Other species detected were gray fox (*Urocyon cinereoargenteus*),

Table 3. Overall Detection Ratios of Four Sooted Track Plate Surveys in Humboldt and Del Norte Counties, CA Conducted on Managed Second Growth Forests between January 1994 and August 1995.

Survey	Year	Number of Stations Sampled	Detection Ratio
Primary	1994	238	0.18
Repeated	1994	48	0.21
Primary	1995	233	0.21
Repeated	1995	48	0.19

spotted skunk (*Spilogale gracilis*), black bear (*Ursus americanus*), raccoon (*Procyon lotor*), opossum (*Didelphis virginiana*), ringtail (*Bassariscus astutus*), weasel (*Mustella* spp), bobcat (*Felix rufus*), and striped skunk (*Mephitis mephitis*).

Detection ratios differed significantly between the three habitat types in 1994 (X^2 = 9.0, df = 2, P = 0.011) in 1995 (X^2 = 33.2, df = 2, P < 0.001) and for both years combined (X^2 = 24.7, df =2, P < 0.001) (Figure 3). Fishers were detected in the Douglas-fir vegetation type more frequently than expected in 1994, 1995 and in the 1994 - 1995 combined analysis ((*Z* = 2.394, P = 0.0083). They were detected less frequently than expected in the redwood vegetation type in 1994, 1995 and in the 1994 - 1995 combined analysis (*Z* = 2.394, P = 0.0083). Fishers were detected in the Douglas-fir - redwood mix vegetation type more than expected in 1994 and in the combined analyses and as expected in the 1995 analysis (*Z* = 2.394, P = 0.0083).

Repeated Surveys

Fishers were detected at 16 of the 48 resampled stations during the repeated surveys for a mean detection ratio of 0.195 (n=2). Fishers were detected at seven stations in the repeated surveys where they had not been detected during the primary surveys. Detection ratios of the repeated surveys were not significantly different than primary surveys (0.21 in 1994 (X^2 = 0.202, df = 1, P = 0.653) and 0.19 in 1995 (X^2 = 0.126, df = 1, P = 0.722)). There was no significant difference in the detection ratios between the primary and repeated

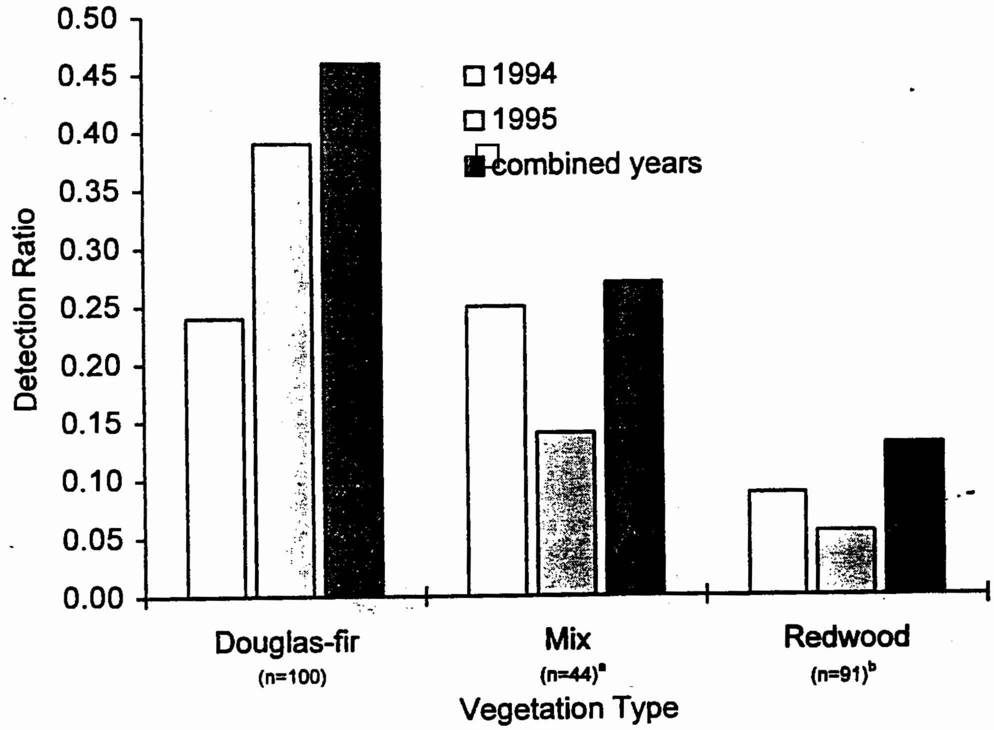

Figure 3. Detection Ratios of Pacific Fisher During the Primary Surveys in Three Forest Vegetation Types on Managed Timberlands in Humboldt and Del Norte Counties, California, (n is the Number of Stations Sampled).
[a] n = 43 in 1995.
[b] n = 90 in 1995.

