HABITAT AT FISHER RESTING SITES

IN THE KLAMATH PROVINCE

OF NORTHERN CALIFORNIA

By

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ABSTRACT

HABITAT AT FISHER RESTING SITES IN THE KLAMATH PROVINCE OF NORTHERN CALIFORNIA

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The resting habitat of fisher (*Martes pennanti*) on the Hoopa Valley Indian Reservation (Hoopa) was compared to resting habitat on the Shasta-Trinity National Forest (Shasta-Trinity) in northern California to identify critical habitat characteristics. Comparison of fisher abundance indices at the two study areas suggested fisher were more numerous at Hoopa, which may represent differing habitat condition at the two study areas. Fishers primarily used live trees for resting at both Hoopa (83%) and Shasta-Trinity (76%) and used live hardwoods and live conifers in proportion to their availability at Hoopa (χ^2 = 1.08, p = 0.298) but not at Shasta-Trinity (χ^2 = 9.72, p = 0.002). Black oak (*Quercus kelloggii*) was used more than expected at both study areas.

When resting in live trees, the actual resting substrate (cavities or platforms) was identified 149 times at Hoopa and 154 times at Shasta-Trinity. At Hoopa, 48% of these were in cavities while 52% were on platforms. At Shasta-Trinity, 19% were in cavities while 81% were on platforms. In live trees, cavity rest sites were generally found in hardwoods while platform rest sites were generally found in confers at both study sites. At Hoopa, more cavity openings were noted in live black oak trees than any other species. The lower availability of large black oaks at Shasta-Trinity and

greater observed use of platforms as resting structures suggests cavities may have been limited there.

Across home range, study site, and study area scales, a general pattern emerged in fisher habitat use. Fishers selected sites made up of stands with large diameter trees and dense canopy cover that were generally situated within drainage-bottoms. Fishers generally used the largest tree available in an area for resting. Rest trees had a larger ($p \leq 0.001$) diameter at breast height (DBH) than the average DBH of the four largest trees on 0.04-ha rest site plots at both study areas. There was no difference in the diameter of rest site structures used between Hoopa and Shasta-Trinity when grouped by all rest sites ($t = 1.57$, df = 316, $p = 0.118$), conifer only ($t = 1.71$, df = 204, $p = 0.089$), or hardwood only ($t = 0.57$, df = 110, $p = 0.597$). Greater than 50% canopy cover occurred at 87% of Hoopa locations and 98% of Shasta-Trinity locations. Use of drainage-bottoms was found to be important at both study sites, but it was difficult to ascertain whether close proximity to water or some other factor was attracting fisher to these locations.

Where fisher populations are a management concern, timber harvest strategies should attempt to maintain scattered groups of the largest diameter trees, dense canopy cover, in close proximity to drainage-bottoms. Homogeneous stand management should be minimized because local structural and growth characteristics of different trees species may affect fisher resting and denning habitat availability.

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INTRODUCTION

The fisher (*Martes pennanti*) is a medium-sized carnivore in the family Mustelidae found in closed-canopy forested areas of northern North America (Powell 1993). Concerns about the status and viability of fisher in the western United States (Thomas et al. 1988, Gibilisco 1994) have been based on their apparent absence from large portions of their historical range in California, Oregon, and Washington (Aubry and Houston 1992, Zielinski et al. 1995, Aubry and Lewis 2003).

Powell and Zielinski (1994) suggested overtrapping and logging may have substantially contributed to the decline of fisher populations and reduced distribution throughout their former range in the United States. California has not had an open trapping season for fisher since 1946 (Lewis and Zielinski 1996), but continued timber harvest in the Pacific Northwest underlines the need to better understand the requirements of this species.

Fishers have been found in conifer, hardwood, and mixed conifer-hardwood forests (Powell 1993). In the western United States, fishers have been associated with late-successional forest (Rosenberg and Raphael 1986, Jones and Garton 1994, Dark 1997), but the specific age of a stand may not be as important as structure within the stand (Jones 1991, Jones and Garton 1994).

Several authors have suggested that fisher selection of resting habitat was more specific than selection of habitats for foraging and traveling (Arthur et al. 1989, Jones 1991, Jones and Garton 1994, Powell 1994), however, Dark (1997) found no difference in resting and foraging/travel habitat. Fishers do not use rest habitat randomly, but select structurally complex forest components (Seglund 1995) across several spatial scales (Weir and Harestad 2003).

Descriptions of rest site and habitat use from one area or local population cannot be extrapolated across a more broad geographical range because local conditions (e.g. vegetation characteristics, slope, and precipitation) may not be comparable. Comparing fisher rest site use at two geographically distinct locations would add insight into the characteristics of fisher rest site and habitat use to a broader scale within western fisher distribution. Recently Zielinski et al. (2004a) studied fisher habitat use in California, allowing for additional comparisons of fisher resting habitat in California.

The goal of my study was to characterize fisher rest site and habitat use at three scales (within home range, within study site, and across study areas) to extrapolate habitat requirements across a more broad geographical range. I described vegetation and topographical characteristics surrounding fisher rest sites on the Hoopa Valley Indian Reservation (Hoopa) in northern California and determined whether these characteristics were used in proportion to their availability within the forest as a whole. Habitat characteristics from Hoopa were then compared to existing unpublished data (Golightly 2000, personal communication) from a study conducted on the Shasta-Trinity National Forest (Shasta-Trinity) located in more interior California. These two forested sites differed in tree species composition because Hoopa is closer to the coast creating a more mesic climate than at Shasta-Trinity.

STUDY AREAS

The Hoopa study area was on the western slopes of the Trinity mountain range of the Northern Klamath Mountain province in Humboldt County, California. The study was conducted on approximately 55 km^2 of the southeastern portion of the 373 km^2 Reservation (Figure 1).

The topography is generally mountainous with deep valleys along rivers and streams. Elevation ranges from 100 m to 1,075 m. Average maximum and minimum temperatures are 21º C and 7º C respectively (Western Regional Climate Center 2000). Annual precipitation averages 156 cm with less than 2% falling during summer. Snowfall is usually moderate ranging from none at lower elevations to 40 cm in higher elevations of the study area.

The study area consisted primarily of montane hardwood-conifer communities (Mayer and Laudenslayer 1988). The western edge of the study area included residential areas of the city of Hoopa that have retained a substantial amount of forest. Dominant tree species include Douglas-fir (*Pseudotsuga menziesii*), tanoak (*Lithocarpus densiflorus*), and Pacific madrone (*Arbutus menziesii*). California black oak (*Quercus kelloggii*) and Oregon white oak (*Quercus garryana*) are also widespread within the study area. Many other species, such as big-leaf maple (*Acer macrophyllum*), chinquapin (*Chrysolepis chrysophylla*), Pacific yew (*Taxus brevifolia*), mountain dogwood (*Cornus nuttallii*), willow (*Salix* spp.), and canyon live oak (*Quercus chrysolepis*) are scattered throughout the forest.

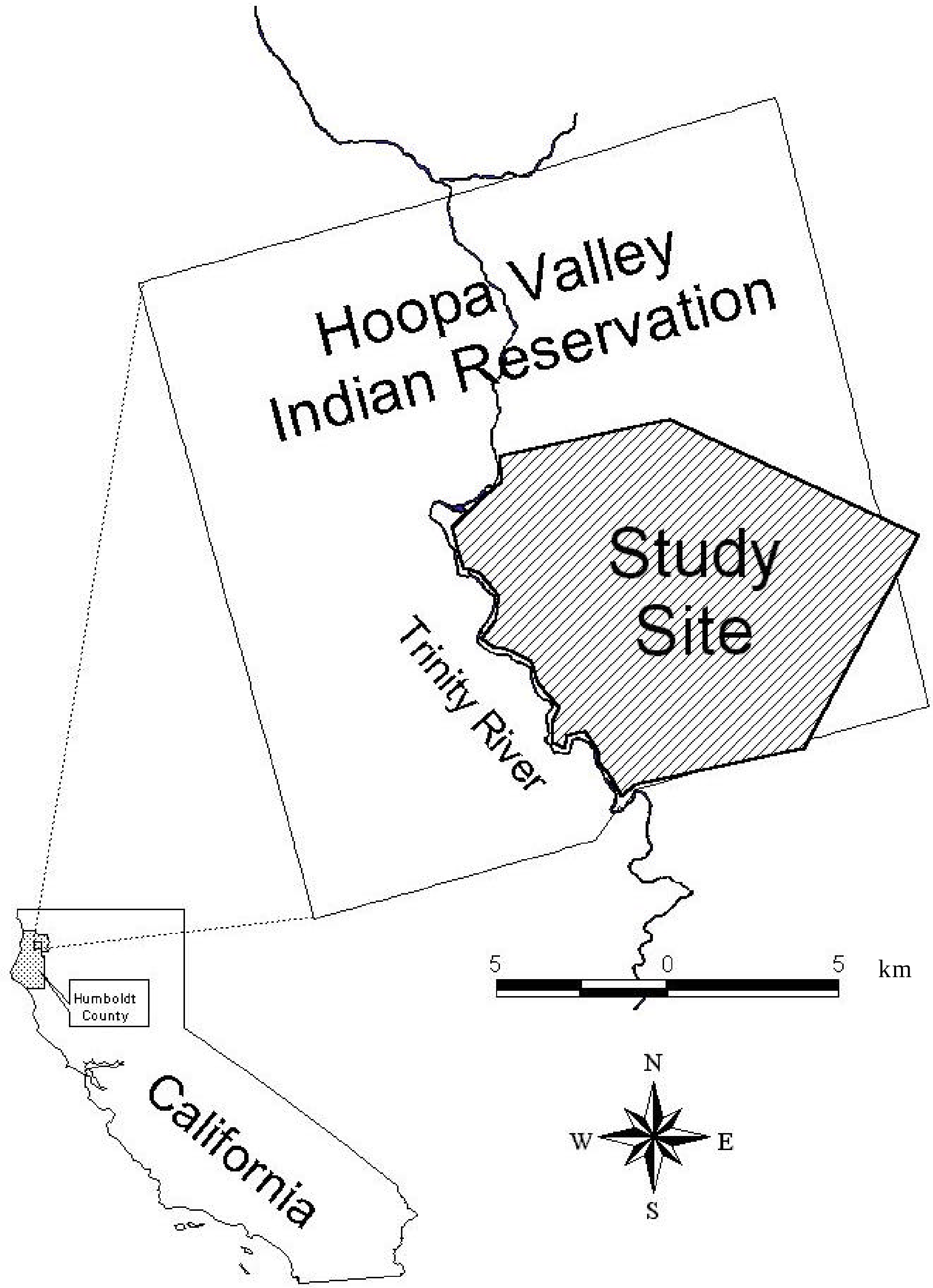


Figure 1. Vicinity map of fisher habitat study area on the Hoopa Valley Indian Reservation, Humboldt County, California (January 1996 to June 1998).

Evergreen huckleberry (*Vaccinium ovatum*), poisonoak (*Toxicodendron diversilobum*), and salal (*Gualtheria shallon*) generally dominate the shrub layer at Hoopa.

Seglund (1995) and Dark (1997) described the Shasta-Trinity study area in detail. The Shasta-Trinity study area is approximately 85 km east of the Hoopa study area. It averages 460 m higher in elevation than the Hoopa study area (ranging from 700 m to 1,400 m). Average maximum and minimum temperatures are 21º C and 4º C respectively (Western Regional Climate Center 2000). Annual precipitation averages 108 cm with less than 8% falling during summer. Snowfall is usually moderate ranging from 3 to 241 cm. The Shasta-Trinity study area consists predominantly of Douglas-fir and Sierran mixed conifer communities (Mayer and Laudenslayer 1988). Although similar tree species generally exist at both study areas, *Pinus* spp. including ponderosa pine (*P. ponderosa*), sugar pine (*P. lambertiana*) and Jeffrey pine (*P. jeffreyi*) were more prevalent (personal observation). Tanoaks (probably the shrub variety, *Lithocarpus densiflorus echinoites*) generally did not grow larger than sapling size at the Shasta-Trinity study area.

METHODS

Habitat characteristics of fisher rest sites at Hoopa (January 1996 – June 1998) were compared with similar data from the Shasta-Trinity study area (September 1992 – October 1996; Golightly (2000, personal communication), Seglund 1995, Dark 1997). Both study areas used similar habitat measures and methods. For comparison to Hoopa, Shasta-Trinity research findings were summarized and new analyses were made of their data.

Tomahawk live traps (model # 207, Tomahawk Live Trap Company, Tomahawk, WI) were used to capture fishers. Fishers were immobilized with an injection of ketamine and diazepam mixed (1 mg diazepam per 200 mg ketamine; approximately 15-20 mg ketamine per kg body weight). Radio collars (models # mod-125 and mod-80, Telonics, Mesa, AZ) and (or) color-coded ear-tags (standard ROTOTAG; Nasco Industries, Ft. Atkinson, WI) were then attached to each animal. Ear tags were used to visually identify individuals if recaptured. All non-target species were released.

A systematic trapping grid was not established at either study site. Instead, to increase chances of capturing a fisher, trapping areas were identified from previous fisher detections at systematic track plate surveys (Fowler and Golightly 1994), and areas regularly used by study animals. Traps were generally placed within 50 m of dirt roads and baited with salmon at Hoopa and chicken at Shasta-Trinity. Traps were checked twice daily, in morning after sunrise and evening before sunset. To protect fishers from inclement weather, potential foot injuries, and to help reduce stress of captured animals, a wooden nest box and flooring was added to each trap (Seglund 1995). Trap success was calculated as the total number of fishers captured divided by the number of trap nights (one trap per 24 hour period equaled one trap night) for each study area.

