A META-ANALYSIS OF REGIONAL VARIATION

IN FISHER MORPHOLOGY, DEMOGRAPHY,

AND HABITAT ECOLOGY IN CALIFORNIA

DRAFT REPORT SUBMITTED TO:

CALIFORNIA DEPARTMENT OF FISH AND GAME

WILDLIFE MANAGEMENT DIVISION

NONGAME BIRD AND MAMMAL SECTION

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SUMMARY

The fisher (*Martes pennanti*) historically occurred throughout forested habitats in northwestern California and the Sierra Nevada. A paucity of information about fisher ecology in California, in conjunction with the recent isolation of fishers in the southern Sierra Nevada from those in northwestern California by over 400 km, prompted several studies during the 1990s. Three of these occurred in different ecological regions of California and used similar field methods, thus providing the opportunity to examine fisher ecology across California. We compared aspects of demography, habitat ecology, and home range for fishers in the Klamath Mountains (Eastern Klamath study area, Shasta-Trinity National Forest), North Coast Ranges (North Coast study area, Six Rivers National Forest), and the southern Sierra Nevada (Southern Sierra study area, Sequoia National Forest). Study areas were approximately 500, 400, and 280 km in size, respectively. Our analysis revealed similarities and differences among study areas as follows:

1. Fisher density appeared to be highest in the Southern Sierra study area where 33 individuals (11 male, 22 female) were captured from 1994-1996 and lowest on the Eastern Klamath study area where only 22 fishers (9M, 13F) were captured from 1992-1996. The North Coast study area appeared to have an intermediate density: 31 individuals (13M, 18F) were captured from 1993-1996.
2. The trends in density suggested by trapping success were supported by results of home range analysis. Minimum Convex Polygon home range estimates for males and females on the Eastern Klamath study were more than twice as large as those on the southern Sierra and considerably larger than those on the North Coast study areas.
3. Fishers tended to use cavities and broken-tops of large trees and snags for daily resting purposes. Diameter at breast height (DBH) of rest sites on the Southern Sierra and North Coast studies averaged >105.0 cm for conifers and >64.0 cm for hardwoods. Trees were typically smaller for the Eastern Klamath study where conifers averaged 77.2 and hardwoods 49.3 cm DBH. This difference is partly due to the prevalent use of platforms (nests *and* mistletoe brooms) on the Eastern Klamath study, which accounted for 31°s of total rest site use and averaged only 49.7 cm DBH.

4. In the two northern California studies, Douglas-fir (*Pseudotsuga menziesii*) was the dominant rest site tree species, accounting for >60% of all rest site use. In the absence of Douglas-fir, fishers in the Southern Sierra used a more diverse array of tree species including California black oak (*Quercus kelloggii,* 42% of rest site use) and white fir (*Abies concolor*, 26% of rest site use).
5. Females were observed resting with kits on 15 occasions. Although individual fishers were found resting in nests of small diameter trees, females were never sighted with kits in such structures. Five natal dens found on the Southern Sierra study area were all located in cavities of large diameter trees (3 white fir averaging 114.0 cm DBH, 2 black oak averaging 87.5 cm DBH).
6. Although samples of radiccollared individuals were typically small for each study from year to year, survival rates were lower for females than for males on all study areas. Survival rates were lowest on the Southern Sierra study area, where only 61% of females survived annually. Predation appeared to be an important source of mortality on the Southern Sierra study area, while a combination of human-related factors and predation accounted for most mortalities on the 2 northern California studies. Two fishers died due to vehicle encounters on the Eastern Klamath study area and two apparently died at the hands of humans on the North Coast study.

Two important conclusions can be drawn from our research: 1) habitat quality currently appears to be lower for fishers on the Eastern Klamath study area as evidenced by lower density, larger home range size, and use of small diameter trees as rest sites; and 2) although fishers appear to occupy relatively high quality habitat in the Southern Sierra, high annual mortality rates raise concerns about the long-term viability of this population. This is particularly true in light of increased risk of catastrophic fire due to nearly a century of fire suppression. Long-term management of fisher habitat in California should aim to retain and recruit large structural elements necessary for resting and denning while maintaining stands with high canopy closure. The restoration of historic disturbance regimes will ultimately benefit fishers through the maintenance of mature forest structure and decrease in stand-replacing fires. Recolonization of the central and northern Sierra Nevada may be the only way to prevent fisher extinction in the isolated southern Sierra Nevada population.

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INTRODUCTION

The fisher (*Martes pennanti*) is a medium-sized carnivore historically distributed in the western United States throughout forests of the northern Rocky Mountain and Pacific states (Gibilisco 1994). During the twentieth century a combination of anthropogenic factors including timber harvest, road building, trapping, and human recreation has resulted in a dramatic decrease in fisher distribution in the western United States (Powell and Zielinski 1994). This range contraction has spurred concern for the long-term viability of fishers in the west and resulted in 2 petitions to list the fisher as threatened under the Endangered Species Act (Central Sierra Audubon Society 1991, Carlton 1995). Both petitions were denied due to lack of empirical data needed to demonstrate the threat of fisher extinction throughout a portion of its range (US Department of Interior Fish and Wildlife Service 1991, 1996). Despite the denial of these petitions, the fisher remains an important management species due to its apparent association with large tracts of mature forest (Rosenberg and Raphael 1986). The fisher is considered a 'Species of Special Concern' by the California Department of Fish and Game (CDFG) and a 'Sensitive

Species' by Region 5 of the US Department of Agriculture Forest Service (USFS)(MacFarlane 1994).

In California the Pacific fisher (*M. p. Pacifica*, the subspecies native to the Pacific States) currently occurs in 2 populations isolated by over 400 km, one occupying the Klamath and North Coast regions of northwestern California and one occupying the Sierra Nevada south of and including Yosemite National Park (Zielinski et al. 1995). These 2 populations occupy less than half of the species' historical distribution in California as described by Grinnell et al. (1937) and appear to be the only extant fisher populations native to the western US. Remaining populations appear to be the result of successful reintroductions of fisher from the eastern US and Canada (Jones 1991, Roy 1991, Heinemeyer 1993, K.B. Aubry, USDA Forest Service, personal communication).

During the 1990's several studies were undertaken to gather data necessary to better understand fisher ecology in California and promote the long-term conservation of fishers in California. Among these, 3 studies conducted using similar methods provided the opportunity to examine differences in fisher ecology across 3 regions of California. The location and duration of these studies were as follows:

1) Eastern Klamath Mountains, Shasta-Trinity National Forest, July 1992 to present.
2) Northern California Coast Ranges, Six Rivers National Forest, May 1993 to September 1997.
3) Southern Sierra Nevada, Sequoia National Forest, April 1994 to present.