surveys in the 3 vegetation types in 1994 or in 1995 (Table 4). The detection ratios for the three habitat types during the repeated surveys were not significantly different in 1994 ($X^2 = 1.212$, df = 2, P = 0.546), in 1995 ($X^2 = 3.314$, df = 2, P = 0.191) or for both repeated surveys combined ($X^2 = 4.398$, df = 2, P = 0.111) (Figure 4).

Microsite Analysis

In the univariate comparisons, stations where fishers were detected differed significantly ($p < 0.05$) from stations where fishers were not detected in all three comparisons (1994, 1995, and combined years) in that they were higher in elevation, a greater distance to coast. They had a greater basal area of hardwood with dbh between 13-27 cm and had a greater basal area of hardwood with dbh greater than 52 cm. They also had a greater total basal area of hardwoods (dbh > 13cm). There were no differences in % canopy cover, number of logs, slope position, number of snags, distance to gap, basal area conifer of all size classes, basal area of hardwood with dbh between 28-51 cm, total basal area of conifer, and total basal area of all trees (Table 5).

1994

Using only the 1994 data, there were also significant differences between stations where fishers were detected and stations where fishers were not detected in the volume of logs, number of logs and the distance to gap. All of the significant variables were included in the logistic regression analysis (LRA)

Table 4. Comparisons of Detection Ratios of Pacific Fishers Obtained During Sooted Track Plate Surveys in Humboldt and Del Norte Counties, California within Vegetation Types Between the Primary and Repeated Surveys of the Same Year.

Vegetation Type	Detection Ratio Primary Survey (n)	Detection Ratio Repeated Survey (n)	X^2	P
1994				
Redwood	0.09 (91)	0.10 (11)	0.001	0.97
Redwood-Douglas-fir mix	0.25 (44)	0.23 (13)	1.488	0.22
Douglas-fir	0.24 (100)	0.25 (24)	0.304	0.58
1995				
Redwood	0.06 (91)	0.00 (11)	0.667	0.41
Redwood-Douglas-fir mix	0.19 (44)	0.23 (13)	0.094	0.76
Douglas-fir	0.37 (98)	0.25 (24)	1.280	0.26

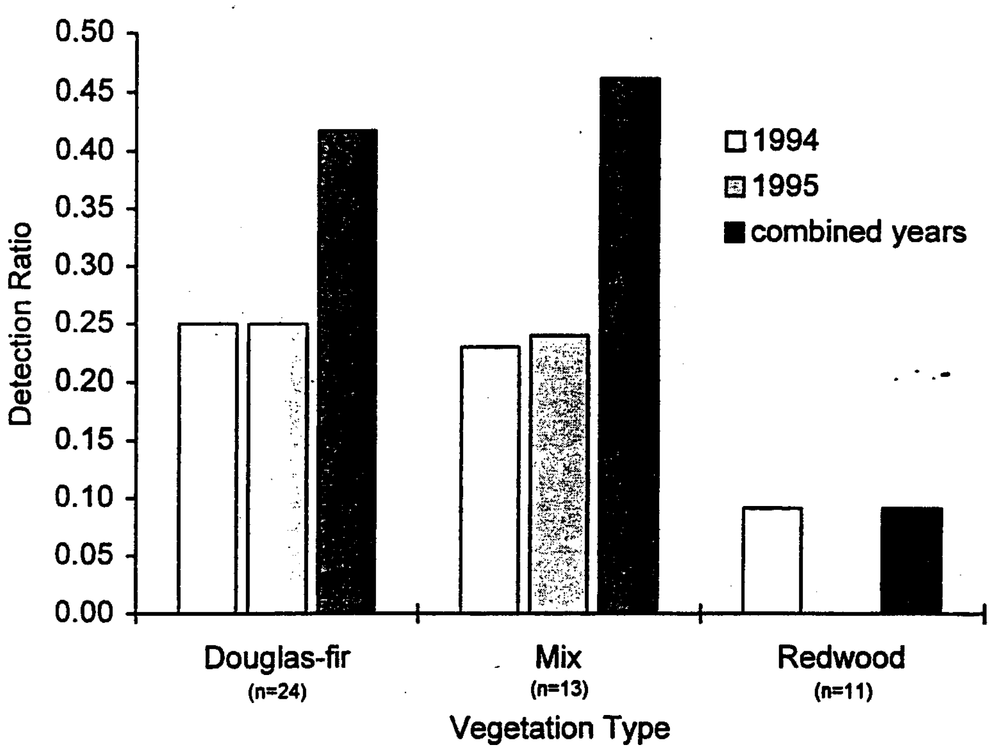

Figure 4. Detection Ratios of Pacific Fisher during Repeated Surveys in Three Forest Vegetation Types on Managed Timberlands in Humboldt and Del Norte Counties, California.