To identify habitats and resting structures being used, fishers were located using a portable receiver and hand-held yagi antenna (Model TR-4 receiver and RA-14K or RA-2A antenna, Telonics Telemetry-Electronics Consultants, Mesa, AZ). Traditional triangulation techniques were inaccurate due to steep terrain at both study areas. Radio-collared fisher, therefore, were located by walking to the strongest signal and determining the point of origin for stationary (presumably resting) animals. Radio-collars used at Hoopa were equipped with a microprocessor indicating activity level of the animal every two minutes. Fishers at Shasta-Trinity were determined to be inactive when their telemetry signal strength remained stable between successive measurements. I attempted to determine diurnal resting locations for each individual at least twice per week with consecutive locations separated by at least one-night to promote independence among successive locations.

Resting locations were assigned to one of two groups depending on the confidence of determining the specific location of the animal. A confirmed location was assigned if the fisher was seen or heard (e.g., vocalization or movement within a cavity), or the signal was unequivocally isolated to one structure. These locations were used for habitat analyses and to calculate estimates of home range. If the exact location of a fisher could not be determined because dense vegetation or tree height prevented visual confirmation, or structures within close proximity (e.g., a snag with cavities leaning on a live hardwood with cavities) prevented isolation to one structure, a general location was assigned. General locations were used only in calculations of home range.

Confirmed resting structures were categorized into one of four groups: live trees, snags, logs, and other (e.g., brush, rootwad, etc.). Tree species used were identified and grouped into either conifer or hardwood categories. Resting substrates in live trees were grouped as either a cavity or platform (e.g., large limb or limb array, broken top trees, animal nests, etc.) to represent either an enclosed or exposed condition respectively.

Fisher locations were plotted on aerial photos and then digitized into a geographic information systems database using ARCVIEW software (ver. 3.1 Environmental Research Systems Institute, Inc., Redlands CA) and 1993 United States Geological Survey (USGS) 1:24,000 digital orthophoto quarter quadrangles (DOQQ). The TELEM computer program (McKelvey 1993, personal communication) was used to generate Minimum Convex Polygon (MCP) (Mohr 1947) estimates of home range area. The MCP is the only technique strictly comparable between studies and is robust to a small sample of locations (Harris et al. 1990). Although the MCP provides no indication of intensity of use, it effectively delineates limits of area used by an animal and is frequently used to delineate limits of available habitat at the scale of the home range. Adequate sampling was ensured by constructed observation-area curves (Odum and Kuenzler 1955) of home range area versus number of locations to determine the minimum number of points necessary for sufficient estimation of area.

To determine if vegetation and habitat characteristics were being used differently from their availability within the forest at Hoopa, five abiotic variables (Table 1) and nine vegetation variables (Table 2) were measured within 0.04-ha circular plots. Variables sampled were indicative of forest age, complexity, microclimate, and findings of previous researchers (Buck 1982, Seglund 1995, Dark 1997). Over the three years of research at Shasta-Trinity, five vegetation and five abiotic variables (Table 3) were measured consistently and used in modeling analysis.

Confirmed resting locations defined habitats used by fisher. Random locations within each individual fisher's MCP home range were sampled to describe available habitat. Random coordinates (Universal Transverse Mercator) were generated in EXCEL 97 (Microsoft Corp. Seattle, WA) and plotted within each individual's MCP using ARCVIEW software. The random locations were superimposed on USGS topographic and DOQQ maps to assist navigation to the specific locations within the forest. To avoid researcher bias in placement of random plots, random plot centers were established 20.1 m along a random azimuth after orienting as closely as possible to the generated coordinates.

Plots for habitat measurement at rest sites were centered at the rest structure. Plots for habitat measurement at random sites were not tree-centered. A comparison of tree-centered plots and non tree-centered random sites, however, could confound interpretation of some vegetation measurements (e.g., basal area, canopy cover) because fishers often rest in large trees (Seglund 1995, Zielinski et al. 2004a). To reduce the contribution of the rest tree to the plot data but maintain accurate tree data, the mean DBH of the four largest trees in the plot were used to characterize the stand (not simply

Table 1. Description of abiotic habitat variables collected on 0.04-ha circular plots surrounding fisher rest sites and random locations on the Hoopa Valley Indian Reservation Humboldt County, California (January 1996 to June 1998).

Abiotic variable	Description	Variable type
Topographic position	Location on main slope in relation to nearest topographical break: Ridge-top, Mid-slope, Drainage-bottom.	Nominal
Aspect	Direction of major slope measured with magnetic compass; grouped into four ordinal directions: N) 316º - 45º, E) 46º- 135º, S) 136º - 225º, and W) 226º - 315º.	Nominal
Water presence	Presence or absence of permanent water within 100 m of plot.	Nominal
Presence of landscape alteration	Presence or absence of human habitat alterations within 100 m of plot center. Includes clear-cuts, selective harvest, and closed roads.	Nominal
Presence of human disturbance	Presence or absence of active human disturbance within 100 m of plot center. Includes open roads, buildings, and timber operations.	Nominal

Table 2. Description of biotic habitat variables collected on 0.04-ha circular plots surrounding fisher rest sites and random locations on the Hoopa Valley Indian Reservation Humboldt County, California (January 1996 to June 1998).

Vegetation variable	Description	Variable type
Canopy cover (%)	Foliar cover estimated to nearest 10%. Grouped into 4 categories: 1) <26%, 2) 26 – 50%, 3) 51 – 75%, and 4) >75%.	Ordinal
Mean DBH[a] (cm) of four largest trees	Mean DBH of the four largest trees in 0.04 ha plot. Measured to nearest 0.25 cm with DBH tape from upslope side of tree.	Continuous
Total basal area (m^2/ha)	All trees in 0.04 ha plot greater than13 cm in diameter measured with DBH tape to nearest 0.25 cm. Basal area calculated = (p / 40000)*(S DBH^2 / 0.04).	Continuous
Number of hardwood species	Count of hardwood species on plot.	Continuous
Conifer presence	Presence or absence of conifer on plot.	Nominal
Composition of four largest trees	Compositional makeup of the four largest trees on the plot. Conifer only, conifer and hardwood combined, and hardwood only.	Nominal
Shrub cover (%)	Estimated to nearest 10%. Grouped into 4 categories: 1) <26%, 2) 26 – 50%, 3) 51 – 75%, and 4) >75%.	Ordinal
Number of logs	Count of downed wood within plot >25 cm diameter at midpoint of log.	Continuous
Volume of logs (m^3)	Volume = (diameter at midpoint of log) * (length of log within plot).	Continuous

[a] DBH = diameter at breast height. The diameter of the trunk of a standing tree, measured 1.3 m above ground surface from the upslope side of the tree.

Table 3. Habitat variables collected on 0.04-ha circular plots surrounding fisher rest sites and random locations on the Shasta-Trinity National Forest, Trinity County, California (September 1992 to October 1996). Summarized from Golightly (2000, personal communication).

Variable	Description	Variable type
Topographic position	Location on main slope in relation to nearest topographical break: Ridge-top, Mid-slope, Drainage-bottom.	Nominal
Aspect (º)	Direction of major slope measured with magnetic compass; grouped into four ordinal directions: N) 316º - 45º, E) 46º- 135º, S) 136º - 225º, and W) 226º - 315º.	Continuous
Water presence	Presence of absence of permanent water within 100m of plot.	Nominal
Presence of landscape alteration	Presence or absence of human habitat alterations within 100 m of plot center. Includes clear-cuts, selective harvest, and closed roads.	Nominal
Presence of human disturbance	Presence or absence of active human disturbance within 100 m of plot center. Includes open roads, buildings, and timber operations.	Nominal
Canopy cover (%)	Foliar cover measured with a spherical densitometer 5 m from plot center and averaged over the 4 cardinal directions.	Continuous
Mean DBH (cm) of four largest trees	Mean DBH of the four largest trees in 0.04-ha plot. Measured to nearest 0.1 cm with DBH tape from upslope side of tree.	Continuous
Total basal area (m^2/ha) of live trees	Measured with a factor 10 or 20 Cruz-All from the center of plot.	Continuous
Number of hardwood species	Count of hardwood tree species on plot.	Continuous
Conifer presence	Presence or absence of conifer on plot.	Nominal

the resting structure). Potential cavities with openings >9 cm in diameter, the approximate minimum size a fisher could use as a rest site (Kilpatrick and Rego 1994, Powell et al. 1997), were recorded for all trees in the 0.04 ha plot. Rest and random plots were sampled for a 1:1 ratio of used to available sites. Measurements were made in English units and converted to metric units for analysis.

At the Shasta-Trinity sites, study periods for investigation were divided into logical time blocks to reduce potential bias resulting from time shifts in areas of concentrated effort around Trinity Lake (also know as Claire-Engle Lake) that bisected the study area. These blocks, referred to as years, represented consistent spatial boundaries of fisher home ranges thus avoided measuring random plots that were unavailable to individual fishers. Years one and two focused on home ranges on the east and west sides of the lake, while year three focused exclusively on the east side of the lake.

Hoopa Habitat Analysis

At each study area, fisher use of tree species in proportion to their availability was analyzed using Chi-square Goodness of Fit and Subdividing Chi-square analyses (Zar 1984). On random plots, trees greater than 40 cm DBH were considered available to fishers. This minimum value was a conservative cut-off more than one standard deviation below the mean of conifers or hardwoods used by fisher at both areas. Fishers did use trees with diameters smaller than 40 cm on rare occasions, but the inclusion of smaller diameter trees in availability analyses would confound interpretation by including trees that were infrequently used as rest sites.

Univariate analyses were used to examine how rest sites used by fisher compared to random locations for all variables. Mann-Whitney two-sample tests for continuous data and contingency table analyses for categorical data were used to compare mean values of each habitat variable measured at rest and random locations.

A correlation matrix for continuous variables using NCSS 2000 (NCSS Products, Kaysville, UT) was used to detect redundant variables. Correlations between nominal variables were investigated using the Pearson correlation coefficient available in the contingency table procedure of SPSS (SPSS v8.0.0 SPSS Inc., Chicago, IL). Redundant variables ($r^2 \geq 0.60$) (Dark 1997) that were considered least important to fisher based on previous studies (Buck 1982, Seglund 1995, Dark 1997, Klug 1997, Truex et al.1998) of fisher in the area were arbitrarily eliminated from further analysis.

Resting locations were pooled across season (summer: April to October and winter: November to March) and gender, to investigate year-round fisher rest site use. Additionally, numbers of male ($n = 12$) to female ($n = 117$) rest sites were too few compare gender.

A Friedman test (Sokal and Rohlf 1981, Zar 1984, Alldredge and Ratti 1986) was used to differentiate habitat variables between rest and random sites for individual fisher. The Friedman two-way analysis of variance is a nonparametric test used to determine if samples with repeated observations on the same individuals are significantly different. The test statistic is computed using ranks of the differences in mean habitat use versus availability (rest versus random locations), determined for each animal from repeated observations. Ranking minimizes among-animal differences and provides a powerful test of use versus available differences (Lehner 1996). When differences were detected, a Fisher's Least Significant Difference Multiple Comparison Procedure (Fisher's LSD) was used to rank variable groups from "least" to "most" used (Sokal and Rohlf 1981). To avoid pseudoreplication (Hurlbert 1984), sampling units were limited to the number of individual animals.

Logistic regression analyses were conducted to identify habitat variables associated with fisher resting locations (Hosmer and Lemeshow 1989). Logistic regression was used because multivariate normality could not be achieved with or without transforming the data (Hintze 1999) and a number of habitat variables measured were nominal. Stepwise model fitting, with both forward and backward Maximum Likelihood Ratio models (Hosmer and Lemeshow 1989, Pereira and Itami 1991, Trexler and Travis 1993), was used to identify variables that significantly ($\alpha \leq 0.05$) improved the model. The Wald statistic, a ratio of each beta estimate (coefficient) to its standard error, was used as an indicator of useful variables (Hosmer and Lemeshow 1989). When compared to a standard normal distribution, values greater than two generally indicate variables that significantly influence the model. Significant variables were included in a final logistic regression model. A model chi-square test was used to test the overall fit of the model.

Study Area Comparison

Vegetation type and structural composition variables at random locations and surrounding fisher rest sites at Hoopa were contrasted to comparable variables for the Shasta-Trinity project. Because random habitat characteristic differences were detected between the east and west sides of Trinity Lake (Golightly 2000, personal communication), I was unable to pool the three separate years of the Shasta-Trinity study. Therefore, Hoopa random habitat variables were compared individually to east and to west side variables individually and Hoopa rest variables to Shasta-Trinity years one, two, and three individually. Continuous variables and contingency table analyses for nominal variables were analyzed using a Mann-Whitney U test with a adjusted to match the number of comparisons (a = 0.05/number of comparisons).

RESULTS

Trapping occurred at Hoopa from 22 January 1996 to 14 August 1998. During this period, 1,324 trap nights resulted in the capture of 50 individual fishers (36 females, 14 males) on 161 occasions (12% trap success) with a 66% recapture rate. At Shasta-Trinity, trapping occurred from 28 June 1992 to 14 November 1994 and 2 March 1996 to 15 September 1996. There, 1,807 trap nights resulted in the capture of 22 individuals (13 females, 9 males) on 36 occasions (2% trap success) with a 61% recapture rate.