Throughout a species' geographic range varying biotic and abiotic conditions can be expected to influence population growth and regulation. Such factors often lead to non-uniform patterns of abundance within a species' range (Rabinowitz et al. 1986, Wiens 1989, Smallwood and Schonewald 1996). In California the fisher currently occupies a relatively small portion of its geographic range. However, the species still occurs in the western and southern fringe of its historic distribution in the US, occupying areas where environmental and physical conditions change rapidly over both latitudnal and elevational gradients. These conditions are quite different from the core of its range in the forests of Canada and the northern United States, where topographic variation is often slight and forests are relatively homogenous over large regions. Certain aspects of fisher ecology in California can thus be expected to differ from fishers elsewhere. Identifying how fisher ecology may differ in California relative to the core of its range, as well as identifying how the expression of such differences may vary between populations in California, represents a crucial step toward long-term conservation of the Pacific fisher.

Recent efforts to develop a consistent approach to classifying ecosystems have resulted in an hierarchical approach to identifying regions sharing similar conditions regulating ecosystem structure and function. Ecological units described under this framework range in size from millions of square kilometers to <10 ha and, from largest to smallest, include: (1) domain, (2) division, (3) province, (4) section, (5) subsection, (6) landtype association, (7) landtype, and (8) landtype phase (McNabb and Avers 1994). Classification and description of ecological units has occurred in California to the subsection scale (Miles and Goudey 1997). Other approaches to classifying geographic regions of California into relatively homogenous units, such as floristic provinces (e.g., Hickman 1993), physiographic regions (e.g., Mason 1970), and bioregions (e.g., Welsh 1994), have largely recognized similar units, though exact boundaries have varied.

The 3 studies examined here occurred in same ecological domain (Humid Temperate), division (Mediterranean), and province (Sierran-Steppe-Mixed Forest-Coniferous Forest). However, they were all located in different ecological sections: the Klamath mountains (Eastern Klamath study), the Northern California Coast Ranges (North Coast study), and the Sierra Nevada section (Southern Sierra study). The majority of the fisher's historical distribution in California (Grinnell et al. 1937) occurred in these 3 ecological sections, with smaller portions found in the Northern California Coastal Section (the coast redwood [*Sequoia sempervirens*] belt) and the Southern Cascades sections (Figure 1).

STUDY AREAS

VEGETATION AND CLIMATE

When compared to the fisher's entire geographic range, the 3 study areas examined here shared grossly similar climate and vegetation characteristics. Weather patterns across the 3 study areas are typical of California's Mediterranean climate: summers are hot and dry while winters are cool and moist, with precipitation often falling as snow in the higher elevations (Table 1). Natural vegetation communities found on all 3 study areas included montane hardwood forests, mixed conifer forests, true fir forests, and chaparral communities in the lower and drier portions of each study area (Mayer and Laudenslayer 1988). Douglas-fir (*Pseudotsuga menziesii*) forests made up an important mountains (Eastern Klamath study), the Northern California Coast Ranges (North Coast study), and the Sierra Nevada section (Southern Sierra study). The majority of the fisher's historical distribution in California (Grinnell et al. 1937) occurred in these 3 ecological sections, with smaller portions found in the Northern California Coastal Section (the coast redwood [*Sequoia sempervirens*] belt) and the Southern Cascades sections (Figure 1).

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Despite these gross similarities, proximity to the Pacific Ocean and latitude (Figure 2) have resulted in important differences among the areas. The North Coast study area was located within 60 km of the Pacific Ocean and generally received more precipitation than either the Eastern Klamath or Southern Sierra study areas. Habitats tended to become more xeric with increased distance from the Pacific Ocean, resulting in a more diverse array of habitats available to fishers in the eastern section of the North Coast and throughout the Eastern Klamath study areas. The combination of its southerly location and lower precipitation resulted in a naturally heterogenous landscape on the Southern Sierra study area.

EASTERN KLAMATH STUDY AREA

The Eastern Klamath study area included approximately 500 km^2 of the Shasta-Trinity National Forest in Shasta and Trinity counties northeast of Weaverville. It included the region surrounding Clair Engle (Trinity) Lake with the exception of the area to the southeast. State Highway 3 bisected the study area, running northeast from Weaverville along the western edge of Clair Engle Lake. Elevations ranged from 600 m to 1500 m, with most research occurring at elevations below 1300 m due to poor accessibility to the higher terrain. The study occurred entirely within the Trinity River watershed and included portions of the North Fork, East Fork, and Stuart Fork. Terrain was typified by deeply cut drainages and steep slopes.

Extensive resource extraction has occurred in this portion of the Trinity River basin during the last 50 to 100 years (USDI 1990). Timber harvest has occurred throughout the study area. Land ownership patterns resulted in a patchwork of privately and publicly owned lands similar to that found in the central and northern Sierra Nevada. Although numerous timber harvest techniques have been used in the area, the prevalent use of clear cutting has lead to a landscape mosaic composed of numerous even-aged, regenerating stands along with mature forest remnants which were often concentrated along stream courses. In addition to timber harvest, extensive mining occurred during the late nineteenth and early twentieth centuries. This history of resource extraction has lead to a high density of paved and unimproved roads throughout the study area.

NORTH COAST STUDY AREA

The North Coast study was conducted in southeastern Humboldt and southwestern Trinity Counties on approximately 400 km^2 of the Six Rivers National Forest (SRNF), and included 2 spatially disjunct subareas near the town of Mad River, separated by approximately 35 km (Figure 2). California Highway 36 occurred between the 2 subareas, though it did not fall within either. Elevations ranged from 600 m in the Grouse Creek watershed to 1800 m at the summit of Blake Mountain. The 2 subareas drained primarily into the Mad River (Pilot Creek in the north, the headwaters of the Mad River in the south), with smaller portions occurring in the South Fork Trinity River (Grouse Creek in the north, and the area around Cedar Gap in the south), and Eel River watersheds (northern portion of the Yolla-Holly Middle Eel Wilderness Area in the southernmost portion of the study area). Similar to the Eastern Klamath study areas, terrain throughout the region was generally steep with deeply dissected drainages.

Land management practices have differed between the Pilot Creek and Cedar Gap portions of the study area. Timber management has occurred in both subareas, but has been more

extensive in the Cedar Gap area and the lower portions of the Pilot Creek watershed. The upper third of the Pilot Creek watershed included large blocks of unroaded, virgin Douglas-fir forest. Since the conclusion of research, experimental commercial thinning of portions of the headwaters has since occurred as part of the Northwest Forest Plan. Clearcutting has been the primary means of timber harvest in the Cedar Gap subarea and, in conjunction with associated road building, has resulted in a landscape with more fragmentation than the Pilot Creek subarea.

SOUTHERN SIERRA STUDY AREA

The Southern Sierra study occurred on 280 km^2 of the Sequoia National Forest (SQNF) in Tulare County. Although most of the study area fell within the jurisdiction of SQNF, approximately 20V of the study area occurred on Mountain Home Demonstration State Forest (California Department of Forestry and Fire Protection [CDF]), the Tule River Indian Reservation (US Bureau of Indian Affairs), and several private inholdings. The area included most of the Middle Fork Tule River drainage as well as some of the South Fork Tule River and Kern River watersheds. Elevations ranged from approximately 800 m in the west-slope foothills to over 3000

m at the crest of the Sierra Nevada. Research was concentrated in the middle elevations, from approximately 1300 to 2300 m. Five small communities occurred within the study area, all accessed from the Central Valley by California Highway 190. The largest of these communities was Camp Nelson, which included nearly 500 homes located at approximately 1500 m in the Middle Fork Tule basin. Terrain in the region was also typically steep, though less so than in the younger mountain systems of northwestern California.