Table 5. Summary of Habitat Variables Measured at Track Plate Stations where Fishers Were and Were Not Detected in Humboldt and Del Norte Counties, California in 1994 and 1995.

		1994			1995		
variable	test[a]	detected $\bar{X} \pm SE$	not detected $\bar{X} \pm SE$	p-value	detected $\bar{X} \pm SE$	non-detected $\bar{X} \pm SE$	p-value
% canopy	MWU	96.1 ± 1.1	94.5 ± 0.8	0.10	96.4 ± 1.01	94.8 ± 0.69	0.023
# logs	MWU	5.7 ± 0.8	4.2 ± 0.3	0.018	4.0 ± 0.48	4.2 ± 0.37	0.216
volume of logs (m^3)	MWU	9.5 ± 1.8	6.0 ± 0.6	0.008	8.2 ± 1.4	6.2 ± 0.6	0.086
% slope	MWU	29.6 ± 3.5	35.1 ± 1.7	0.053	30.4 ± 3.45	35.3 ± 1.66	0.038
slope position	X^2	-	-	0.15	-	-	0.10
aspect	X^2	-	-	0.09	-	-	0.02
# snags	MWU	0.38 ± 0.17	0.34 ± 0.06	0.360	0.33 ± 0.11	0.35 ± 0.07	0.415
elevation (m)	t-test	619 ± 6.5	400 ± 14.0	<0.001	663 ± 37	380 ± 22	<0.001
d to coast (km)	MWU	19.8 ± 0.4	15.8 ± 0.2	0.001	19.8 ± 1.0	15.6 ± 0.74	<0.001
d to gap (m)	MWU	362 ± 24.3	296 ± 45.9	0.03	290 ± 38	318 ± 26	0.495
basal area of conifer							
13-27cm	MWU	5.55 ± 1.19	5.38 ± 0.57	0.428	6.98 ± 1.67	4.96 ± 0.47	0.333
28-51cm	MWU	11.74 ± 2.03	14.27 ± 1.17	0.251	12.58 ± 2.23	14.09 ± 1.17	0.183
52-89cm	MWU	5.02 ± 1.29	8.63 ± 1.05	0.064	4.96 ± 1.36	8.88 ± 1.08	0.016
>90cm	MWU	1.49 ± 0.61	2.02 ± 0.42	0.343	1.74 ± 0.57	0.57 ± 0.44	0.290
total	MWU	23.81 ± 3.12	30.29 ± 2.10	0.200	26.26 ± 3.61	29.92 ± 2.11	0.225
basal area of hardwood							
13-27 cm	MWU	9.40 ± 1.56	7.77 ± 0.84	0.026	10.93 ± 1.69	7.22 ± 0.83	0.003
28-51 cm	MWU	9.72 ± 2.07	7.27 ± 0.76	0.131	8.54 ± 1.73	7.53 ± 0.81	0.286
>52 cm	MWU	2.56 ± 0.69	1.41 ± 0.33	0.005	2.48 ± 0.82	1.41 ± 0.30	0.061
total	MWU	22.31 ± 3.18	16.55 ± 1.31	0.018	22.59 ± 2.82	16.23 ± 1.36	0.007
basal area total	t-test	46.12 ± 3.38	46.84 ± 1.98	0.436	48.84 ± 3.41	46.15 ± 2.01	0.262

[a] MWU is Mann-Whitney U, X^2 is Chi-square

except number of logs, which was not included because it was highly correlated with volume of logs (r_S = 0.86, $P < 0.001$). Although elevation and distance to coast were correlated, (r_S = 0.68, $P < 0.001$) they were both included in the LRA because I felt they could represent different environmental conditions. Only elevation and volume of logs were selected ($P < 0.05$) for inclusion in a logistic regression model (r^2 = 0.087, df = 2, X^2 = 19.56, $P < 0.001$).