Radio-collars were attached to 19 fishers (11 females, 8 males) at Hoopa. Hoopa fishers were located 326 times, with 218 individual confirmed rest structures identified. Each animal was located a mean of 18 times (range 0 - 68). Reuse of previously identified rest sites (not including den sites) occurred at 59 locations. At Shasta-Trinity, 19 fishers (10 females, 9 males) were tracked across the three years, locating each animal a mean of 15 times (range 1 - 50). At Shasta-Trinity 296 individual confirmed rest structures were located.

Observation-area curves of home range estimates (Appendix A) appeared to approach their asymptote at approximately 17 locations. Because two animals were located fewer than 17 times, I tested for a difference in home range area estimates between 10 and 17 locations. There was no difference in home range size between 10 points (110 ha) and 17 or greater points (155 ha) ($t = 1.393$, $df = 10$, $p = 0.194$). Therefore, home range estimates were calculated for animals with a minimum of 10 locations. MCP home range estimates of female fishers at Hoopa (168 ± 17 ha; $\bar{x}$ ± SE; n = 7) were smaller than female fishers at Shasta-Trinity (2,347 ± 471 ha, n = 7; *t* = 4.62, df = 13, p = 0.004). Only two male fishers at Hoopa had enough points for home ranges estimates (873 ha and 615 ha). Shasta-Trinity male fishers (n = 9) home range estimates were 3,827 ± 895 ha.

Rest Structure

Fisher primarily used live trees for resting at both Hoopa and Shasta-Trinity (Figure 2). Other structures used included snags and logs, and rarely included on the ground under shrubs, slash piles, rootwads, or in wood rat (*Neotoma fuscipes*) nests. At Hoopa, fishers used live hardwood trees (black oak, tanoak, etc.) most frequently for resting (55%) followed by live conifer trees (Douglas-fir, sugar pine, etc.; 29%; Figure 3). Shasta-Trinity fisher used live conifers most frequently (64%), while live hardwoods were only 12% of resting locations (Figure 3).

Of live trees used by fishers at Hoopa, hardwoods (65%) and conifers (35%) were used in proportion to their availability (70% and 30% respectively; χ^2 = 1.08, p = 0.298). Of live trees used by fishers at Shasta-Trinity, hardwoods (16%) and conifers (84%) were not used in proportion to their availability (7% and 93% respectively; χ^2 = 9.72, p = 0.002).

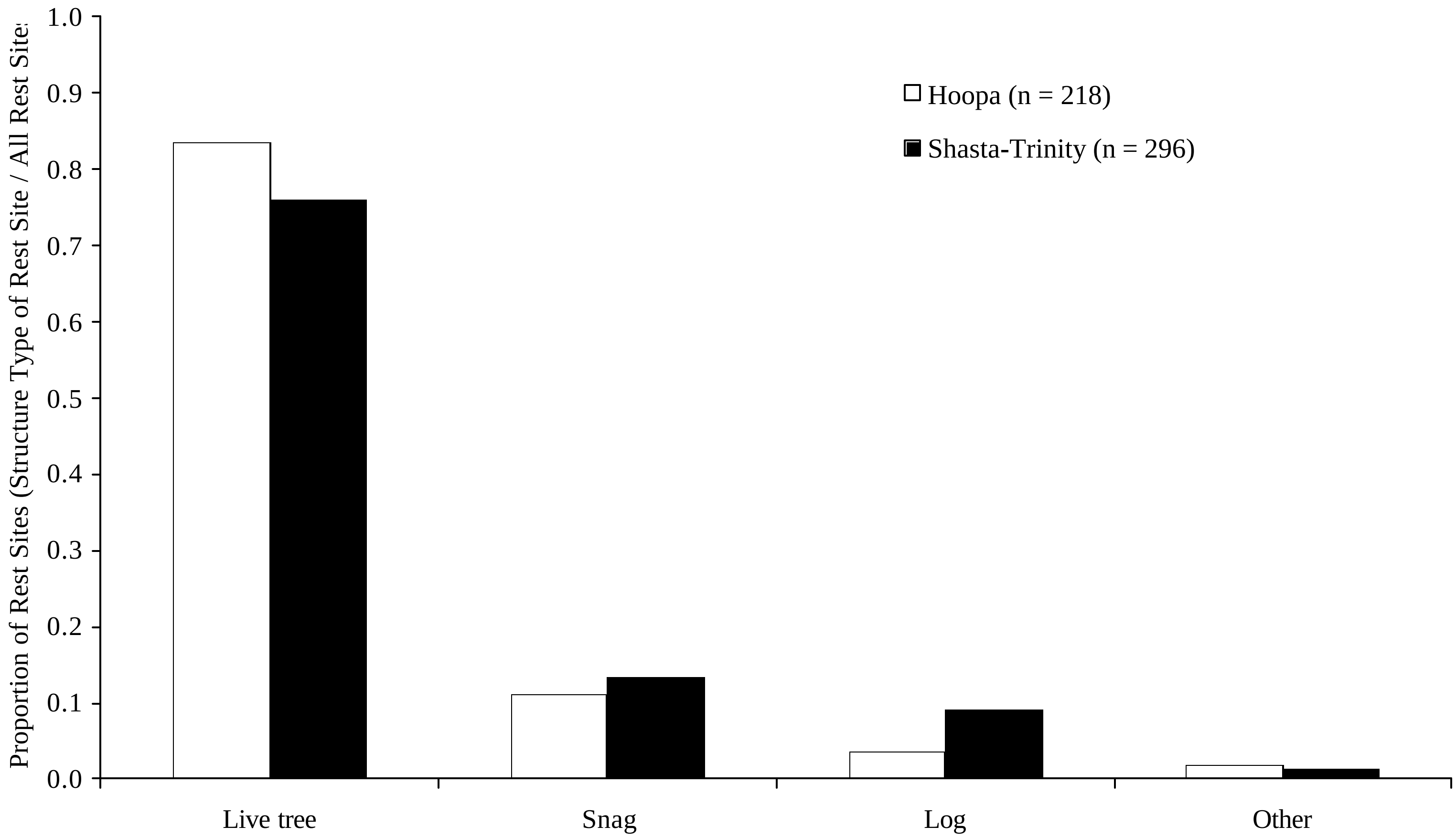


Figure 2. Proportional use of rest site structure by fisher at the Hoopa Valley Indian Reservation (January 1996 to June 1998) and Shasta-Trinity (September 1992 to October 1996) study areas in northwestern California. Shasta-Trinity data summarized from Golightly (2000, personal communication).

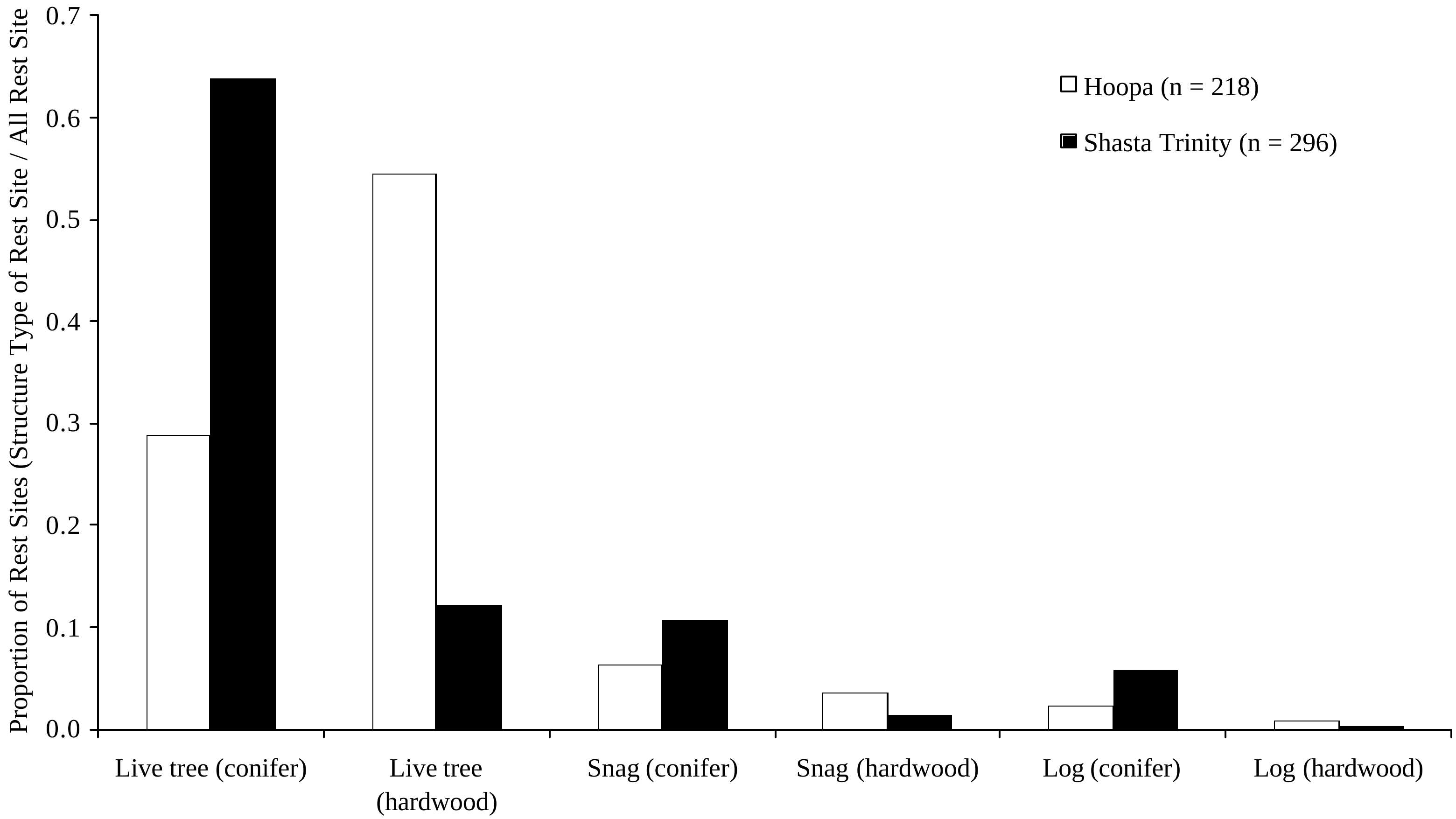


Figure 3. Proportional conifer and hardwood composition of fisher rest site structures at the Hoopa Valley Indian Reservation (January 1996 to June 1998) and Shasta-Trinity (September 1992 to October 1996) study areas in northwestern California. Shasta-Trinity data summarized from Golightly (2000, personal communication).

Douglas-fir was the most used tree species for resting at both Hoopa and Shasta-Trinity (Table 4). At Hoopa, tanoak and black oak followed Douglas-fir in frequency of use. After Douglas-fir, ponderosa pine (10%) and black oak (10%) were the two most used species at Shasta-Trinity.

At Hoopa, fishers used Douglas-fir, and tanoak in proportion to availability, black oak more than expected, and Pacific madrone less than expected (Table 4). At Shasta-Trinity, fishers used Douglas-fir and ponderosa pine in proportion to availability, sugar pine less than expected, and black oak more than expected. Red alder (*Alnus rubra*) and Pacific dogwood (*Cornus nuttallii*) were not used as rest sites at either study site.

When resting in live trees, the actual resting substrate was identified 149 times at Hoopa and 154 times at Shasta-Trinity. At Hoopa, 48% of these were in cavities while 52% were on platforms. At Shasta-Trinity, 19% were in cavities while 81% were on platforms. In live trees, cavity rest sites were generally found in hardwoods while platform rest sites were generally found in confers at both study sites (Figure 4). With a few exceptions, this pattern of cavity and platform use continued when hardwood and conifer groups were separated by individual trees species (Table 5). Two hardwood species, tanoak and canyon live oak, did not follow this pattern with both having a similar number of cavity and platform rest-site observations. At Hoopa, cavities in live trees appeared to be generally more available on rest plots and were most frequent in black oaks (Figure 5).

Fishers used rest trees that had a significantly larger DBH than the average DBH of the four largest trees on rest site plots at Hoopa (Table 6). At Hoopa, the rest tree was

Table 4. Count by species of live trees used by resting fishers and counts of live trees greater than 40 cm on 129 random plots at the Hoopa Valley Indian Reservation (January 1996 to June 1998) and 103 random plots at Shasta-Trinity (September 1992 to October 1996) study areas in northwestern California. Shasta-Trinity data summarized from Golightly (2000, personal communication).

	Hoopa						Shasta-Trinity					
					Test values						Test values	
Species	Rest trees	Percent of total rest trees	Random plot trees	Percent of total random	χ^2	p	Rest trees	Percent of total rest trees	Random plot trees	Percent of total random	χ^2	p
Douglas-fir	61	34	97	30	0.30	0.129	146	65	160	65	2.82	0.093
Ponderosa pine	0	0	0	0	---[a]		23	10	29	12	1.21	0.271
Sugar pine	1	1	0	0	---[a]		11	5	20	8	4.18	0.041
Jeffrey pine	0	0	0	0	---[a]		3	1	0	0	---[a]	
White fir	1	1	0	0	---[a]		4	2	9	4	---[a]	
Pacific yew	0	0	0	0	---[a]		1	0	0	0	---[a]	
Incense-cedar	0	0	0	0	---[a]		1	0	11	4	---[a]	
Tanoak	49	27	114	35	3.76	0.053	0	0	0	0	---[a]	
Black oak	48	26	49	15	21.43	$\leq$ 0.001	23	10	13	5	8.71	0.003
Canyon live oak	9	5	1	0	---[a]		11	5	4	2	---[a]	
Pacific madrone	8	4	50	16	15.70	$\leq$ 0.001	0	0	0	0	---[a]	
White oak	3	2	2	1	---[a]		0	0	0	0	---[a]	
Chinquapin	1	1	2	1	---[a]		2	1	0	0	---[a]	
Big leaf maple	1	1	7	2	---[a]		0	0	0	0	---[a]	
Total	182	100	322	100			225	100	246	100		

[a] Observed or expected frequencies less than five; not tested.