Land management practices on the Southern Sierra study area have been quite different from the two northern California studies. Whereas clearcutting has been an important timber management practice on the Eastern Klamath and North Coast study areas, individual-tree-selection harvest has been the dominant silvicultural technique within the Southern Sierra study area. Clearcutting has been common on the Sierra Plateau to the east and north of the Middle Fork Tule basin and in other portions of SQNF, but has been minimal where most research occurred. The landscape is therefore relatively unfragmented, though moisture and temperature gradients have resulted in a high degree of natural heterogeneity. Although several paved and unimproved dirt roads traversed the study area, large blocks of roadless habitat were common.

OBJECTIVES

This meta-analysis (sensu Burnham et al. 1996) was conducted to explore the extent of regional variation in fisher ecology. that may affect management of fisher populations and their habitats across California. Using a combination of quantitative and qualitative data we compared morphology, demography, and habitat characteristics among study areas.

Morphological comparisons included body mass and length. Examination of demographic profiles included comparisons of sex and age ratios, survival rates and mortality sources, and an index of reproductive success. Habitat comparisons included the following: vegetation types occurring in each study area, rest structures used, floristic and environmental features in the vicinity of rest structures, and the home range sizes of males and females in each study area. Not all of the studies had completed collection and analysis of randomly sampled habitat availability data (from either ground-based plots or from a Geographic Information System [GIS]). Accordingly, our habitat analysis was constrained by the absence of availability dirt roads traversed the study area, large blocks of roadless habitat were common.

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A complete review of habitat use would include a description of habitat used while animals are resting and while they are active, however the analysis of fisher habitat reported here is limited to resting habitat only. Two potential sources of information on the habitat choices of active animals include the location of radio-collared animals whose signals indicate they are active and the visits by animals to track-plate stations. None of the studies has more than a few occasions where active and undisturbed animals were located with any degree spatial accuracy and temporal independence. Additionally, comparisons of track plate data among studies were not possible due to fundamentally different sampling methods. Thus, we exclude discussions of habitat associations of active or foraging animals from this report.

METHODS

Although all 3 studies shared the overall goal of expanding our knowledge of fisher ecology, the methods used at each study area were not identical. The objectives and information to contrast with habitat characteristics that were used; we were not able to directly assess habitat preference.

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METHODS

Although all 3 studies shared the overall goal of expanding our knowledge of fisher ecology, the methods used at each study area were not identical. The objectives and methods used in the North Coast and the Southern Sierra studies were most similar because both studies were initiated by the same investigator (W. Zielinski). Identical protocols for data collection were used at the outset to compare fisher ecology between the 2 regions. As a result, the methods and site-specific analyses differ most between either of these studies and the study in the Eastern Klamath region, which was initiated earlier and by a different investigator (R. Golightly). Although the North Coast and Southern Sierra studies have used identical methods, the North Coast study has collected considerably less data during the winter than has the Southern Sierra study due to difficult winter access in the Pilot Creek portion of the study area. In the following sections, field methods described have been used by all 3 studies except where noted.

TRAPPING METHODS

Trapping occurred throughout the year except on the North Coast study area where road closures limited winter access. Trapping was conducted at the onset of each study to radiocollar an initial cohort of animals; additional trapping was conducted as necessary to replace nonfunctional collars. Trapping was generally avoided during March and April to minimize stress on females during the reproductive season. However, trapping on the Southern Sierra and North Coast studies was periodically undertaken to examine females for evidence of lactation from late May through July.

Traps were typically set near roads in habitat considered to maximize the probability of capture. All 3 studies used Tomahawk live traps (Tomahawk Live Trap Co., Tomahawk, WI, model #207), modified by attaching a plywood nest box to the back of the trap (adapted from Wilbert 1992, see Seglund 1995 for details). Traps were almost always baited with chicken, and commercial trapping lure was usually placed on a nearby tree. Traps were checked daily and closed during inclement weather.

When an animal was captured, it was coaxed out of the nest box, through a canvas handling bag, and into a metal restraining cone. Animals were immobilized with a mixture of Ketamine hydrochloride and Diazepam (10 mL Ketamine / 5 mL Diazepam) and typically received between 0.15 and 0.20 mL / kg body mass. Additional drug was administered as necessary to radiocollar, ear tag, and weigh and measure each animal.

A variety of morphometric data were collected during Bach processing, although the same group of measurements was iot recorded at each study area (Appendix 1). In addition to standard measurements such as body mass and total length, field technicians estimated each animal's age class (juvenile, young adult, adult) based on its dentition, sagittal crest development, and overall body condition. Upon completion of processing, each animal was returned to the nest box and given ample time to recover from immobilization, at which point it was released.

TELSMETRY METHODS

Ground-based 'walk in' surveys were conducted to locate radio-collared animals at rest and den sites. Rest sites referred to sites used by fishers between foraging bouts and other periods of activity; rest sites were typically occupied for <24 hours. Numerous rest sites were used by individuals throughout the year, though reuse of rest sites by individual fishers was occasionally observed. We distinguished 2 types of den sites: natal dens and maternal dens. Natal dens were defined as the site were parturition was assumed to have occurred and were identified by a distinct behavioral change by breeding females during the early spring. This change was signaled by a shift from occupying numerous rest sites per week to occupying a single rest site repeatedly for at least 3 consecutive weeks (the natal den). Maternal dens were defined as any rest site where females were observed with one or more kit(s) during the period following natal den occupancy and prior to juvenile dispersal.

Field technicians used hand-held antennas to home on an individual's signal. These direct approaches frequently resulted in identifying the exact resting or denning structure being used by the animal. Efforts were made to visually confirm the presence of adults (and / or kits) and exact resting location within each structure. Rest sites often occurred in tree cavities or high in dense canopies, thus limiting the observer's ability to visually confirm the animal's presence and exact resting location. All 3 studies conducted walk-in surveys only after an animal had been inactive for a minimum time (generally at least 1 hour). The majority of rest sites were thus assumed to have been selected by the animal, not as a result of pursuit by field technicians.

Triangulation was used to estimate the general location of a target animal prior to a walk-in, but only on special occasions was triangulation used to estimate the location of inactive or active animals. No triangulation-derived data were included in this analysis. Fixed-wing aircraft were used to relocate animals (especially wide-ranging males) throughout the year by the North Coast and Southern Sierra studies, and aircraft were used by all 3 studies to locate animals that had moved outside the study area.

REST SITE HABITAT SAMPLING

Although the exact rest site habitat variables measured and methods used to describe rest site structures and surrounding habitat characteristics varied somewhat between the Eastern Klamath and the North Coast and Southern Sierra studies, several variables assumed to be important to fishers were measured by all 3 studies (details presented in Appendix 1). Rest sites were either categorized into structure categories defined *apriori* or described by field technicians and later categorized. Rest site size and species were also recorded.