1995

The results of the univariate comparisons were similar to 1994 except that there was also a significant difference between stations with fisher detections and stations without fisher detections in % slope, aspect, and basal area of conifer between 52-90 cm and no difference in number of logs and distance to gap (Table 3). Percent canopy cover was not included in the LRA despite being significant because of a relatively small difference in the mean (94.4% and 94.9%). Six variables were selected by the stepwise logistic procedure (Table 6) to include in the final model (r^2 = 0.175, df = 6, X^2 = 42.98, $P < 0.001$).

1994-1995 Combined Data

The combined results were similar to 1995 except that, as in 1994, number of logs was also significant (Table 3). Five variables were selected by the stepwise procedure (Table 6) to be included in the final logistic model (r^2 = 0.194, df = 5, Model X^2 = 46.13, $P < 0.001$).

Table 6. Results of Forward Stepwise Logistic Regression of Habitat Variables, Measured at Track Plate Stations, Chosen to Predict the Presence of Pacific Fishers on Managed Timberlands in Humboldt and Del Norte Counties, California.

variable[a]	Coefficient	Chi-square	P
1994			
Elevation	0.002	14.19	<0.001
Volume logs	0.013	5.37	0.021
1995			
Elevation	0.003	30.22	<0.001
Basal area conifer 52cm-90cm	-0.008	3.67	0.055
Aspect	-0.144	2.58	0.108
Volume logs	0.011	2.85	0.092
% slope	-0.013	2.40	0.121
Distance to coast	-0.033	1.66	0.198
Combined			
Elevation	0.003	20.29	<0.001
Volume logs	0.013	6.54	0.01
Basal area conifer 52cm-90cm	-0.008	3.71	0.054
% slope	-0.015	4.13	0.04
Distance to coast	-0.03	1.99	0.16

[a] See Table 2 for definition of variables.

Stand Analysis

1994

Results of the univariate comparisons of the 13 stand level habitat variables indicated that there were significant differences between stands that had stations with fisher detections and stands that did not have fisher detections in regard to vegetation type, % hardwood, and residual trees/ha redwood (Table 7). Only percent hardwood was selected by the logistic model (Table 8).

1995

The 1995 univariate results were similar to 1994 except that residual trees per ha fir, basal area young growth redwood, and residual also had significant differences between stands that had stations with detections and stands that had stations without detections (Table 7). Vegetation type was the only variable selected in the logistic regression (Table 8).

Combined Years

The combined univariate results were similar to 1995 except that basal area of young growth fir also had a significant difference between stands that had stations with detections and stands that had stations without detections (Table 9). Again vegetation type was the only variable to enter the logistic regression (Table 8).

Table 7. Summary of Habitat Variables Measured in Stands where Fisher Were and Were Not Detected During the Primary Survey Using Sooted Track Plates in Humboldt and Del Norte Counties, California in 1994 and 1995.

		1994			1995		
variable	test[a]	detected $\bar{X} \pm$ SE (n)	not detected $\bar{X} \pm$ SE (n)	p-value	detected $\bar{X} \pm$ SE (n)	non-detected $\bar{X} \pm$ SE (n)	p-value
age	MWU	42.6 ± 4.4 (72)	43.6 ± 2.3 (146)	0.147	40.7 ± 4.46 (47)	44.0 ± 2.36 (171)	0.26
size (ha)	MWU	78.9 ± 11.1(64)	90.2 ± 15.0 (136)	0.17	67.8 ± 14.5 (46)	93.5 ± 10.9 (151)	0.15
vegetation type	X^2	-	-	<0.001	-	-	<0.001
basal area	t-test	46.0 ± 3.6 (59)	43.8 ± 2.7 (111)	0.31	45.1 ± 4.1 (43)	44.4 ± 2.5 (127)	0.44
% hardwood	MWU	51.7 ± 37.1 (59)	31.7 ± 33.7 (111)	0.001	51.5 ± 5.6 (43)	34.3 ± 3.1 (127)	0.01
residual	X^2	-	-	0.80	-	-	0.03
residual trees/ha							
redwood	MWU	1.46 ± 1.03 (64)	4.08 ± 0.57 (136)	0.003	0.54 ± 0.44 (47)	4.08 ± 0.53 (153)	0.003
fir	MWU	1.98 ± 0.67 (64)	0.94 ± 0.32 (136)	0.01	1.61 ± 0.42 (47)	1.16 ± 0.37 (153)	0.007
other conifer	MWU	0.54 ± 0.42 (64)	0.15 ± 0.28 (136)	0.22	0.20 ± 0.12 (47)	0.32 ± 0.17 (153)	0.25
total	MWU	3.98 ± 1.43 (64)	5.16 ± 1.63 (136)	0.37	2.35 ± 0.64 (47)	5.53 ± 1.56 (153)	0.34
basal area young growth							
redwood	MWU	6.6 ± 1.5 (63)	17.1 ± 2.1 (136)	<0.001	6.1 ± 1.8 (47)	16.2 ± 1.9 (152)	0.001
fir	MWU	10.3 ± 1.7 (63)	6.8 ± 1.0 (136)	0.04	10.6 ± 2.1 (47)	7.1 ± 0.9 (152)	0.08
other conifer	MWU	0.7 ± 0.2 (63)	0.8 ± 0.2 (136)	0.25	0.7 ± 0.2 (47)	0.8 ± 0.2 (152)	0.34
total	MWU	17.6 ± 2.4 (63)	25.0 ± 2.3 (135)	0.11	17.4 ± 2.8 (47)	24.3 ± 2.2 (151)	0.13