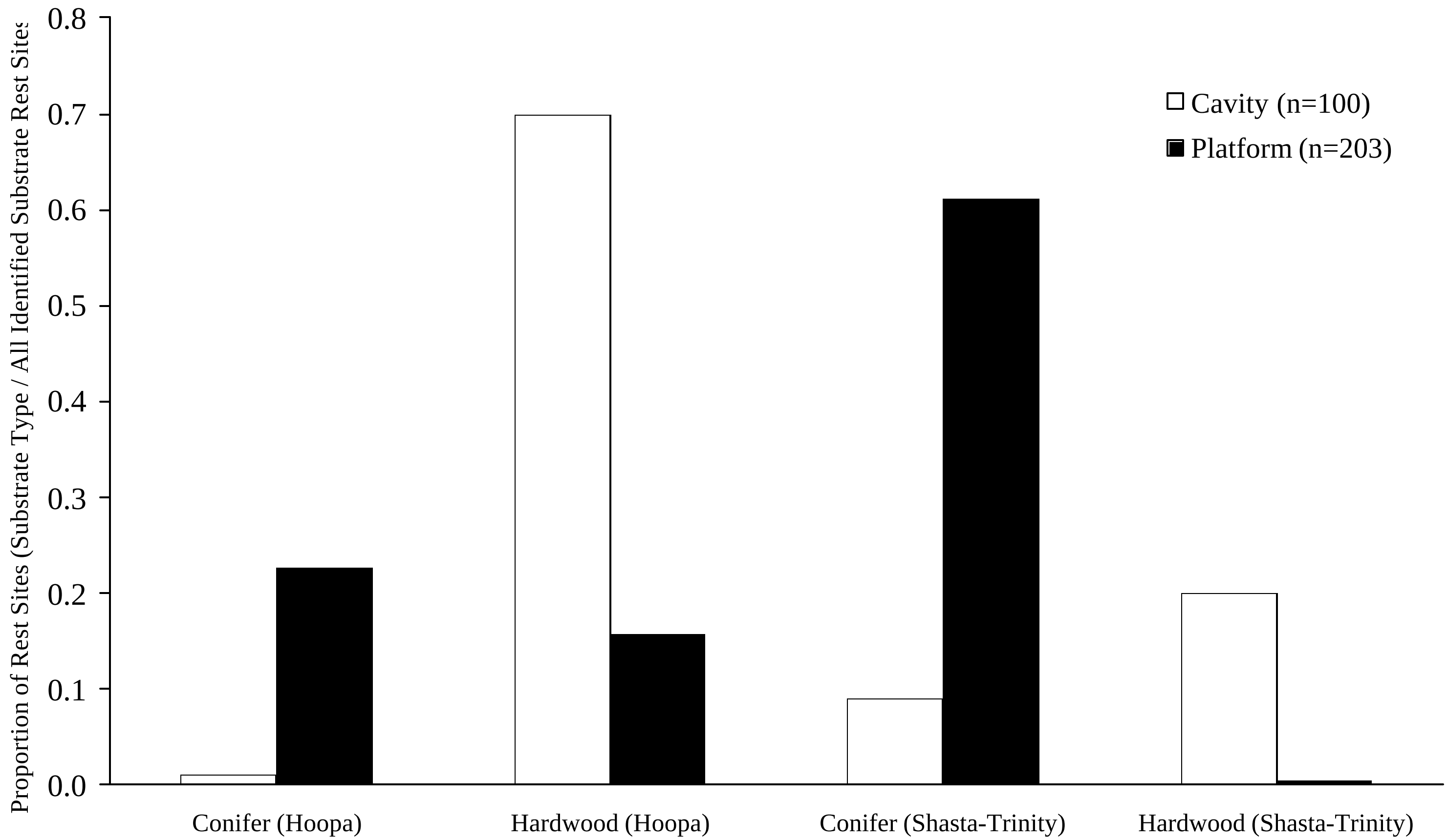


Figure 4. Proportion of cavity and platform rest sites in live conifer and hardwood trees used by fisher at the Hoopa Valley Indian Reservation (January 1996 to June 1998) and Shasta-Trinity (September 1992 to October 1996) study areas in northwestern California. Shasta-Trinity data summarized from Golightly (2000, personal communication).

Table 5. Counts and percentages of fisher cavity and platform use by tree species at the Hoopa Valley Indian Reservation (January 1996 to June 1998) and Shasta-Trinity (September 1992 to October 1996) study areas in northwestern California. Shasta-Trinity data summarized from Golightly (2000, personal communication).

	Hoopa				Shasta-Trinity			
Species	Cavity	Percent of total cavities	Platform	Percent of total platforms	Cavity	Percent of total cavities	Platform	Percent of total platforms
Douglas-fir	1	1	45	58	6	21	95	76
Ponderosa pine	0	0	0	0	0	0	16	13
Sugar pine	0	0	1	1	1	3	8	6
Jeffrey pine	0	0	0	0	0	0	2	2
White fir	0	0	0	0	1	3	2	2
Pacific yew	0	0	0	0	1	3	0	0
Incense cedar	0	0	0	0	0	0	1	1
Tanoak	17	24	21	27	0	0	0	0
Black oak	39	55	5	6	16	55	0	0
Canyon live oak	4	6	4	5	4	14	1	1
Pacific madrone	5	7	2	3	0	0	0	0
White oak	3	4	0	0	0	0	0	0
Chinquapin	1	1	0	0	0	0	0	0
Big-leaf maple	1	1	0	0	0	0	0	0
Total	71	100	78	100	29	100	125	100

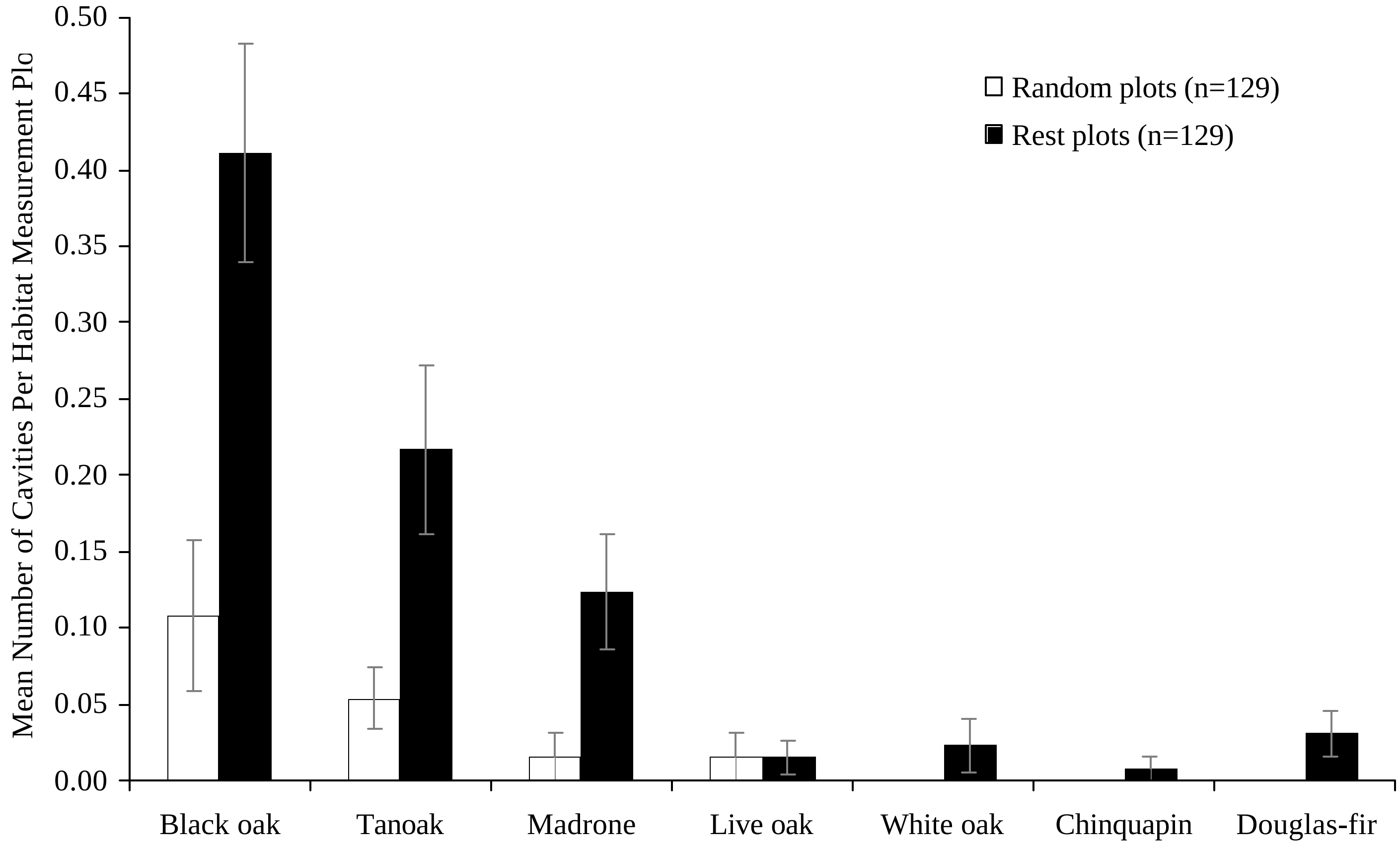


Figure 5. Mean (+ standard error) number of potential cavity openings (> 9 cm diameter) observed in live trees per 0.04-ha rest and random fisher habitat measurement plots at the Hoopa Valley Indian Reservation (January 1996 to June 1998) study area in northwestern California.

Table 6. Paired comparison of diameter at breast height (cm) of fisher resting structures to the mean diameter of the four largest trees on rest site plots at the Hoopa Valley Indian Reservation (January 1996 to June 1998) and Shasta-Trinity (September 1992 to October 1996) study areas in northwestern California. Shasta-Trinity data summarized from Golightly (2000, personal communication).

			DBH			
Study area	Comparison	n	$\bar{x}$	SE	t	p
Hoopa	Rest Site	129	87.4	3.1		
	Mean of four largest trees	129	64.2	1.7	7.87	≤ 0.001
Shasta-Trinity Year 1	Rest Site	15	124.8	8.2		
	Mean of four largest trees	15	73.3	4.8	8.57	≤ 0.001
Shasta-Trinity Year 2	Rest Site	43	94.5	6.9		
	Mean of four largest trees	43	67.8	2.8	4.49	≤ 0.001
Shasta-Trinity Year 3	Rest Site	89	91.9	4.1		
	Mean of four largest trees	89	63.4	1.9	7.51	≤ 0.001

one of the four largest trees on 91% of rest site plots measured, and was the single largest tree on 46% of these plots. The DBH of rest sites at Shasta-Trinity was also found to be greater than the average DBH of the four largest trees on the plot during all three years of the study (Table 6). There was no difference in the diameter of rest site structures used between Hoopa and Shasta-Trinity when grouped by all rest sites, conifer only, or hardwood only (Table 7).

Habitat Characteristics

At Hoopa, mean DBH of the four largest trees, canopy cover, presence of conifer and topographic position differed between rest and random sites in univariate comparisons (Table 8). Intervariable correlation was identified for three of the 14 variables measured (Table 9). Total basal area and log volume were removed from further analysis to avoid redundancy. Although topographic position and presence of permanent water were correlated, both were left in the analysis because they represented biologically distinct conditions.

When analyzed with the Friedman test (Table 10), the habitat variables mean DBH of the four largest trees, canopy cover, and topographic position differed between rest and random locations in Hoopa. The mean DBH of the four largest trees at rest sites was larger than at random sites, canopy cover categories 26-50% and 51-75% were used more often than their availability, and fisher were found resting in drainage-bottoms more often than on mid-slope or ridge-top locations (Table 11).

Table 7. Diameter at breast height (cm) of fisher resting structures at the Hoopa Valley Indian Reservation (January 1996 to June 1998) and Shasta-Trinity (September 1992 to October 1996) study areas in northwestern California. Shasta-Trinity data summarized from Golightly (2000, personal communication).

			DBH						
Tree type	Study area	n	$\bar{x}$	SE	Minimum	Maximum	Median	t	p
All rest trees	Hoopa	138	88.1	3.1	22.4	215.1	84.7		
	Shasta-Trinity	180	94.8	2.9	25.2	187.3	93.4	1.57	0.118
Conifer only	Hoopa	52	109.6	5.6	37.9	215.1	101.2		
	Shasta-Trinity	154	98.6	3.2	25.5	187.3	97.7	1.71	0.089
Hardwood only	Hoopa	86	75.1	2.8	22.4	144.0	77.2		
	Shasta-Trinity	26	71.9	5.3	31.2	132.6	63.5	0.57	0.597

Table 8. Means ± standard errors or percentage observed in each category, and test statistics of habitat variables collected at fisher rest and random sites on the Hoopa Valley Indian Reservation, Humboldt County, California (January 1996 to June 1998).