Variable radius sampling (20 factor American scale prism) was used to estimate basal area (BA) of live trees and snags (Grosenbaugh 1952). However, only the Southern Sierra and North Coast studies recorded the tree species, diameter at breast height (DBH, 1.37 m), height, and condition class (Maser et al. 1979) of each tree 'in' the prism sweep. In contrast, the Eastern Klamath study measured the DBH for the 4 largest diameter trees within a 0.04-ha circular plot centered on the rest site. In situations when rest sites were located in trees, the rest site tree was included in calculating this parameter if it was among the 4 largest. Concave spherical densiometers were used by all 3 studies to measure canopy closure at rest sites (Lemmon 1957).

Methods used to sample coarse woody debris (CWD) differed slightly between studies as well. Each study used 0.04-ha plots to describe CWD, however the Klamath study used direct counts to census logs on the plot whereas the Southern Sierra and North Coast studies recorded only the CWD that intercepted 2 perpendicular transects. Line intercept methods were also used to sample additional ground cover attributes (e.g., litter cover and rock cover) and percent cover of small trees and shrubs (Canfield 1941); no comparable data were collected by the Klamath study.

The habitat type in the immediate vicinity of the rest site was classified using the California Wildlife Habitat Relations (CWHR) system (Mayer and Laudenslayer 1988). Field technicians at all 3 study areas classified the area surrounding the rest site into CHWR cover types. However, CWHR tree size class and canopy closure class were estimated only on the Southern Sierra and North Coast studies. A summary of the variables considered appropriate for study area comparisons is presented in Appendix 2. Information about additional data collected by each study can be obtained from the appropriate principal investigator.

HABITAT AVAILABILITY

At the time data were summarized, plot-level (microsite) habitat availability data had only been collected at two of the 3 study areas (Klamath and Southern Sierra). Thus, we were unable to compare the availability of microsite habitat features across study areas. However, existing GIS data layers were available to compare the distribution of vegetation types across the 3 study areas by calculating the proportion of CWHR habitat types, size classes, and canopy classes found within each study area using ARC/INFO (version 7.1) GIS software.

Two different data sources were used to calculate the availability of CWHR vegetation classes. The North Coast and Klamath study areas both occur within the boundaries of the Timberland Task Force (TTF) study, which created a seamless vegetation coverage for much of northwestern California using unsupervised classification of 30 m pixel resolution LANDSAT Thematic Mapper satellite imagery (California Timberland Task

Force 1993). Ground referencing of the TTF-classified data resulted in 60-80% classification accuracy.

Existing GIS vegetation data for the Southern Sierra study is also based on unsupervised classification of LANDSAT TM data, though the data were classified into CALVEG cover types and later crosswalked to the CWHR habitat classification system. Unlike the TTF data for northwestern California, the classified data for the Southern Sierra study has never been ground referenced. During 1994 field personnel on the Southern Sierra-study conducted a small ground referencing exercise which highlighted potential problems with the existing GIS vegetation coverage; less than 60°s of ground referenced plots were classified to the same CWHR habitat type by both field personnel and the unsupervised classification of LANDSAT data (R. Barrett, unpublished data).

DATA ANALYSIS

Before data could be compared among studies, it was necessary to assess and inventory the type and quality of data collected at each study area. This assessment allowed determination of variables that could be compared quantitatively and those that could only be compared

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DATA ANALYSIS

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Descriptive statistics and frequency distributions were calculated for all relevant variables for each study area. Generating frequency distributions required creating similar categories for all 3 studies to allow comparison among study areas. Direct, quantitative comparisons were conducted for certain variables while others were compared only qualitatively by either ranking means or visually comparing frequency distributions.

CAPTURE RATES

Capture rates were divided into initial capture rate and overall capture rate. The initial capture rate was calculated using data from the first trapping phase of a study or when the trapping expanded to a new area (e.g., the Cedar Gap subarea of the North Coast study area). In these cases, there was usually no prior knowledge of resident fisher home ranges and specific individuals were not targeted. The overall capture rates were calculated using all trap-nights for each study area, including trap-nights when individual fishers were targeted for recapture (usually to replace radiocollars). The initial capture rate was calculated as the number of individual fishers captured divided by the number of trap-nights, excluding recaptures. The overall capture was calculated in the same fashion, but rate recaptures were included.

MORPHOLOGY

Body mass (kg) and total length (cm) were compared among the 3 study areas. One way analysis of variance (ANOVA) was conducted for males and females for both variables (4 separate analyses). Analyses were limited to adult animals; juveniles were excluded because they were captured irregularly throughout the year and accordingly during different stages of development. All measurements were recorded during the first handling of each adult animal, regardless of capture date. Although capture date may influence body mass, captures occurred at irregular intervals and animals were seldom recaptured frequently enough to examine seasonal variation.

DEMOGRAPHY

Survivorship and Mortality

Small samples of annually radiocollared individuals for each study limited our ability to calculate survival with high precision. We chose to use 2 methods of survival estimation to examine trends among study areas. The first involved developing an index to standardize survival by comparing the fate of individuals to the total time all individuals were monitored ('effort' method). The second involved calculating the proportion of radiocollared individuals living from one year to another ('annual' method). Although these annual periods were defined based on the date each study began trapping, the data reflected survival from one breeding season to the next. Additionally, data were available and samples size were sufficient, though minimally so, to calculate Kaplan-Meier survival estimates based on the method described by Pollock et al. (1989) for the Southern Sierra study.

Calculating effort-based survival estimates required first determining the fate of each radiocollared individual and the amount of time it was monitored. Three fates were possible: 1) the animal lived throughout its monitoring period; 2) the animal died during the monitoring period, determined by the recovery of part of all of a carcass or strong evidence of mortality (e.g., a radiocollar found with puncture holes); and 3) the fate of the animal was unknown. Unknown fates occurred when an animal's radiocollar stopped functioning prior to being recollared and the animal was not recaptured, and when an animal slipped a collar and was not recaptured.

Once fates and temporal extent of monitoring were determined, the percent mortality and survival were compared against total time monitored to create a relative survival index to compare across study areas. Based on this method, lower index values indicate greater mortality per fisher-year monitored. Effort-based survival estimates have been pooled across sexes. Despite small sample sizes from year to year, annual survival was calculated for males and females. Kaplan-Meier survival estimates were calculated with 95% confidence intervals for males and females annually for the Southern Sierra and North Coast studies.

Causes of mortality were described in detail for each carcass recovered, as were the circumstances surrounding the recovery of only a radio collar when mortality was suspected. For the Southern Sierra and North Coast study areas, fresh carcasses were sent to the CDFG's Wildlife Investigation Laboratory (WIL) for necropsy whenever possible. The WIL conducted soft tissue necropsy and examined the animal's external condition. A lower premolar was removed by the WIL from each carcass and age was determined by Matson's Laboratory (Milltown, MT) using cementum annuli techniques (Strickland et al. 1981). Carcasses recovered by the Klamath study were generally frozen until a necropsy was conducted by faculty of Humboldt State University's Wildlife Department. Teeth from these animals were not removed for cementum annuli analysis.