[a] MWU is Mann-Whitney U, X^2 is Chi-square

Table 8. Variables Selected by Forward Stepwise Logistic Procedure to Be Included in the Final Model for Primary Surveys in 1994 and 1995 in Humboldt and Del Norte Counties, California.

Variable[a]	Coefficient	Chi-square	P
1994			
% hardwood	0.012	3.49	0.06
1995			
Vegetation type	-1.10	12.58	<0.001
Combined			
Vegetation type	-0.998	16.05	<0.001

[a] See Table 1 for definition of variables.

Table 9. Means of Habitat Variables Measured from STC GIS Database in Stands with Fisher Detections and Stands without Fisher Detections in 1994 and 1995 Combined, in Humboldt and Del Norte Counties, California.

variable[a]	detection $\bar{x} \pm$ (SE,n)	no detection $\bar{x} \pm$ (SE,n)	test[b]	P
Age	42.6 (4.4, 72)	43.6 (2.3, 146)	MWU	0.147
Size (ha)	78.9 (11.1, 64)	90.2 (15.0, 136)	MWU	0.17
Vegetation type	-	-	X^2	<0.001
Residual	-	-	X^2	0.087
Basal area	46.0 (3.6, 59)	43.8 (2.7, 111)	t-test	0.31
% hardwood	51.7 (37.1, 59)	31.7 (33.7, 111)	MWU	0.001
Residual trees/ha				
Redwood	1.46 (1.03, 64)	4.08 (0.57, 136)	MWU	0.003
Fir	1.98 (0.67, 64)	0.94 (0.32, 136)	MWU	0.01
Other conifer	0.54 (0.42, 64)	0.15 (0.28, 136)	MWU	0.22
Total	3.98 (1.43, 64)	5.16 (1.63, 136)	MWU	0.37
Basal area young growth				
Redwood	6.6 (1.5, 63)	17.1 (2.1, 136)	MWU	<0.001
Fir	10.3 (1.7, 63)	6.8 (1.0, 136)	MWU	0.04
Other conifer	0.7 (0.2, 63)	0.8 (0.2, 136)	MWU	0.25
Total	17.6 (2.4, 63)	25.0 (2.3, 135)	MWU	0.11

[a] See Table 1 for definition of variables.
[b] MWU is Mann-Whitney U, X^2 is Chi-square.

DISCUSSION

Vegetation Type

Although fishers on my study area used all vegetation types, they were detected significantly more often than expected in areas with Douglas-fir either as a predominant or co-dominant component, at higher elevations, and at greater distances from the coast . There are several possible explanations for this trend. Hardwood, especially tan oak (*Lithocarpus densiflorus*) and madrone (*Arbutus manziesii*) were a major component of higher elevation inland stands. Conversely alder (*Almus rubra*) was the major hardwood species in redwood stands that occurred at lower elevations and closer to the coast. Tan oak and madrone are both mast producing species that could provide substantial food to potential prey species such as gray squirrels (*Sciurus griseus*), dusky-footed woodrats (*Neotoma fuscipes*), and other small mammals. Golightly (unpub. data, 1995) found squirrel (*S. griseus, Tamiasciurus douglasii, Spermophilus beecheyi, Eutamias* spp.) and other small mammal remains (*Neotoma* spp., *Peromyscus* spp., *Microtus* spp., *Clethrionomys* spp.) in 58% of fisher scats examined from northwestern California. The nests of these prey species may also provide fishers with resting sites. Kilpatrick and Rego (1994) reported that fishers would often capture prey in or near their dens and then use the den of the prey for resting. Spencer (1987) suggested that red squirrel nests were preferred rest sites for marten (*Martes americana*).