Variable[a]	Rest sites	Random sites	Test value[b]	p
Number of sites	129	129		
Mean DBH of 4 largest trees (cm)	64.2 ± 1.7	47.4 ± 1.7	U = 4275	$\leq$ 0.001
Composition of 4 largest trees (%)			χ^2 = 3.97	0.138
Conifer only	6.9	11.6		
Conifer/Hardwood	60.5	48.8		
Hardwood only	32.6	39.5		
Shrub cover (%)			χ^2 = 0.86	0.836
<26% coverage	61.2	65.9		
26-50% coverage	17.1	16.3		
51-75% coverage	9.3	8.5		
>75% coverage	12.4	9.3		
Canopy cover (%)			χ^2 = 12.90	0.005
<26% coverage	1.6	2.3		
26-50% coverage	11.6	6.2		
51-75% coverage	27.1	12.4		
>75% coverage	59.7	79.1		
Number of logs	2.2 ± 0.2	2.1 ± 0.2	U = 7307	0.081
Number of hardwood species	3.2 ± 0.1	3.1 ± 0.1	U = 7996	0.574
Conifer presence (%)	95.3	86.8	χ^2 = 5.78	0.016
Aspect (%)			χ^2 = 4.14	0.247
North	28.7	23.3		
South	38.0	48.8		
East	10.9	6.2		
West	22.5	21.7		
Topographic position (%)			χ^2 = 8.40	0.015
Ridge-top	31.0	34.9		
Mid-slope	17.8	30.2		
Drainage-bottom	51.2	34.9		
Presence of human disturbance (%)	27.1	34.9	χ^2 = 1.81	0.178
Presence of landscape alteration (%)	45.7	42.6	χ^2 = 0.25	0.616
Water presence within 100 m (%)	27.9	24.8	χ^2 = 0.32	0.572

[a] See Tables 1 and 2 for definition of habitat variables.
[b] Continuous variables were tested with Mann-Whitney U rank test, nominal variables were tested with contingency analysis.

Table 9. Twelve habitat variables used in stepwise procedure to discriminate fisher rest sites and random sites on the Hoopa Valley Indian Reservation, Humboldt County, California (January 1996 to June 1998).

Retained variables[a]	Correlated variables	r^2
Mean DBH 4 of largest trees on plot	Total live tree basal area (m^2/ha)	0.915
Number of logs	Volume of logs	0.927
Topographic position[b]	Water presence within 100 m[b]	0.688
Composition of four largest trees	None	
Shrub cover (%)	None	
Canopy cover (%)	None	
Number of hardwood species	None	
Conifer presence	None	
Aspect	None	
Presence of human disturbance	None	
Presence of landscape alteration	None	

[a] See Tables 1 and 2 for definition of habitat variables.
[b] Although strongly correlated, both variables retained for analysis because they represent biologically distinct conditions.

Table 10. Friedman's test results comparing mean difference of fisher rest sites versus random sites on the Hoopa Valley Indian Reservation, Humboldt County, California (January 1996 to June 1998).

Variable[a]	df	Friedman's Q	p
Mean DBH of 4 largest trees	1	8.00	0.005
Composition of 4 largest trees	2	1.74	0.419
Shrub cover	3	2.92	0.404
Canopy cover	3	9.13	0.028
Number of logs	1	0.50	0.480
Number of hardwood species	1	0.50	0.480
Presence of conifer	1	2.67	0.102
Aspect	3	2.09	0.554
Topographic position	2	6.75	0.034
Presence of human disturbance	1	0.00	1.000
Presence of landscape alteration	1	0.50	0.480
Water presence within 100 m	1	2.00	0.157

[a] See Tables 1 and 2 for definition of habitat variables.

Table 11. Fisher's Least Significant Difference Multiple Comparison Procedure (underline indicates grouping) of rest and random site variables fisher were found to use significantly different with Friedman's test (Table 10) on the Hoopa Valley Indian Reservation, Humboldt County, California (January 1996 to June 1998).

Variable[a]	Variable group				df	t	error[b]
Mean DBH of 4 largest trees	Random	Rest			7	2.36	0.05
Canopy cover	< 26%	26 - 50%	51 - 75%	> 75%	21	2.08	0.06
Topographic position	Ridge-top	Mid-slope	Drainage-bottom		14	2.14	0.09

[a] See Tables 1 and 2 for definition of habitat variables.
[b] Probability of making one or more type 1 errors with multiple comparison procedures. $1-(1- a)^m$ where m = the number of independent tests (Winer et al. 1991).

At Hoopa, five variables were selected by the stepwise procedure and correctly classified rest and random locations 70% and 76% of the time respectively. In the most parsimonious model (Table 12), rest sites tended to be in larger-diameter stands composed of conifer and hardwood, in drainage-bottoms with greater than 50% canopy cover, and were closer to landscape alterations than random sites. Although composition of the four largest trees was not significant in the model (Table 12), its inclusion improved classification accuracy.

Variables predicting fisher rest sites at Shasta-Trinity differed slightly over the three years of research due to slight shifts in areas of concentrated sampling effort. Ten habitat variables examined at the Shasta-Trinity study area significantly predicted fisher rest sites in logistic regression models in at least one of the three years of the study (Table 13). Stands that included large diameter trees, extensive canopy cover, presence of water within 100 m, and a greater number of hardwood species, with a greater distance to roads and human disturbance than random locations ultimately characterized specific habitat configurations of resting locations at Shasta-Trinity.

Table 12. Final model of habitat variables that stepwise logistic regression analyses discriminated between fisher rest sites and random sites on the Hoopa Valley Indian Reservation, Humboldt County, California (January 1996 to June 1998).

Model variable[a]	Wald statistic	p
Mean DBH of 4 largest trees	34.54	$\leq$ 0.001
Composition of 4 largest trees	4.91	0.086
Canopy cover	12.02	0.007
Topographic position	6.61	0.037
Presence of landscape alteration	4.92	0.027

[a] See Tables 1 and 2 for definition of habitat variables.

Table 13. Habitat variables that logistic regression analyses significantly predicted fisher rest sites from random sites on the Hoopa Valley Indian Reservation (January 1996 to June 1998) and Shasta-Trinity (September 1992 to October 1996) study areas in northwestern California. Shasta-Trinity data summarized from Golightly (2000, personal communication).

		Shasta-Trinity		
Model variable[a]	Hoopa	Year1	Year2	Year3
Mean DBH of 4 largest trees	X[b]	X		
Composition of 4 largest trees	X	n/a[c]	n/a	n/a
Shrub cover		n/a	n/a	n/a
Canopy cover	X		X	X
Number of logs		n/a	n/a	n/a
Number of hardwood species			X	X
Presence of conifer				X
Aspect		X		
Topographic position	X		X	
Presence of human disturbance		X		
Presence of landscape alteration	X	X		X
Water presence within 100 m		X	X	X
Basal Area	n/a			X
Model Statistics				
Model Chi-square	74.4	103.5	66.9	180.4
Significance	$\leq$0.001	$\leq$0.001	$\leq$0.001	$\leq$0.001

[a] See Tables 1 and 2 for definition of habitat variables.
[b] X = variable found significant (a = 0.05) in logistic regression analysis.
[c] Variable not analyzed (n/a) in the stepwise logistic regression procedure for indicated area.

Study Area Comparisons

Eight habitat variables were comparable between the Hoopa and Shasta-Trinity study areas. Mean DBH of four largest trees, topographic position, and presence of permanent water within 100 m did not differ on random plots between study areas (Tables 14, 15). Canopy cover did not differ between Hoopa and Shasta-Trinity west and presence of conifer did not differ between Hoopa and east random plots. The number of hardwood species was greater on Hoopa random plots. Aspect did differ between study areas, but presence of human disturbance within 100 m was lower at Hoopa that at Shasta-Trinity.

Of the eight comparable variables at fisher rest sites, only the mean DBH of the four largest trees and presence of conifer did not differ between rest sites at Hoopa and Shasta-Trinity (Tables 16, 17). Differences were detected between Hoopa and all three years of Shasta-Trinity data for canopy cover, number of hardwood species, and the presence of permanent water.

Although canopy cover differed between Hoopa and all three years at Shasta-Trinity, dense canopy cover occurred at a majority of rest sites at both study areas. At Hoopa, 86.8% of all rest sites had more than 50% canopy cover and 59.7% had greater than 75% canopy cover. At Shasta-Trinity 97.6% of all rest sites had more than 50% canopy cover and 87.5% had greater than 75% canopy cover. More hardwood species were present on Hoopa rest site plots than plots for all three years at Shasta-Trinity.

Table 14. Means ± standard errors or percentage observed in each category of habitat variables collected at random sites on the Hoopa Valley Indian Reservation (January 1996 to June 1998) and Shasta-Trinity (September 1992 to October 1996) study areas in northwestern California. Shasta-Trinity data summarized from Golightly (2000, personal communication).

Variable[a]	Hoopa	Shasta-Trinity West	Shasta-Trinity East
Number of sites	129	37	66
Mean DBH of 4 largest trees (cm)	47.4 ± 1.7	52.5 ± 2.9	44.2 ± 2.3
Canopy cover (%)			
<26% coverage	2.3	5.4	9.1
26-50% coverage	6.2	2.7	15.2
51-75% coverage	12.4	18.9	31.8
>75% coverage	79.1	73.0	43.9
Number of hardwood species	3.1 ± 0.1	1.3 ± 0.1	1.2 ± 0.1
Presence of conifer (%)	86.8	100.0	95.5
Aspect (%)			
North	23.3	27.0	21.2
South	48.8	24.3	24.2
East	6.2	40.5	19.7
West	21.7	8.1	34.8
Topographic position (%)			
Ridge-top	34.9	35.1	34.8
Mid-slope	30.2	24.3	37.9
Drainage-bottom	34.9	40.5	27.3
Presence of human disturbance (%)	34.9	81.1	84.8
Water presence within 100 m (%)	24.8	16.2	13.6

[a] See Tables 1 and 2 for definition of habitat variables.

Table 15. Test statistics of habitat variables collected at random sites on the Hoopa Valley Indian Reservation (January 1996 to June 1998) compared to east and west sides of the Shasta-Trinity (September 1992 to October 1996) study area in northwestern California. Shasta-Trinity data summarized from Golightly (2000, personal communication).

Variable[a]	Hoopa (n = 129): Shasta-Trinity West (n = 37)		Hoopa (n = 129): Shasta-Trinity East (n = 66)	
	Test value[b]	p	Test value[b]	P
Mean DBH of 4 largest trees	U = 2747	0.939	U = 4499	0.309
Canopy cover	$\chi^2 = 2.57$[c]	0.462	$\chi^2 = 24.81$[c]	≤ 0.001[d]
Number of hardwood species	U = 4172	≤ 0.001[d]	U = 7647	≤ 0.001[d]
Presence of conifer	$\chi^2 = 5.43$[c]	0.019[d]	$\chi^2 = 3.53$[c]	0.060
Aspect	$\chi^2 = 31.46$[c]	≤ 0.001[d]	$\chi^2 = 16.86$	≤ 0.001[d]
Topographic position	$\chi^2 = 0.60$	0.740	$\chi^2 = 1.56$	0.458
Presence of human disturbance	$\chi^2 = 24.77$[c]	≤ 0.001[d]	$\chi^2 = 43.65$	≤ 0.001[d]
Water presence within 100 m	$\chi^2 = 1.20$	0.027	$\chi^2 = 3.28$	0.070

[a] See Tables 1 and 2 for definition of habitat variables.
[b] Continuous variables were tested with Mann-Whitney U, nominal variables were tested with contingency analysis.
[c] $\geq$ 1 cells contain fewer than the expected count of five.
[d] Significant at 0.025.

Table 16. Means ± standard errors or percent observed in each category of habitat variables collected at fisher rest sites on the Hoopa Valley Indian Reservation (January 1996 to June 1998) and Shasta-Trinity (September 1992 to October 1996) study areas in northwestern California. Shasta-Trinity data summarized from Golightly (2000, personal communication).

		Shasta-Trinity		
Variable[a]	Hoopa	Year 1	Year 2	Year 3
Number of sites	129	107	66	119
Mean DBH of 4 largest trees (cm)	64.2 ± 1.7	65.4 ± 2.9	57.8 ± 2.4	61.5 ± 1.7
Canopy cover (%)				
<26% coverage	1.6	1.9	0.0	0.0
26-50% coverage	11.6	4.7	0.0	0.0
51-75% coverage	27.1	10.4	19.7	4.2
>75% coverage	59.7	83.0	80.3	95.8
Number of hardwood species	3.7 ± 0.1	1.4 ± 0.1	1.7 ± 0.1	2.5 ± 0.1
Presence of conifer (%)	95.3	99.1	100.0	97.5
Aspect (%)				
North	28.7	37.4	22.7	28.8
South	38.0	18.7	30.3	22.9
East	10.9	25.2	21.2	16.9
West	22.5	18.7	25.8	31.4
Topographic position (%)				
Ridge-top	31.0	24.3	9.1	18.5
Mid-slope	17.8	23.4	53.0	30.3
Drainage-bottom	51.2	52.3	37.9	51.3
Presence of human disturbance (%)	27.1	40.2	83.3	58.0
Water presence within 100 m (%)	27.9	60.7	50.0	56.3

[a] See Tables 1 and 2 for definition of habitat variables.

Table 17. Test statistics of habitat variables collected at fisher rest sites on the Hoopa Valley Indian Reservation (January 1996 to June 1998) compared to each year of the Shasta-Trinity (September 1992 to October 1996) study area in northwestern California. Shasta-Trinity data summarized from Golightly (2000, personal communication).