Reproduction

Efforts to index female reproductive success varied among the 3 study areas. The North Coast and Southern Sierra studies generally conducted trapping to maximize the chance of capturing lactating females from mid-May through July; this typically coincided with trapping necessary to replace radio collars, though efforts were occasionally made solely to observe lactation status of radiocollared females. These data were used to annually estimate the proportion of lactating females in the population. Although the Klamath study periodically trapped animals when females were lactating, this was not a focus of the research and no similar index of reproductive success was calculated.

In addition to focusing on reproductive condition of females during the late spring and summer, the Southern Sierra study spent considerable effort locating females at natal dens (the site where parturition is assumed to have occurred) and subsequently occupied maternal dens (sites occupied by a female and her offspring during the postnatal. period). Neither the North Coast nor the Klamath studies emphasized locating natal dens due to difficult winter access at the former and different research objectives at the latter. Nevertheless, some maternal dens were located by each study during the summer prior to juvenile dispersal.

HABITAT ECOLOGY AND HOME RANGE

Direct, quantitative comparisons of habitat variables important to fishers at each study area were limited because data describing the type and amount of habitat available to fishers were not yet available for all 3 areas. The present analysis is based on comparing only the habitat elements that were used by fishers at each study area; we do not address habitat preference explicitly in this paper.

Rest Site Structure and Habitat

We categorized rest site structures into 5 functional groups we assumed were perceived differently by fishers selecting rest sites. These groups included live trees, snags and stumps, logs (including individual logs and log piles), platforms, and rock piles. Platforms included live trees or snags that had mistletoe (*Arceuthobium* spp., *Phoradendron* spp.) brooms, large nests, or some other type of platform where a fisher was found resting. The 'rock pile' category included rest sites in rock piles or large boulders as well a minority of rest sites located in other ground cavities and subnivean sites. Structures were also aggregated into standing trees (live trees, snags, stumps, and platforms) and ground structures (logs, subnivean sites, rock piles, and other ground cavities).

Tree and log species used as rest sites were categorized into groups representing different floristic and physiognomic characteristics. Tree species were grouped into true firs (*Abies* spp.), pines (*Pinus* spp.), Douglas-fir, other conifers (giant sequoia [*Sequoiadendron giganteum*] and incense cedar [*Calocedrus decurrens*]), and hardwoods (*Quercus* spp., tan oak [*Lithocarpus densiflora*], and madrone [*Arbutus menziesii*]). Although no Douglas-fir occur on the Southern Sierra study area, this was the predominant tree species used by fishers on the Klamath and North Coast study areas and was included as a separate category. Rest site tree species were also categorized as conifer or hardwood, to represent a coarser scale of functional form.

The measured. DBH of standing trees and the estimated maximum diameter of logs used as rest sites by fishers were examined and compared qualitatively. Several habitat variables measured in the vicinity of the rest structure were also compared among study areas. These included total basal area (m^2 / ha), DBH of the 4 largest trees (cm), percent canopy closure, and CWHR cover types.

Home Range

Before calculating home range estimates, we examined the relationship between home range size and time monitored to determine a minimum threshold of monitoring effort necessary to accurately estimate home range size using 100% Minimum Convex Polygon (MCP [Mohr 1947]) and 95% Adaptive Kernel (AK [Worton 1989]) methods. Individuals meeting minimum effort criteria were included in home range analysis.

RESULTS AND DISCUSSION

CAPTURE RATES

The Southern Sierra and North Coast studies each captured more than 30 individuals (33 and 31, respectively) and the Eastern Klamath study captured 22 individuals. In addition to capturing the most individuals, the Southern Sierra. study also had the highest initial and overall capture rates (Figure 3). This was apparently due to the initially high capture rate for females and the apparently 'trap-happy' behavior demonstrated by females throughout the study; several females were captured more than 6 times, one of whom was captured a total of 13 times. Initial and overall capture rates for the Klamath and North Coast studies were quite similar, but the North Coast had a slightly higher overall capture rate. Similar numbers of individuals were radiocollared by each study: 23 at Southern Sierra (8M, 15F), 22 at Klamath (9M, 13F), and 22 at North Coast (8M, 14F).

MORPHOLOGY

Morphological comparisons among study areas demonstrated significant differences in both body mass and total body length, though trends were not the same for males and females. Although ranking the means indicated that male and female fishers in the two northern California studies were larger in both body mass and total length than those in the southern Sierra Nevada (Figure 4), ANOVA results indicated females on the Klamath study area were significantly larger than those on either the North Coast or Southern Sierra study areas for both body mass and total length (Table 2). A somewhat different trend was evident for males: although ranking of means was the same, body mass was significantly less for males on the Southern Sierra study while no difference among study areas was observed for total length (Table 2). Although the results for body mass were somewhat confounded by our inability to control for seasonal variation, the magnitude of differences is relatively large and likely represented real differences among the sampled population segments.

DEMOGRAPHY

Sex and age ratios

The Southern Sierra and North Coast studies each captured more than 30 individuals (11 males, 22 females and 13 M, 18 F, respectively), while the Eastern Klamath study captured only 22 individuals (9 M, 13F). More females than males were captured at each study area, though males comprised a larger proportion of the captured sample in the 2 northern California studies relative to the Southern Sierra study (Figure 5).

Age ratios differed considerably among the 3 study areas. The Eastern Klamath study captured the same number of juveniles as the Southern Sierra study (4 M, 4 F) and accordingly had a relatively higher overall proportion of juveniles captured (Figure 5). The North Coast study captured far fewer juveniles (2 M, 0 F). The smaller proportion of juveniles trapped during the North Coast study likely reflects limited trapping conducted during late fall and winter when dispersing individuals may have a higher probability of capture.

Survivorship and Mortality

Using the effort-based method, and including only animals with known fates, the North Coast study had the lowest relative survival index (SI) with only 50% of individuals surviving over 8.3 animal-monitoring years (SI = 4.25). The Southern Sierra study had an intermediate survival index; 35% of individuals survived over 19.3 animal-monitoring years (SI = 6.8) while the Klamath study shows the highest relative survival rate (58% of individuals survived over 15.7 animal-monitoring years, SI = 9.2). When the index was calculated including animals with unknown fates, slightly different trends were evident. The SI was adjusted by calculating the cummulative monitoring effort from the time of initial capture to loss of radio contact and considering the animal alive when calculating the SI (despite not knowing the ultimate fate of the animal). Under these circumstances, the survival index was highest for the North Coast study (SI = 17.0), intermediate for the Eastern Klamath study (SI = 14.6), and lowest for the Southern Sierra study (SI = 13.4). These differences were due to loss of radio contact with several individuals on the North Coast Study, including one male who was monitored for more than 2 years but whose ultimate fate was unknown.

When annual survival estimates were pooled across years for each study, somewhat different qualitative results were evident. Using this method overall survival was lowest for the Southern Sierra and highest for the North Coast study. Annual survival rates for females on the Southern Sierra study were quite low, (61.2%) while Eastern Klamath had an intermediate (72.9%) and the North Coast study the highest survival rate (83.8%). Male survival rates were consistently higher than female survival rates across the study areas

(73.3%, 85.5%, and 83.8% for the Southern Sierra, Eastern Klamath, and North Coast studies, respectively).