Tan oak and madrone also have an irregular branching pattern which may provide fishers with abundant rest sites in these stands. Zielinski et al. (1995) reported that fishers in the southern Sierra Nevada and in the northern California coast range used cavities of black (*Quercus kellogii*) and canyon live oaks (*Q. chrysolepis*) most frequently as rest sites. Zielinski (1995) reported that live hardwoods were the third most frequently type of rest site used by fishers in the northern California Coast Range.

Stand Age

Fishers were detected in stands ranging in age from 6 years to old-growth. There was no significant difference in age between stands where fishers were detected and where fishers were not detected. Unlike other studies of fishers in the western U.S. (Buck et al. 1994, Jones 1991, Aubry and Houston 1992, Seglund 1995), I found no relation between fishers and old-growth or late seral forests. However, considering that less than 2% of the study area was composed of small isolated stands of old-growth or late seral timber, any relationship between fisher detections and old-growth would not have been easy to detect in my analyses. This may be attributed to the rapid growth of stands in the study area. Vegetation grows rapidly along the Pacific coast because of moderate temperatures and abundant precipitation,. Within 5-7 years after harvest (usually clearcutting), it is possible to have a nearly closed "canopy" cover. This "canopy" is often formed by thick brush (*Ceanothus* spp.) and small trees but would be sufficient to provide overhead cover for fishers.

Unlike telemetry studies of fisher which concentrate on resting and denning locations, track-plates probably detect fishers in foraging and travel areas, as well as areas used for resting and denning. Many studies (Kelly 1977, Arthur et al. 1989, Jones and Garton 1994) have suggested that fishers are less selective of habitat when foraging as opposed to resting.

Young stands also support high densities of potential prey for fishers. Hamm (1995) found mean densities of 31 woodrats (*Neotoma fuscipes*) per ha (7200-7235 g biomass/ha) in stands between 5 and 20 years of age within the study area while stands from 21 to 60 and 61 to 80 years of age averaged only 2.1 and 0.3 woodrats per ha respectively. Other potential prey items such as brush rabbits (*Sylvilagus bachmani*), and chipmunks (*Tamias senex*) are frequently observed in young regenerating stands. Strickland et al. (1982) suggested that fishers could inhabit any forested habitats provided that a suitable prey base was available.

Topographic Position

Buskirk and Powell (1994) suggested that fishers prefer mesic forests over xeric forests and at temperate latitudes these mesic forests often occur in riparian areas. Jones (1991) suggested that fishers used riparian areas for resting areas. These areas may provide a more desirable microclimate for fishers when resting, especially in summer when cooler temperatures are found in drainage bottoms. Seglund (1995) found 83% of fisher rest sites within 100 m of a drainage, and suggested that the observed use of riparian areas may be related to the availability of large decadent trees and the general old-growth characteristics of these areas. Buck et al. (1994) and Heinemeyer (1993) reported that topographic position was important in determining where fishers were present. In contrast, I found no relationship between fisher occurrence and riparian habitat or topographic position. Again this may be due, in part, to the fact that I was sampling a more complete representation of all the habitats used by fishers as opposed to only identifying habitats used for resting and denning which are the focus of most telemetry studies. Another explanation may be that due to past timber yarding and hauling, riparian areas in my study area were often the first and most heavily impacted sites on the landscape resulting in few late seral characteristics in these areas. Seglund (1995) noted that riparian areas on her study area had characteristics of late seral stage forests due to the fact that no timber harvest had occurred in these areas while the upland areas were heavily harvested.

The lack of a relationship to topographic position may be also attributed to the abundance of water courses and abundant free water in my study area. It is not unusual to travel 100 m across a slope and cross one or more water courses. Consequently, it was difficult to even assign a station to a particular slope position. The climate of the study area may also help explain the lack of an apparent relationship with topographic position. Summer temperatures in this area seldom rise above 30° C during the hottest part of the day. With these moderate temperatures, rest site microclimate may not be as important as in other regions.