	Hoopa (n=129): Shasta-Trinity Year 1 (n=107)		Hoopa (n=129): Shasta-Trinity Year 2 (n=66)		Hoopa (n=129): Shasta-Trinity Year 3 (n=119)	
Variable[a]	Test value[b]	p	Test value[b]	p	Test value[b]	p
Mean DBH of 4 largest trees	U = 6953	0.725	U = 4976	0.053	U = 8110	0.374
Canopy cover	χ^2 = 16.16[c]	$\leq$ 0.001[d]	χ^2 = 12.46[c]	0.006[d]	χ^2 = 45.92[c]	$\leq$ 0.001[d]
Number of hardwood species	U = 1211	$\leq$ 0.001[d]	U = 7279	$\leq$ 0.001[d]	U = 9861	$\leq$ 0.001[d]
Presence of conifer	χ^2 = 2.81[c]	0.093	χ^2 = 3.17[c]	0.075	χ^2 = 0.80	0.370
Aspect	χ^2 =16.17	$\leq$ 0.001[d]	χ^2 = 4.77	0.189	χ^2 = 8.05	0.044
Topographic position	χ^2 = 1.84	0.398	χ^2 = 28.73	$\leq$ 0.001[d]	χ^2 = 7.90	0.019
Presence of human disturbance	χ^2 = 4.51	0.034	χ^2 = 55.49	$\leq$ 0.001[d]	χ^2 = 24.19	$\leq$ 0.001[d]
Water presence within 100 m	χ^2 = 25.77	$\leq$ 0.001[d]	χ^2 = 9.32	0.002[d]	χ^2 = 20.55	$\leq$ 0.001[d]

[a] See Tables 1 and 2 for definition of habitat variables.

[b] Continuous variables were tested with Mann-Whitney U, nominal variables were tested with contingency analysis.

[c] $\geq$ 1 cells contain fewer than the expected count of five.

[d] Significant at 0.016.

Presence of permanent water within 100 m of the rest site was less at Hoopa than plots for all three years at Shasta-Trinity. Aspect differed between Hoopa and year one at Shasta-Trinity, but not in years two and three. Topographic position differed between Hoopa and year two at Shasta-Trinity, but not years one and three. Over 50% of rest sites were located in drainage-bottoms at Hoopa and Shasta-Trinity Years one and three. Presence of human disturbance within 100 m did not differ between Hoopa and year one. Years two and three at Shasta-Trinity had more human disturbance than Hoopa.

DISCUSSION

Although estimates of fisher abundance have not been conducted at the two areas, relative abundance of fishers at each study area could be inferred from track plate indices, trapping indices, and home range size differences. Track plate surveys use a detection ratio index calculated as the number of stations at which the species of interest was detected divided by the total number of stations available (Fowler and Golightly 1994). Previous studies conducted at Hoopa and Shasta-Trinity all showed substantially greater detection ratios of fisher abundance at Hoopa. Fowler et al. (1992) reported a detection ratio of 0.65 (n = 20) at Hoopa in 1992. Higley (2000, personal communication) obtained a detection ratio of 0.85 (n = 59) at Hoopa in 1993. At Shasta-Trinity, Dark (1997) had detection ratios of 0.13 (n = 126) and 0.15 (n = 48) during summer and fall 1994 surveys conducted on both the west and east sides of the lake, and 0.18 (n = 60) during a 1995 summer survey concentrated on the east side of the lake.

Both trap success and number of individuals captured were greater at Hoopa than Shasta-Trinity. Although baits used for trapping differed at the two areas (salmon at Hoopa and chicken at Shasta-Trinity) similar recapture rates suggested both baits were equally effective and sampling effort was comparable.

Estimates of female fisher home range sizes at Hoopa from this study were smaller than estimates of female home range estimates from Shasta-Trinity. Insufficient numbers of male home range estimates at Hoopa precluded making meaningful comparisons with males at Shasta-Trinity. Not only were home range estimates for female fisher smaller at Hoopa than Shasta-Trinity, but they were also much smaller (from 504 to 5350 ha) than any reported for western fisher (Buck 1982, Mullis 1985, Seglund 1995, Dark 1997, Zielinski et al. 1997, Weir and Harestad 2003, Zielinski et al. 2004b).

Although many factors may affect size of an animal's home range, the greater relative population and smaller home ranges at Hoopa may be indicative of better habitat conditions there. Buskirk and McDonald (1989) reported a strong relationship between home range size and site conditions for American martens (*Martes americana*). Their hypothesis was supported by Thompson and Colgan (1987) who reported that home ranges of marten were smaller in uncut versus cutover forests. Zielinski et al. (2004b) hypothesized that the smaller home ranges of fishers on one of their two California study sites was due to productive habitats rich in black oak.

Track plate indices, trapping indices, and home range size differences all indicate the number of fishers were greater at Hoopa than at the Shasta-Trinity study area. If population density reflected qualitative and quantitative differences between habitats (Morris 1989), Hoopa may have offered a better condition of habitat than Shasta-Trinity. Van Horne (1983), however, cautioned that inferences of habitat quality could be misleading without survival and productivity data. But Van Horne also predicted species with low reproductive capacity that are habitat specialists and lack a social pattern of dominance interactions, may couple population density to habitat quality. Fishers exhibit two of these characteristics, but they are intrasexually territorial (Powell 1993) and may violate the third criterion.

Rest Structures

Weir and Harestad (2003) suggested fishers have stringent requirements for structural attributes for activities such as resting or rearing kits because fisher appeared to select habitat elements that were structurally different than generally available within patches. At both Hoopa and Shasta-Trinity, fishers predominantly rested in live trees (> 75%) with snags and logs comprising a majority of the remainder. Other studies have documented similar patterns of high percentage live tree use by fisher in the western United States (Jones 1991, Seglund 1995, Truex et al. 1998, Zielinski et al. 2004a). Live trees presumably provide a greater abundance of sturdy substrates (cavities or platforms) than may be available from either snags or logs. Furthermore, living trees with dead portions typically stand longer than snags and can take hundreds of years to fully undergo the decay process (Bull et al. 1997) supplying rest sites for many generations of fisher in an area.

Live hardwoods appeared to be an important element of fisher resting habitat. When live trees were grouped into conifer and hardwood categories, fisher use of each group for resting was in proportion to its availability at Hoopa but not at Shasta-Trinity. This difference was likely a result of the lower availability but greater than expected use of hardwoods at Shasta-Trinity. At Hoopa, hardwoods may be sufficiently numerous as to not be limiting, thus no selection was detected.

When individual tree species were investigated at both sites, each conifer species was used in proportion to its availability. Of hardwood species at Hoopa, tanoak was used in proportion to its availability while Pacific madrone was used less than available.

At Shasta-Trinity, tanoak and Pacific madrone were sufficiently sparse or small in diameter that they were not represented in random plots. At both sites, black oaks were used more than they were available.

The greater than expected use of black oaks was likely best explained by differences in fisher use of cavities or platforms as resting substrates. Rest sites in conifers were generally on platforms while cavity use was most frequent in hardwoods. In the Pacific Northwest, hardwoods generally rot at younger ages and smaller sizes than do conifers (Bunnell et al. 1999). At Hoopa, live Douglas-firs had very few cavity openings while more cavity openings were observed in live black oak trees than any other species. Black oaks may be particularly important to fisher in the Klamath region because they are especially susceptible to fungi that often reduce the bole and large limbs of older decadent trees to simple shells (McDonald 1990), thus, creating suitably-sized cavities for fishers.

Cavity availability and use appeared to be associated with the availability of hardwoods. The proportional use of cavities was similar to proportional use of live hardwood trees at both study areas. Use of cavities as resting substrates was greater at Hoopa (48% of all rest sites) than at Shasta-Trinity (19% of all rest sites). Live hardwoods were more available at Hoopa (70%) than at Shasta-Trinity (7%). This suggested the availability of hardwoods, and probably cavities, may be limited at Shasta-Trinity.

A potential bias existed in the greater observed use of cavities at Hoopa because a majority of the Hoopa data-set was from female fishers. The smaller body size of females may allow them greater access to smaller cavity openings. Other researchers suggested that female and male fishers used different resting structures. Zielinski et al. (2004a) reported female fishers used cavities more often than males, while males used platforms more than females. Regardless of this potential bias, cavities were an important habitat component, especially for denning. In Maine, Paragi et al. (1996) found 31 of 33 dens in cavities in hardwoods. At Hoopa 11 of 12 dens located were cavities in hardwoods (Appendix B). At Shasta-Trinity 4 of 6 dens located were cavities in hardwoods (Golightly 2000, personal communication). Hardwoods may provide a critical role in providing cavities for denning.

In addition to providing cavities, mast-producing hardwoods, such as black oak and tanoak, may play an important habitat role because they provide substantial food for potential prey species and may increase mast-eating rodent abundance (Wolff 1996). Across their geographic range, fishers are generalized predators feeding on small- to medium-sized mammals, birds, ungulate carrion, vegetation, and insects (Martin 1994, Zielinski et al. 1999). Rodents were found to be a major component of the fisher diet at Hoopa (66%; Higley 2000, personal communication), Shasta-Trinity (58%; Golightly 2000, personal communication) and in southern California (47.8%; Zielinski et al. 1999). The greater availability of hardwoods, and consequently greater mast production, may result in increased prey abundance at Hoopa, which could explain differences in population abundance.

Fishers used trees that were much larger in diameter than available trees at both Hoopa and Shasta-Trinity study areas. Furthermore, diameters of rest trees were larger than the mean of the four largest trees on rest plots at both study areas. Other studies of fisher rest site use in California (Zielinski et al. 2004a) and British Columbia (Weir and Harestad 2003) report use of trees larger than available, suggesting fishers generally used larger trees for resting.

The size of these large diameter trees also appeared to be consistent across different areas. There was no difference in diameter of rest structures used between Hoopa and Shasta-Trinity study areas when grouped by all rest sites, conifer only, or hardwood only. Zielinski et al. (2004a) reported similar mean diameters for fisher rest sites in conifers and hardwoods at two other sites in California. Mean conifer diameter at Hoopa (109.6 cm) and Shasta-Trinity (98.6 cm) were slightly smaller than mean conifer diameter (117.2 cm) reported by Zielinski et al. (2004a). Mean hardwood diameter at Hoopa (75.1 cm) and Shasta-Trinity (71.9 cm) were slightly larger than mean hardwood diameter (69.0 cm) reported by Zielinski et al. (2004a).

Resting structures (trees, snags, and logs) need to be sufficiently large in diameter to supply resting substrates (cavities or platforms) that can accommodate the large-bodied fisher. The likelihood of larger lateral limbs, horizontally fan shaped branch arrays, or pockets of decay suitably-sized for resting fisher increases with tree diameter (and presumably tree age). For cavity formation, trees must be old enough for ecological processes (e.g., decay, woodpecker activity) to form cavities of sufficient size for fisher access. Fan et al. (2003) reported that tree diameter was the primary determinant of relative cavity abundance on their midwestern study site. Hardwoods may be particularly important to cavity availability because they are more susceptible to rot than conifers

(Bunnell et al. 2002b). In the Pacific Northwest, hardwoods generally rot at younger ages and smaller sizes than conifers (Bunnell et al. 1999). More time was required for heart rot to develop in conifers. Therefore conifers were larger before sizeable decay pockets developed (Bunnell et al. 2002a).

Although fishers generally selected larger trees for resting, they may not be dependent on large tracts of late-seral stage forest. Jones (1991) observed fisher rest sites in young forests that had at least one remnant large tree, snag, or log that had survived stand-replacing fires. This behavior was also observed in timber-harvested areas at Hoopa. Fishers may benefit from a juxtaposition of older forest with large structures, and some younger forest because a mixture of different-aged forests increases the density and diversity of prey (Scrivner and Smith 1984, Sakai and Noon 1993).

Habitat Characteristics

Fisher rest sites were strongly associated with larger trees available at both study areas. The mean DBH of the four largest trees on rest plots was greater than on random plots at Hoopa and all three years of the Shasta-Trinity study. No difference was detected in the mean DBH of the four largest trees on random plots between Hoopa and Shasta-Trinity suggesting large diameter trees were equally available at both sites. Zielinski et al. (2004a) also reported the diameter of trees were larger at fisher rest sites.

Dense canopy cover was associated with fisher rest sites at both Hoopa and Shasta-Trinity study areas. In general, fishers have been reported in forests with continuous canopy closure (Buck et al. 1994, Jones and Garton 1994, Seglund 1995, Dark 1997, Carroll et al. 1999, Zielinski et al. 2004a). Canopy closure had the highest predictive significance of vegetation variables used in landscape modeling of fisher distribution in the Klamath region of California (Carroll et al. 1999). It has been suggested that greater levels of overhead cover may provide increased protection from predators, more favorable microclimates, and increased abundance and (or) vulnerability of prey species (Buskirk and Powell 1994, Powell and Zielinski 1994). It remains unclear whether fishers selected greater canopy cover for the above reasons or for other reasons such as canopy cover or large diameter trees. Larger trees may provide more suitable resting structures in the form of larger platforms or cavities.

Buskirk and Powell (1994) suggested that fishers would select mesic forests over xeric forests where these habitat types occur together. At temperate latitudes, mesic forests often occur in riparian areas. Jones (1991) reported that fishers in Idaho used riparian areas for resting sites in winter and summer. Other studies in the western United States have commonly found fisher associated with riparian areas (Buck 1982, Mullis 1985, Dark 1997) or water (Jones 1991, Seglund 1995, Zielinski et al. 2004a).