Although Kaplan-Meier survival estimates were calculated only for the Southern Sierra study area, the results were similar to those derived using the annual survival method. Survival estimates were lower for females than for males in the Southern Sierra; annual survival rate was 0.57 for 1994-1995 and 0.60 for 1995-1996 for females and 0.86 and 0.71 for males during the same periods. Due to small sample sizes, 95% confidence intervals for these estimates are quite large (females: 0.2504-0.8924 for 1994-1995, 0.2439-0.9560 for 1995-1996; males: 0.4494-1.0 and 0.3796-1.0). For both years, survival estimates using our annual method fall within the confidence limits for males and females.

The differences in annual survivorship between study areas warranted closer examination of mortality sources. Unfortunately mortality sources have generally been unclear and many deaths were not attributable to a single cause. Several factors influenced the ability to successfully determine the exact source of an animal's death. First was the efficiency of nature; during certain times of year carcasses were scavenged quickly and minimal portions of the carcass were recovered. Second, successful necropsy required prompt collection of the carcass to minimize scavenging and to assure the integrity of soft tissues. Lastly, even if complete carcasses were delivered to necropsy facilities promptly, there was no guarantee a necropsy would be diagnostic.

A total of 7, 11, and 6 mortalities occurred during the period of study on the Eastern Klamath, Southern Sierra, and North Coast study areas, respectively (Table 3).

Mortality sources on the Klamath study included 2 road-kills (both males), 3 predations (1 male, 2 female), and 2 unknown causes (both female).

Several mortalities on the Southern Sierra study were due to unknown causes (1 male, 4 female); these carcass recoveries often included only small portions of the animal. Predation was assumed to have caused the death of 2 females and 2 males while severe head trauma (concluded to be unrelated to vehicle encounters) appeared to have caused the death of 1 male and 1 female. One 5-year-old female died due to a combination of starvation and exposure after becoming entrapped in an uncovered, empty water storage tank.

Mortality sources on the North Coast Study area were generally inconclusive due to either advanced states of decay or limited recovery of carcasses. Two females were suspected to have died at the hands of humans. Only their collars were found and neither female was subsequently recaptured. Both collars appeared to have been cut with knives, and one was covered with blood. Two mortalities were suspected to be due to predation, though necropsies were unable to determine the source of predation.

Reproduction

The Southern Sierra and North Coast studies had considerable success capturing females during the late spring and summer. In the Southern Sierra study 50-60% of the females captured have been lactating during each of the three reproductive seasons (6 of 12 during 1994, 6 of 10 in 1995, and 3 of 6 in 1996). Sample sizes were small for the North Coast study from 1992 to 1994 (maximum of 2 females captured during any year). More females were captured during 1995 and 1996, though the proportion of lactating females varied considerably between years. During the 1995 breeding season, 8 of 11 (73%) of females were lactating, while only 1 of 7 (14%) was found lactating during 1996. A total of 3 lactating females were captured over the course of the Klamath study.

Based on our definitions of natal and maternal dens (page 16), a total of 5 natal dens were located on the Southern Sierra study from 1995 to 1996 and none on the 2 northern California studies (Table 4). Although 2 sites were reused by females on the North Coast Study area during the late spring of 1995 and may have been natal dens, reuse was not observed with the temporal resolution necessary to be considered natal dens as we have defined them. Female fishers tend to use natal dens for extended periods during the spring; however, females have been found occupying rest sites away from natal dens during the spring and often reuse one or more maternal dens for several days following moving kits from the natal den (York 1996, Paragi et al. 1996, Arthur and Krohn 1991, R. Truex, pers. obs.).

All natal dens on the Southern Sierra study have been located in large trees, 3 in white firs (*Abies concolor*) and 2 in black oaks (Table 4). All natal dens were established during the last week of March or the first week in April and were occupied for 4 to 7 weeks. In addition to these natal dens, females with kits have been observed at several maternal dens on each study area. Most maternal dens have also occurred in large diameter trees, with kits usually observed peering from within a cavity. Although habitat characteristics vary considerably from site to site, natal and maternal dens occurred in forest habitats typically with dense overhead cover (Table 4).

HABITAT ECOLOGY AND HOME RANGE

Vegetation cover type comparison

Despite the differences in GIS vegetation layer quality between the 2 northern California studies and the Southern Sierra study, comparing the availability of habitat types between study areas highlights fundamental differences among regions. Water was considered unsuitable fisher habitat and eliminated from the analysis. Although riparian habitats may provide an important resource for fisher, none of the vegetation layers used in this analysis recognized riparian habitat as a distinct type due to its typically linear occurrence on the landscape and the coarse spatial resolution of LANDSAT imagery.

All 3 study areas were dominated by forested habitats, though the distribution of forest types varied considerably (Table 5). The differences in relative proportions of habitat types on each study area were due to two factors: (1) fundamental differences in botanical composition among the three regions and (2) the use of different classification methods during the development of GIS vegetation layers for the Southern Sierra study and the 2 northern California studies.

Important among these differences was the absence of Douglas-fir and Montane Hardwood Conifer (MHC) habitats on the Southern Sierra study area. While the former represents an important regional difference (Douglas-fir is absent from this portion of the Sierra Nevada), the latter is due to different remote sensing classification methods. Although MHC habitats were prevalent on the Southern Sierra study area, they have been split into three forest types during the classification of LANDSAT data: montane hardwood, mixed conifer, and pine types.

The general proportion of habitat types in the 2 northern California study areas was similar. However, the North Coast study area included a greater proportion of Douglas-fir and montane hardwood habitats whereas mixed conifer and montane hardwood Conifer habitats were more common on the Klamath study. The prevalence of Douglas-fir habitat on the North Coast study can be attributed to the large tracts of mature Douglas-fir habitat in the upper portion of the Pilot Creek watershed.

Perhaps the biggest difference among study areas is on the basis of tree size class. The largest size class reported ('4') comprised only about 14% of the Eastern Klamath study area, whereas 43% and 28% of the Southern Sierra and North Coast study areas, respectively (Table 5). Although the CWHR system recognizes size class '5' (average diameter >24"DBH) and 6 (multi-layered forest), we chose to lump size classes '5' and '6' with class '4' for comparison purposes. None of the GIS layers classified habitats into size class '6', and the Southern Sierra study did not classify habitats into size class '5'. Despite these methodological considerations, the data demonstrate the lack. of mature size classes ('4' and larger) and the prevalence of smaller size classes on the Eastern Klamath study area.

Home Range Estimation

Several caveats must be presented before results of home range analysis are described. First, home range estimates will be dependent on sampling effort, particularly for wide ranging carnivores such as the fisher. This effort can be measured in terms of the total time an animal was monitored and the total number of locations. Second, home range estimates will be influenced by the temporal distribution of locations; locations aggregated during certain times of year may provide misleading annual home range estimates, though such aggregated effort may be important in understanding, for example, movement patterns of females with kits. Third, comparable relocation methods should be used among study areas to minimize the impacts of varying accuracy of mapped animal locations. Although the Southern Sierra and North Coast study areas have relied on aerial relocations during winter months, these locations were not included in home range estimation due to their relatively poor accuracy when compared to ground relocations (W. Zielinski, unpublished data) and because aerial locations were not used regularly by the Eastern Klamath study.