Survey Limitations

Stations at which I did not detect fishers do not equate to unused areas. Track plates sampled the landscape over a relatively short time period and each track plate was probably sampling a relatively small area around it. Another drawback to track plates is that, at this time, they only allow quantification of detections compared to non-detections. Track-plate surveys cannot be used to distinguish between areas of occasional use and areas of regular use; among areas used for resting, traveling and foraging; or between areas that serve as sources (i.e., for successful reproduction) and areas that act as sinks of the population. There was high variation in the number of visits to individual stations and segments. At one station, I obtained fisher detections on 20 of 22 visits, with 10 detections each year. At other stations I recorded only one detection over the entire length of all surveys, up to 44 visits. In the analyses these were weighted equally. The same type of variation was seen in the sample segments. There were two segments at which I obtained fisher detections at all six stations in one survey. There were two other segments at which I obtained detections at all 6 stations over the two years, but not more than four stations in any one year. Conversely there were several segments at which I obtained detections at only one station over the course of all surveys, in one case, all four surveys. As Fowler and Golightly (1994) noted, the detection ratio is an extremely conservative response variable; patterns detected with this technique may actually be stronger than these analyses would suggest. I assumed that there was no difference in the probability of detecting fishers in different vegetation types other than differences based on density of fishers or frequency of use by fishers of a vegetation type. If fishers were detected in one or more of the vegetation types statistically more often than the other(s), then it is probable that they occur in higher densities or use that vegetation type more frequently; however, it should not be assumed that this is preferred habitat (VanHorne 1983).

Fishers and owls

Folliard (1993) found that 62% of the northern spotted owls on my study area nested in areas with some residual component. He suggested that leaving small clumps of residual trees may benefit spotted owls by providing suitable nesting habitat. Although my residual measurement was only significant in the 1994 analysis, this may be an important aspect of fisher habitat when considering resting and denning sites (Seglund 1995). Folliard (1993) also found that spotted owls nest closer to water than random sites, leading to the suggestion that these clumps of residuals be left, when possible, in conjunction with watercourse protection zones. Large woody debris was also a significant factor in spotted owl nest sites as it was with my fisher detection. Folliard (1993) suggested that log recruitment and retaining canopy cover should be goals of owl management. Based in part on these suggestions, STC has been operating under their Northern Spotted Owl Habitat Conservation Plan (Simpson Timber Co. 1992) since 1992. This plan calls for the retention of a residual component (habitat retention areas or HRA's) whenever feasible. These HRA's are often in drainage bottoms in conjunction with watercourse protection zones and often include large hardwoods and snags. Recent changes in forest practice rules (Calif. Dept. of Forestry and Fire Protection, 1992) and Simpson's HCP have provided protection for these riparian areas and adjoining HRA's. This protection should allow the development of late seral characteristics in these areas, which may provide additional rest and den sites for fishers (Seglund 1995).

Despite Simpson's HCP and the measures it takes to enhance spotted owl habitat, it cannot be assumed that these protection measures will provide benefits to fishers. Although there have been no studies conducted to estimate spotted owl home range sizes on my study area, adjacency of spotted owl territories suggests that about 400 ha is an average home range size for spotted owls. This is at least one order of magnitude smaller than even the smallest published home range size estimate for fishers (Buck et al. 1983). Given this difference in home range size and differences in motility, the scale at which fishers should be managed may need to be considerably larger than the scale used to manage for spotted owls. Travel and dispersal abilities probably also differ between fishers and spotted owls. Spotted owls can fly over barriers that would block a movement of a fisher. Kelly (1977) noted that a 20m-wide river on his study area was a barrier to fisher movement, while Rosenberg and Raphael (1986) found fishers to be sensitive to forest fragmentation. This would suggest that travel corridors may be an important factor in fisher management. These corridors may already be provided through watercourse protection zones and forest practice rules that place restrictions on the timing of adjacent clearcuts. Currently, clearcutting is not permitted contiguous to a previously harvested clearcut unless the dominant and codominant trees average at least five years of age or average at least 1.52 m tall and three years of age (California Dept. of Forestry and Fire Protection 1997). On this study area, three to five years may be enough time to allow sufficient regeneration of harvested stands so they would no longer be a barrier to fisher movements.

Variation in detection ratios

The detection ratios on my study area were higher (mean detection ratio for all surveys was 0.21) relative to most other track plate surveys in California. Dark (1996) had a mean detection ratio of 0.15 (SE 0.014) on the Shasta-Trinity National Forest located approximately 100 km east of my study area. Zielinski (pers. comm.) had a mean detection ratio of 0.11 on the Pilot Creek study area (adjacent to the east of the southern portion of my study area) but the surveys were only conducted for 12 days. Fowler and Golightly (1994) detected no fishers in Placer County, California in the central portion of the Sierra Nevada Mountains. Zielinski et al. (in press) reported that 23.5% of surveys conducted in California detected fishers, but each survey had from six to more than 20 track plate stations so that the actual detection ratios were considerably lower. In contrast, Higley (pers. comm.) had a very high average detection ratio of 0.66 (n=116 track plate stations) on the Hoopa Valley Indian Reservation during 1992 and 1993, located to the east immediately adjacent to the central portion of my study area, while Fowler et al. (1992) had a detection ratio of 0.65 (n=20) also on the Hoopa Valley Indian Reservation.