It was difficult to separate the influence of distance to water and use of drainage-bottoms in the steep valleys of both study areas. Rest sites at Hoopa were located in drainage-bottoms more often than on mid-slopes or ridge-tops than random plots, but were not closer to water than random sites. Rest sites at Shasta-Trinity were located in drainage-bottoms more often than random plots during year two of the study, while proximity to water was a significant predictor of fisher rest sites in all three years of the Shasta-Trinity study. Drainage-bottoms may provide a more desirable microclimate for resting fishers than upslope areas. Riparian areas may reduce thermal stressors because they maintain cooler more stable temperatures in summer months (Oakley et al. 1985) and furnish thermal cover and intercept snow at higher altitudes in winter. Jones (1991) suggested warm summer temperatures might stress fisher more than winter weather because fishers had a strong affinity for locations that were closer to water than random plots during summer.

Although no difference was detected in random plot distance to water between Hoopa and Shasta-Trinity, closer coastal proximity and greater rainfall at Hoopa may explain the lack of observed difference in distance to water between rest and random sites. Zielinski et al. (2004a) reported the presence of surface water within 100 m of rest sites was important in selected habitat models at their hotter and drier southern Sierra site. However, they detected no influence of water on rest site selection in their northern California study area that received more annual precipitation. Association with water at the Shasta-Trinity site may be a result of drier site conditions there, but this hypothesis may be confounded by historical timber practices. Timber harvests on the Shasta-Trinity National Forest have been required by law to preserve buffers around streams and rivers (United States Department of the Interior 1994). Thus, larger trees or a denser canopy may be the primary attractant and thus correlated with water.

Food availability along riparian areas may be another reason fisher rested in drainage-bottoms because fisher may rest near foraging locations to reduce energy expenditure. Kilpatrick and Rego (1994) supported this hypothesis with observations of fisher killing prey in or near prey dens or nest sites, then using these sites for resting.

Approximately 25% of all small mammal species found in California are limited to, or largely dependent on, riparian and other wetland habitats (Williams and Kilburn 1984). Smith (1977) reported that riparian habitats of the western United States support more species of plants and animals than any other habitat type in that region, although riparian habitats comprise less than one percent of the land area.

Study Area Comparison

Caution should be exercised in inferring habitat quality from population abundance (Van Horne 1983). However, the differences in fisher abundance between the Hoopa and Shasta-Trinity study areas would suggest some habitat attribute(s) differed. Comparisons of habitat use across the three spatial scales examined in my study allowed me to identify differences and similarities in several habitat attributes that may be important for fisher resting habitat.

Foremost of these attributes was the selection of trees larger in diameter than were generally available within home ranges and the study site. Across study areas, trees of the same mean diameter were used as resting structures. Research in British Columbia (Weir and Harestad 2003) and elsewhere in California (Zielinski 2004a) also reported fishers to use trees with diameters larger than generally available.

At both study areas, fishers typically avoided areas with low canopy cover supporting the findings of Buck et al. (1983), Arthur et al. (1989), and Powell (1993). It has been suggested that adequate cover may be important to fisher resting habitat for a number of reasons including concealment from predators or to balance thermoregulatory factors (Buskirk and Powell 1994, Powell and Zielinski 1994). Continuous canopy has been associated with fisher habitat across their geographic range (Arthur et al 1989, Buck et al. 1994, Jones and Garton 1994, Klug 1997, Carroll et al. 1999, Zielinski et al. 2004a).

Use of drainage-bottoms and proximity to water also differed between Hoopa and Shasta-Trinity depending on the scale examined. Within home ranges and across study sites, position on the slope appeared to be more important at Hoopa while the association of water (or other confounding factors such as historical timber practices) appeared to have been the primary attractant at Shasta-Trinity. Regardless of whether fishers used drainage-bottoms for water, increased prey abundance, larger trees, denser canopy cover, or some other factor, these areas appeared to be an important habitat element at both study sites. Other researches have reported extensive use of riparian habitats by fishers, especially as travel corridors and rest sites (Buck et al. 1983, Jones and Garton 1994, Seglund 1995). Drainage-bottoms should be considered an important element of western fisher habitat, especially in more xeric forests.

At each study area, hardwoods and conifers were used in proportion to their availability. The availability of conifers and hardwoods, however, differed considerably between sites and may have affected prey availability and use of cavities or platforms. The greater observed use of platforms at Shasta-Trinity may have been a result of the lower availability of hardwoods in general, or more specifically of tree species that have a propensity towards cavity formation.

Across their geographical range, fishers use a variety of tree species for resting. Zielinski et al. (2004a) hypothesized that tree species alone was not as important for selection of a rest site by a fisher as the trees' structural characteristics. Furthermore, tree species with a tendency to decay and form cavities were more important for resting than those that did not. Black oaks in Hoopa had more cavities than any other species. At both the Hoopa and Shasta-Trinity study areas, black oaks were used more than they were available and accounted for a majority of cavity resting substrates in live trees. Zielinski et al. (2004a) also found that black oaks accounted for 85% of hardwood species used by fishers. The lower availability of large black oaks at Shasta-Trinity and greater observed use of platforms as resting structures suggests cavities may have been limited there.

If cavities were limited at Shasta-Trinity, the reduced number of suitable den sites could potentially affect reproduction. Weir and Harestad (2003) suggested that the low availability of large diameter black cottonwoods (*Populus balsamifera trichocarpa*) at their British Columbia study area may be a factor affecting fisher reproductive capacity. Fisher resting and denning habitat availability in the west is likely a result of local structural and growth characteristics of individual trees species occurring in a particular location.

Conclusions and Management Recommendations

Jones (1991) suggested the factor most likely to limit fisher populations in a managed forest would be the availability of mature and old-growth forests to provide optimal resting habitat. My study supports the perception that fishers require habitat elements with some older forest characteristics in the form of large diameter decadent trees. However, landscape timber harvest strategies emphasizing a juxtaposition of young-, mid-, and older-successional forests, with a retention of large diameter conifers and hardwoods in all successional stages, could promote prey diversity as well as supply required resting and denning habitat.

Where fisher populations are a management concern, timber harvest strategies should attempt to maintain some of the largest diameter live trees possible, dense canopy cover, and close proximity to drainage-bottoms. Homogeneous stand management should be minimized because large diameter hardwood species likely improves site conditions for fisher. Tree species that have a propensity toward cavity formation, such as black oak in the Klamath region, should be retained and allowed to reach large diameters. These conditions, however, need to be evaluated for local biotic and abiotic conditions in the formation of a conservative management plan.

LITERATURE CITED

Alldredge, J. R. and J. T. Ratti. 1986. Comparison of some statistical techniques for analysis of resource selection. Journal of Wildlife Management 50:157-165.

Arthur, S. M., W. B. Krohn, and J. R. Gilbert. 1989. Habitat use and diet of fishers. Journal of Wildlife Management 53:680-688.

Aubry, K. B. and D. B. Houston. 1992. Distribution and status of the fisher (*Martes pennanti*) in Washington. Northwestern Naturalist 73:69-79.

Aubry, K. B. and J. C. Lewis. 2003. Extirpation and reintroduction of the fisher (*Martes pennanti*) in Oregon: implications for their conservation in the Pacific States. Biological Conservation 114:79-90.

Buck, S. G. 1982. Habitat utilization by fisher (*Martes pennanti*) near Big Bar, California. Master's Thesis. Department of Wildlife, Humboldt State University, Arcata, California.

Buck, S. G., C. Mullis, and A. S. Mossman. 1983. Corral-Bottom/Hayfork Bally fisher study. Unpublished final report. United States Department of Agriculture, Forest Service and Humboldt State University, Arcata, California.

Buck, S. G., C. Mullis, A. S. Mossman, I. Show, and C. Coolahan. 1994. Habitat use by fishers in adjoining heavily and lightly harvested forest. Pages 368-376 in S. W. Buskirk, A. S. Harestad, M. G. Raphael, and R. A. Powell, editors. Martens, sables, and fishers: biology and conservation. Cornell University Press Ithaca, New York.

Bull, E. L., C. G. Parks, and T. R. Torgersen. 1997. Trees and logs important to wildlife in the interior Columbia River Basin. United States Department of Agriculture, Forest Service, Pacific Northwest Research Station, General Technical Report PNW-GTR-391. Portland, Oregon.

Bunnell, F. L., L. L. Kremsater, E. Wind. 1999. Managing to sustain vertebrate richness in forests of the Pacific Northwest: relationships within stands. Environmental Reviews 7: 97-146.

Bunnell, F. L., E. Wind, M. Boyland, I. Houde. 2002a. Diameters and heights of trees with cavities: their implications to management. Pages 717-737 in W. F. Laudenslayer Jr., P. J. Shea, B. E. Valentine, C. P. Weatherspoon, T. E. Lisle, technical coordinators. Proceedings of the symposium on the ecology and management of dead wood in western forests. 1999. November 2-4 Reno, Nevada. United States Department of Agriculture, Forest Service, Pacific Southwest Research Station, General Technical Report PSW-GTR-181. Albany, California.

Bunnell, F. L., E. Wind, and R. Wells. 2002b. Dying and dead hardwoods: their implications to management. Pages 695-716 in W. F. Laudenslayer Jr., P. J. Shea, B. E. Valentine, C. P. Weatherspoon, T. E. Lisle, technical coordinators. Proceedings of the symposium on the ecology and management of dead wood in western forests. 1999. November 2-4 Reno, Nevada. United States Department of Agriculture, Forest Service, Pacific Southwest Research Station, General Technical Report PSW-GTR-181. Albany, California.

Buskirk, S. W. and L. L. McDonald. 1989. Analysis of variability in home-range size of the American marten. Journal of Wildlife Management 53:997-1004.

Buskirk, S. W. and R. A. Powell. 1994. Habitat ecology of fishers and American martens. Pages 283-296 in S. W. Buskirk, A. S. Harestad, M. G. Raphael, and R. A. Powell, editors. Martens, sables, and fishers: biology and conservation. Cornell University Press Ithaca, New York.

Carroll, C., W. J. Zielinski, and R. F. Noss. 1999. Using presence-absence data to build and test spatial habitat models for the fisher in the Klamath Region, U.S.A. Conservation Biology 13:1344-1359.

Dark, S. J. 1997. A landscape-scale analysis of mammalian carnivore distribution and use of habitat by fisher. Master's Thesis. Department of Wildlife, Humboldt State University, Arcata, California.

Fan, Z., R. S. Shifley, M. A. Spetich, F. R. Thompson III, and D. R. Larsen. 2003. Distribution of cavity trees in midwestern old-growth and second-growth forests. Canadian Journal of Forestry Research 33:1481-1494.

Fowler, C. H. and R. T. Golightly. 1994. Fisher and marten survey techniques on the Tahoe National Forest. Final Report. California Department of Fish and Game Wildlife Management Division. Nongame Bird and Mammal Section, Report 94-9. Sacramento, California.

Fowler, C. H., R. T. Golighlty, and J. S. Yaeger. 1992. Fisher survey techniques progress report. Unpublished progress report. California Department of Fish and Game, Agreement FG0539. Sacramento, California.

Gibilisco, C. J. 1994. Distributional dynamics of modern *Martes* in North America. Pages 59-71 in S. W. Buskirk, A. S. Harestad, M. G. Raphael, and R. A. Powell, editors. Martens, sables, and fishers: biology and conservation. Cornell University Press Ithaca, New York.

Harris, S., W. J. Cresswell, P. G. Forde, W. J. Trewhella, T. Woollard, and S. Wray. 1990. Home-range analysis using radio-tracking data – a review of problems and techniques particularly as applied to the study of mammals. Mammal Review 20:97-123.

Hintze, J. L. 1999. Number cruncher statistical system products. Kaysville, Utah.

Hosmer, D. W. and S. Lemeshow. 1989. Applied logistic regression. John Wiley & Sons, New York, New York.

Hurlbert, S. H. 1984. Pseudoreplication and the design of ecological field experiments. Ecological Monographs 54:187-211.

Jones, J. L. 1991. Habitat use of fisher in northcentral Idaho. Master's Thesis. College of Graduate Studies, University of Idaho, Moscow, Idaho.

Jones, J. L. and E. O. Garton. 1994. Selection of successional stages by fishers in North-Central Idaho. Pages 377-387 in S. W. Buskirk, A. S. Harestad, M. G. Raphael, and R. A. Powell, editors. Martens, sables, and fishers: biology and conservation. Cornell University Press Ithaca, New York.

Kilpatrick, H. J. and P. W. Rego. 1994. Influences of season, sex, and site availability on fisher (*Martes pennanti*) rest-site selection in the central hardwood forest. Canadian Journal of Zoology 72:1416-1419.

Klug, R. R. 1997. Occurrence of Pacific fisher (*Martes pennanti pacifica*) in the redwood zone of northern California and the habitat attributes associated with their detections. Master's Thesis. Department of Wildlife, Humboldt State University, Arcata, California.

Lehner, P. N. 1996. Handbook of ethological methods, Second edition. University Press, Cambridge, United Kingdom.

Lewis, J. C. and W. J. Zielinski. 1996. Historical harvest and incidental capture of fishers in California. Northwest Science 70:291-297.

Martin, S. K. 1994. Feeding ecology of American martens and fishers. Pages 297-315 in S. W. Buskirk, A. S. Harestad, M. G. Raphael, and R. A. Powell, editors. Martens, sables, and fishers: biology and conservation. Cornell University Press Ithaca, New York.