Examining the relationship between home range estimates and the duration of time monitored revealed some similarity, but also some differences, among studies. Minimum Convex Polygon (MCP) estimates for females on the Southern Sierra study area increased quickly until approximately 10-14 months of monitoring, at which point home range estimates appeared to reach an asymptote (Figure 6a). Females from the 2 northern California study areas showed similar patterns to the Southern Sierra study, though some differences were observed. Estimates for two animals (one on the Klamath and one on the North Coast study areas) showed another period of home range growth after stabilizing for 6-10 months. This may represent excursions into previously unsampled portions of the home range, or may represent shifts in home range location over time. Adaptive Kernel estimates (95% contour) for females on the Southern Sierra study (Figure 6b) were inconsistent until about 24 months of monitoring effort.

Male MCP home range estimates for the Southern Sierra study appeared to stabilize in a similar fashion as females (Figure 6c). Males on the 2 northern California study areas showed similar trends with one notable exception: an adult male from the Eastern Klamath study was tracked for more than two years but never seemed to establish an upper bound on the MCP estimate. His home range appeared to grow linearly throughout the time he was monitored.

Despite some of the potential problems discussed above, we chose to compare MCP estimates among study areas for a subset of animals from each study area. Adaptive Kernel estimates were not compared due to the long monitoring times and numerous data points apparently needed to derive accurate estimates. Based on home range asymptote plots and the number of locations per animal, we compared home ranges only for animals monitored at least 9 months and located a minimum of 10 times. This limited the pool of individuals to 11 for Southern Sierra (4 male, 7 female), 11 for Klamath (6 male, 5 female), and 7 for North Coast (2 male, 5 female).

Variance estimates were not equal among study areas and home range data were not normally distributed. Accordingly, we used Kruskal-Wallis tests to compare means (Zar 1984). Comparison of means demonstrated a significant difference in female home range size (χ^2 = 11.827, *P* = 0.0027, df = 2). The rank of means indicated that female home ranges were considerably larger on the Klamath Study area than on the North Coast or Southern Sierra Study areas (Figure 7). Although the Kruskal-Wallis test failed to detect a difference in MCP estimates among study areas for males (χ^2 = 5.190, *P* = 0.0748, df = 2), the same trend demonstrated for females was evident: home ranges on the Klamath study area were considerably larger than those on the North Coast and Southern Sierra study areas. The lower statistical power of nonparametric tests in combination with the high variance estimates for the Klamath and North Coast studies and the small sample size for North Coast likely prevented detecting significant differences among study areas, despite the differences demonstrated by ranking means (Figure 7).

Rest Site Structure

Comparisons of rest site structure types and sizes highlighted important differences in habitat use among the 3 study areas. Recall, rest sites were categorized into one of 5 functional structure types: live trees, snags, platforms (including growths and nests in live trees and snags), logs and log piles, and rock piles (which included subnivean site and other ground cavities). Examining frequency distributions of rest site structure use, along with diameter and species for tree and log rest sites, revealed 5 important patterns:

1) Fishers were found resting more frequently in platforms on both northern California study areas than on the Southern Sierra study area (Figure 8). Between the 2 northern California studies, fishers on the Eastern Klamath study area were found in nests approximately 12% more often than on the North Coast study area. This 12% difference was compensated by a comparable increase in snag use on the North Coast study area.

2) Fishers on the Southern Sierra study used rock piles (and other ground cavities) more often than at either northern California study area. When structure types were aggregated into 2 classes, standing trees and ground

structures, the differences in structure use between the 2 northern studies disappeared (91.6% vs. 90.4% standing tree use for the Eastern Klamath and North Coast studies, respectively) while the Southern Sierra study still showed less use of standing trees (82.3%).

3) Although each study observed fishers using several tree species for resting, Douglas-fir was the most common species used on both northern California studies while several species were used extensively on the Southern Sierra study (Figure 9a). Importantly, over 40% of fisher rest sites located on the Southern Sierra study area were found in hardwoods (particularly California black oak [*Quercus kelloggii*]), nearly twice the use of hardwoods on either northern California study (Figure 9b).

4) Considerable use of small diameter trees was observed on the Eastern Klamath Study while the Southern Sierra study showed a much more even distribution of rest site diameters (Figure 10). The diameter distribution of rest site trees for the North Coast study was positively skewed due to the prevalent use of large diameter Douglas-fir, particularly in the Pilot Creek watershed. However, closer examination of frequency distributions and summary statistics for rest site tree species groups revealed that

the distributions are probably 2 compounded distributions, one representing hardwoods and one representing conifers (Table 6, Figure 10). For the Eastern Klamath study, rest site diameter distribution was further decomposed into a distribution of hardwoods encompassing broad range of diameters, a distribution of small-diameter trees including many of the platforms used (mean DBH = 49.7 cm, SD = 35.1, n = 71), and a distribution of large-diameter conifers.

5) The use of logs by resting fishers was slightly more prevalent at the Southern Sierra study area than at either northern California study areas. Despite considerably smaller sample sizes for logs than for trees, similar trends in species and size were evident. Douglas fir logs were used most commonly on the Eastern Klamath and North Coast studies (73.3 and 58.3%, respectively) while a variety of species was used at Southern Sierra, including nearly 20% hardwood logs. Again, the logs used by fishers on the Eastern Klamath tended to be considerably smaller than those used at North Coast and Southern Sierra areas (Figure 10).

Habitat in the Vicinity of Rest Structures

Methodological differences limited our ability to make comparisons of habitat and physical environment surrounding rest sites across study areas. However, the following vegetation parameters were compared qualitatively: basal area, canopy closure, average of the 4 largest trees surrounding the rest site, and CWHR habitat type.

The trends in rest site structure characteristics observed among study areas were evident for some of the habitat variables recorded in the vicinity of the rest structures as well. Although all 3 study areas reported dense canopies surrounding rest sites, canopies were slightly more dense at the North Coast and Southern Sierra study areas (93.9% and 92.5%, respectively) than at the Eastern Klamath study area (88.2%). While the same pattern of directionality was observed for basal area and the diameter of the 4 largest trees surrounding the rest site as for canopy closure, the magnitude of the differences was somewhat greater (Table 7). Average basal area for the North Coast sites was 75.6 m^2/ ha, while sites on the Southern Sierra averaged 62.6 m^2/ ha and 59.8 m^2 / ha on the Eastern Klamath.

The average DHH of the 4 largest trees surrounding the rest site structure was dramatically different between Klamath and the remaining studies, averaging only 46.2 cm. The mean of the four largest trees closest to the rest site was nearly twice as large for Southern Sierra (89.6 cm) and even larger for North Coast (118.3 cm). These differences may be due in part to differences in field methods. The Eastern Klamath study identified the four largest trees from within a fixed radius whereas both Southern Sierra and North Coast studies sampled vegetation using a variable radius plot. It was possible for trees to be >12 m from the rest site and be tallied and measured during the prism sweep, thus resulting in a potential bias toward higher estimates for on the Southern Sierra and North Coast study areas. Despite the potential bias, we believe the magnitude of difference, in conjunction with the prevalent use of small diameter trees on the Eastern Klamath study, likely reflect real differences in habitat characteristics surrounding rest sites among study areas.