At this time there is little data to suggest why detection ratios vary among study areas. It is also not clear what correlation there is between detection ratios and density of fishers, although I suspect that higher detection ratios would suggest higher fisher densities or greater use of study areas by fishers. There are, however, several speculative explanations for the observed differences in detection ratios among study areas. These study areas had varying proportions of old-growth ranging from 41% on the Hoopa Valley Indian Reservation to less than 2% on my study area. Fishers may either be able to find the rest and den sites they need in the scattered residual trees found throughout my study area or they may not need a large number of large trees. Another explanation may be that most of the other study areas, with the exception of the Hoopa Reservation, are located primarily on public property.

These areas may receive much higher vehicle traffic during most parts of the year than my study area. The vast majority of roads on my study area are gated and closed to all public traffic. Traffic on the national forest study areas may be much higher throughout the year for recreational uses such as camping, boating, hunting, fishing, and hiking. Dark (1997) found that fishers were detected significantly more often in areas with a greater than average density of low use roads and less often in areas with moderate and high road use. Higher traffic on public land may lead to a significant source of mortality for fishers(Golightly pers. comm.).

Conclusions

Contrary to previous studies in the western U.S. (Buck et. al 1994, Jones 1991, Seglund 1995), I found no relation to stand age or old-growth habitats and fisher occurrence. However, this is the first study that did not focus specifically on resting and denning sites and the amount of old-growth in the study area is very small. Contrary to other studies, I found no relation between fisher occurrence and topographic position. Unlike Seglund (1995) who found riparian areas to contain largely old-growth type habitats, riparian areas on my study area were frequently the target of past timber harvest activities and in most cases few large trees were left. A third explanation may be that the very thick forests that are present on my study area may provide abundant cover for fishers. Studies have generally suggested that fishers use habitats with a high degree of canopy cover and avoid open areas (Allen 1983, Thomasma et al. 1991, Kelly 1977, Buck et al. 1994). The mean canopy cover for all stations that I sampled was 94.7% ranging from 44.7% to 100% with 221 of the 238 stations (93%) having greater than 80% canopy cover. With canopy cover this great, a large portion of the study area may be suitable for fishers.

If fishers are of management concern when planning timber harvest operations in this area, results of this study indicate that particular attention should be paid to the Douglas-fir vegetation zone. Similar to Beyer and Golightly (1996), fishers were detected in redwood dominated stands. However, they appeared to use them much less frequently, perhaps only for dispersal or by individuals that have not established home ranges. In addition, "rehabilitation" of hardwood stands to homogeneous stands of fir may be detrimental to fishers. Also, the removal of large dead and down material may have impacts on the availability of potential resting and foraging sites.

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Appendix A. Sampling protocol and accuracy of STC FRIS database.

Simpson Timber Company's' Forest Resource Inventory System includes a Geographic Information System using a pair of networked Intergraph workstations that execute GIS programs developed by Intergraph Corporation and relational database software developed by Oracle Corporation. The software is used to input, store, and retrieve spatial data such as stand boundaries, vegetation types, watercourses, ridges, and roads. This is a vector based system capable of accuracy to 0.305 cm. Actual on ground accuracy is approximately +/- 10m. Since all of STC ownership cannot be cruised each year, a computer program is used to "grow" the inventory to the current year. The program extracts stand-level information for each vegetation type and applies the appropriate growth routine from the database. The growth and yield models are based on permanent growth plots scattered throughout STC's ownership and represent the naturally occurring range in stand and site conditions. The data used by the GIS have come from both field collection and aerial photo interpretation. Field data were collected from a series of cruise strips using variable radius plots at 40.23 m intervals. Adjacent cruise strips were separated by 201.2 m. Cruise data have been collected since 1969. These data originally contained only data on timber volume (conifers) but in order to address the growing need to assess wildlife habitat, stand structure, and species diversity, it has evolved to include estimates of understory vegetation and downed woody debris. Goals in 1997 were to cruise approximately 2400 ha each year. Data on uncruised areas comes primarily from acquisition cruises and aerial photo interpretation. Acquisition cruises (used to determine the monetary value of a piece of property before purchase) were used as a source of data on species composition and stand volumes. Both recent and older aerial photographs were used to assign stand ages and vegetation types and to delineate stand boundaries in areas where no cruises have been conducted. When any uncruised stands were thought to have a significant merchantable conifer volume (>25%) and were of an appropriate age (35-40 years) they were scheduled for cruising in order to update the database.