Mayer, K. E. and W. F. Laudenslayer Jr., editors. 1988. A guide to wildlife habitats of California. California Department of Forestry and Fire Protection, Sacramento, California.

McDonald, P. M. 1990. *Quercus kelloggii* Newb. California black oak. Pages 661-671 in R. M. Burns, B.H. Honkala, technical coordinators. Silvics of North America. Volume 2, hardwoods. Agricultural Handbook 654. United States Department of Agriculture, Washington DC.

Mohr, C. O. 1947. Table of equivalent populations of North American small mammals. American Midland Naturalist 37:223-249.

Morris, D. W. 1989. Density-dependent habitat selection: testing the theory with fitness data. Evolutionary Ecology 3:80-94.

Mullis, C. 1985. Habitat utilization by fisher (*Martes pennanti*) near Hayfork Bally, California. Master's Thesis. Department of Wildlife, Humboldt State University, Arcata, California.

Oakley, A. L., J. A. Collins, L. B. Everson, D. A. Heller, J. C. Howerton, and R. E. Vincent. 1985. Riparian zones and freshwater wetlands. Page 65 in E. R. Brown, editor. Management of wildlife and fish habitats in forests of western Oregon and Washington. United States Department of Agriculture, Forest Service, Pacific Northwest Research Station, Publication No. R6-F & W-192-1985. Portland, Oregon.

Odum, E. P., and E. J. Kuenzler. 1955. Measurement of territory and home range size in birds. Auk 72:128-137.

Paragi, T. F., S. M. Arthur, and W. B. Krohn. 1996. Importance of tree cavities as natal dens for fishers. Northern Journal of Applied Forestry 13:79-83.

Pereira, J. M. and R. M. Itami. 1991. GIS-based habitat modeling using logistic multiple regression: A study of the Mt. Graham red squirrel. Photogrammetric Engineering and Remote Sensing 57:1475-1486.

Powell, R. A. 1993. The fisher: Life history, ecology, and behavior, Second edition. University of Minnesota Press, Minneapolis, Minnesota.

Powell, R. A. 1994. Effects of scale on habitat selection and foraging behavior of fishers in winter. Journal of Mammalogy 75:349-356.

Powell, R. A. and W. J. Zielinski. 1994. Fisher. Pages 38-73 in Ruggiero, L. F., K. B. Aubry, S. W. Buskirk, L. J. Lyon, and W. J. Zielinski, editors. The scientific basis for conserving forest carnivores: American marten, fisher, lynx, and wolverine in the western United States. United Staes Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experimental Station, General Technical Report RM-254. Ft. Collins, Colorado.

Powell, S. M., E. C. York, J. J. Scanlon, and T. K. Fuller. 1997. Fisher maternal den sites in central New England. Pages 265-278 in G. Proulx, H. N. Bryant, and P. M. Woodard, editors. *Martes*: Taxonomy, Ecology, Techniques, and Management. Provincial Museum of Alberta, Edmonton, Alberta, Canada.

Rosenberg, K. V. and R. G. Raphael. 1986. Effects of forest fragmentation on vertebrates in Douglas-fir forests. Pages 263-272 in J. Verner, M. L. Morrison, and C. J. Ralph, editors. Wildlife 2000: Modeling habitat relationships of terrestrial vertebrates. University of Wisconsin Press, Madison, Wisconsin.

Sakai, H. F. and B. R. Noon. 1993. Dusky-footed woodrat abundance in different-aged forests in northwestern California. Journal of Wildlife Management 57:373-382.

Seglund, A. E. 1995. The use of resting sites by the Pacific fisher. Master's Thesis. Department of Wildlife, Humboldt State University, Arcata, California.

Scrivner, J. H. and H. D. Smith. 1984. Relative abundance of small mammals in four successional stages of spruce-fir forest in Idaho. Northwest Science 58:171-175.

Smith, F. 1977. A short review of the status of riparian forests in California. Pages 1-2 in A. Sands, editor. Riparian forests of California: their ecology and conservation. Institute of Ecology Publication 15. Davis, California.

Sokal, R. S. and F. J. Rohlf. 1981. Biometry: The principles and practice of statistics in biological research, Second edition. W.H. Freeman and Company, San Francisco, California.

Thomas, J. W., L. F. Ruggiero, R. W. Mannan, J. W. Schoen, and R. A. Lancia. 1988. Management and conservation of old-growth forests in the United States. Wildlife Society Bulletin 16:252-262.

Thompson, I. D. and P. W. Colgan. 1987. Numerical responses of martens to a food shortage in northcentral Ontario. Journal of Wildlife Management 51:824-835.

Trexler, J. C. and J. Travis. 1993. Nontraditional regression analysis. Ecology 74:1629-1637.

Truex, R. L., W. J. Zielinski, R. T. Golightly, R. L. Barrett, and S. M. Wisely. 1998. A meta-analysis of regional variation in fisher morphology, demography, and habitat ecology in California. United States Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station, Arcata, California. Unpublished draft report submitted to California Department of Fish and Game

United States Department of the Interior. 1994. Standards and guidelines for management of habitat for late-successional and old-growth forest related species within the range of the northern spotted owl: Final Supplement Environmental Impact Statement. Appendix J2. United States Department of the Interior, Portland Oregon.

Van Horne, B. 1983. Density as a misleading indicator of habitat quality. Journal of Wildlife Management 47:893-901.

Weir, R. D. and A. S. Harestad. 2003. Scale-dependent habitat selectivity by fishers in south-central British Colombia. Journal of Wildlife Management 67:73-82.

Western Regional Climate Center. 2000. Western United States climate historical summaries. Western Regional Climate Center, Reno, Nevada.

Williams, D. F. and K. S. Kilburn. 1984. Sensitive, threatened, and endangered mammals of riparian and other wetland communities in California. Pages 950-956 in Warner, R. E., and K. M. Hendrix, editors. California riparian ecosystems: ecology, conservation, and productive management. University of California Press, Berkeley, California.

Winer, B. J., D. R. Brown, and K. M. Michels. 1991. Statistical principals in experimental design, Third edition. McGraw-Hill, Inc., New York, New York.

Wolff, J. O. 1996. Population fluctuations of mast-eating rodents are correlated with production of acorns. Journal of Mammalogy. 77:850-856

Zar, J. H. 1984. Biostatistical analysis. Prentice-Hall, Inc, Englewood Cliffs, New Jersey.

Zielinski, W. J., R. H. Barrett, and R. L. Truex. 1997. Southern Sierra Nevada fisher and marten study: progress report IV. Unpublished progress report. United States Department of Agriculture, Forest Service. Pacific Southwest Forest and Range Experiment Station, Arcata, California.

Zielinski, W. J., N. P. Duncan, E. C. Farmer, R. L. Truex, A. P. Clevenger, and R. H. Barrett. 1999. Diet of fishers (*Martes pennanti*) at the southernmost extent of their range. Journal of Mammalogy 80:961-971.

Zielinski, W. J., T. E. Kucera, and R. H. Barrett. 1995. Current distribution of the fisher, *Martes pennanti*, in California. California Fish and Game 81:104-112.

Zielinski, W. J., R. L. Truex, G. A. Schmidt, F. V. Schlexer, K. N. Schmidt, and R. H. Barrett. 2004a. Resting habitat selection by fishers in California. Journal of Wildlife Management 68:475-492.

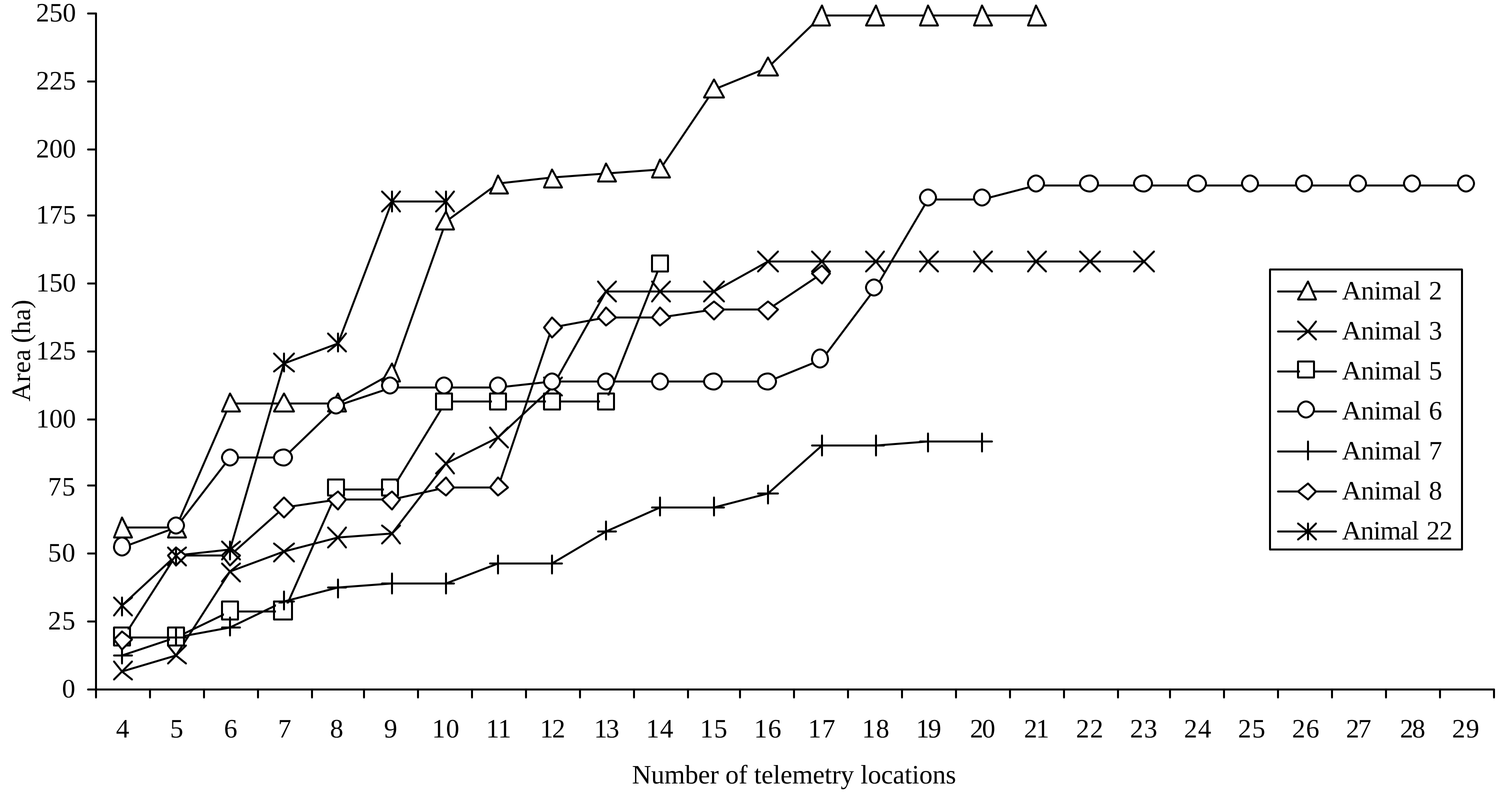
Zielinski, W. J., R. L. Truex, G. A. Schmidt, F. V. Schlexer, K. N. Schmidt, and R. H. Barrett. 2004b. Home range characteristics of fishers in California. Journal of Mammalogy 85:649-657.

PERSONAL COMMUNICATIONS

Golightly, R. T. 2000. Department of Wildlife, Humboldt State University, 1 Harpst Street, Arcata, California 95521.

Higley, J. M. 2000. Hoopa Valley Tribal Council, Natural Resources Department, Forestry Division, P.O. Box 368, Hoopa, California 95546.

McKelvey, K. S. 1993. United States Department of Agriculture, Forest Service, Pacific Southwest Research Station, 1700 Bayview, Arcata, California 95521.



Appendix A. Observation-area curves of home range estimates with increasing number of telemetry locations for fisher at the Hoopa Valley Indian Reservation (January 1996 to June 1998) study area in northwestern California.

Appendix B. Descriptions of fisher den locations at the Hoopa Valley Indian Reservation (January 1996 to June 1998) and Shasta-Trinity (September 1992 to October 1996) study areas in northwestern California. Shasta-Trinity data summarized from Golightly (2000, personal communication).

Site	Structure	Tree species	DBH (cm)	Presence of cavities
Hoopa	Live tree	Black oak	84.1	yes
Hoopa	Live tree	Black oak	50.5	yes
Hoopa	Live tree	Black oak	67.6	yes
Hoopa	Live tree	Black oak	82.6	yes
Hoopa	Live tree	Black oak	49.8	yes
Hoopa	Live tree	Black oak	43.9	yes
Hoopa	Live tree	Tanoak	66.8	yes
Hoopa	Snag	Chinquapin	61.0	yes
Hoopa	Snag	Douglas-fir	96.3	yes
Hoopa	Live tree	White oak	51.3	yes
Hoopa	Live tree	White oak	71.1	yes
Hoopa	Live tree	Tanoak	71.1	yes
		Mean $\pm$ SE	66.3 $\pm$ 4.4	
Shasta-Trinity	Snag	Ponderosa pine	78.0	yes
Shasta-Trinity	Live tree	Black oak	88.0	no
Shasta-Trinity	Live tree	Canyon live oak	52.2	yes
Shasta-Trinity	Live tree	Canyon live oak	40.5	yes
Shasta-Trinity	Live tree	Black oak	51.3	yes
Shasta-Trinity	Live tree	Black oak	125.6	yes
		Mean $\pm$ SE	73.7 $\pm$ 10.9	