CWHR cover type was classified at each rest site and these data were aggregated into 5 classes: true fir (RFR, WFR), Montane Hardwood Conifer (MHC), Montane Hardwood (MHW), Mixed Conifer (SMC, KMC), Douglas-Fir (DFR), and pine (PPN, JPN). At the Southern Sierra study area, rest sites occurred mainly in Mixed Conifer and Montane Hardwood Conifer habitats (83.6% of all rest sites, Figure 11). At the North Coast study area, the majority of rest sites were located in Douglas-fir and Mixed Conifer habitat (76.2% total). Two habitat types accounted for nearly 90% of all rest sites found on the Eastern Klamath study area: Montane Hardwood Conifer was used most often (52.4%), followed by Douglas-fir (37.8%). As straightforward as assigning CWHR type appears, the results may be prone to inter and intra-observer error and results should accordingly be interpreted with caution.

CONCLUSIONS

INDICES OF RELATIVE HABITAT QUALITY ACROSS STUDY AREAS

A number of the comparisons above point to the same conclusions: 1) the habitat in the Eastern Klamath study area may be less suitable for fishers and 2) the population density there is lower than at either the North Coast or the Southern Sierra study areas. Of course, none of the studies have collected sufficient demographic information to associate population growth rates with habitat quality, but a number of independent indices of forest structure, habitat use, and demography suggest that the Eastern Klamath population occurs in poorer habitat and may be more characteristic of 'sink' habitat (Pulliam 1988) than either of the other study areas.

Consider first the relative proportion of each study area characterized by large-diameter stands. The GIS habitat types accounted for nearly 90% of all rest sites found on the Eastern Klamath study area: Montane Hardwood Conifer was used most often (52.4%), followed by Douglas-fir (37.8%). As straightforward as assigning CWHR type appears, the results may be prone to inter and intra-observer error and results should accordingly be interpreted with caution.

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Consider first the relative proportion of each study area characterized by large-diameter stands. The GIS interpreted CWHR data suggested that the Eastern Klamath study area had a much lower ratio of size class 4 to size class 3 habitat than the other areas (Table 5). Furthermore, ground data collected at rest sites indicated that the average DBH of rest trees, the mean diameter of the 4 largest trees, and the basal area were all the lowest on the Eastern Klamath area. Large trees provide rest sites, increase the structural complexity of a stand, and ultimately increase the number of large snags and logs. Each of these features has been associated with good fisher habitat (Buskirk and Powell 1994, Powell and Zielinski 1994).

Unfortunately, the potential misclassification of habitat type, size, and canopy class in existing GIS data layers and the differences in the method of collecting diameter information at rest sites provide reason to be cautious about the conclusion that large-diameter trees are least abundant on the Eastern Klamath. When the randomly-located vegetation plot data are available for each study area we will be in a much better position to assess the difference in the distribution of important habitat elements, including the availability of large-diameter trees and logs.

Additional support for the conclusion that habitat is poorer on the Eastern Klamath study area comes from contrasting the use by fishers of rest structures. Fishers in the Eastern Klamath rest more often in small-diameter trees and small-diameter logs than in the other two study areas (Figure 10). Moreover, they more frequently used platforms (Figure 8); structures that may substitute for tree cavities when the latter are uncommon but likely do not provide the same benefits, especially in regards to natal and maternal dens. If we assume that fisher rest choice involves the rule 'select the largest diameter trees and logs in a stand', then the rest site data suggest that the North Coast and Southern Sierra study areas provide a greater abundance of large structures than does the Eastern Klamath study area.

Habitat quality can also be inferred from home range size and population density. Individuals are expected to use larger areas in poorer quality habitat and therefore to exist at lower densities. Both of these indices support the relatively lower quality of habitat on the Eastern Klamath study area than the North Coast or Southern Sierra studies. Female home ranges were significantly larger on the Eastern Klamath than the other study areas and male ranges were larger, though only at the P=0.07 level.

Furthermore, the Eastern Klamath area had the lowest overall capture rate (number of individuals/number of trap nights) and had captured the fewest total number of animals, despite its longer duration and larger size. Although these circumstantial data are suggestive of poorer quality habitat on the Eastern Klamath area, it is also possible that the larger home ranges and lower abundance may be related to the larger body masses of males and females on the Klamath, especially when compared with the Southern Sierra study area. Empirical support for intraspecific allometry of body size and home range size is far poorer than for the interspecific relationship (Harestad and Bunnell 1979), but the possibility of its confounding the habitat quality - home range size relationship cannot be dismissed.

Finally, the proportion of juveniles captured by the Eastern Klamath study may be suggestive of a population segment occurring in lower quality habitat. Although age distribution skewed toward younger age classes may be indicative of a healthy, growing population, it may also be suggestive of sink habitat. These are largely speculations, but they direct attention to the fact that demographic profiles can interact with habitat characteristics to affect population viability.

Unfortunately, some of the most compelling data necessary to conclude that population growth rate is lower in the Eastern Klamath area are unavailable. Insufficient number of natal dens have been located to compare reproductive rates, and while the North Coast and Southern Sierra studies trapped females in the spring to assess reproductive condition, the Eastern Klamath study did not. However, the estimates of adult survival are comparable among the studies and these data do not suggest that mortality rates are any higher in the Klamath than the other studies, though small samples of radiocollared individuals make confound survival analysis somewhat. Surprisingly, the Southern Sierra study had the highest mortality of adult females, a characteristic that has been shown to be the most important single factor in PVA sensitivity analyses.

HIGH FEMALE MORTALITY RATES, ESPECIALLY IN THE MOST ISOLATED POPULATION

The higher female than male mortality rates, across all 3 study areas, raises concern. Especially noteworthy was the low annual survival rate (61.2%) of females in the Southern Sierra population; one that is already handicapped by being disjunct from the remainder of the California fisher population (Zielinski et al. 1995).

Although we have provided reasons earlier for our belief that the fisher population in the Eastern Klamath is occupying something less than optimal habitat, this population appears less vulnerable than the isolated population in the southern Sierra. The Eastern Klamath population segment is probably buffered from extinction in the near future by its close proximity the robust population in the North Coast, centered largely on the lower Trinity River area (Carroll 1997, Carroll and Zielinski, in prep.). Based on observed fisher dispersal in other parts of North America (York 1996, Arthur et al. 1993), it is highly unlikely that fisher would successfully disperse over 400 km from northwestern California to the southern Sierra; for all intents and purposes the southern Sierra population is a demographically closed population.

Unfortunately, the cause of most mortalities is unknown. However, it is clear that road mortality and predation are important causes of death. Vehicles killed more fishers in the Eastern Klamath study area than in the other areas combined, largely due to the presence of a number of state highways that dissect the Eastern Klamath study area. Humans were also directly involved in the mortality of 2 females from the North Coast population, but in this case we suspect the animals became the targets of hunters. All sources of fisher mortality in the Southern Sierra were considered 'natural' except an incident where a female entered an empty water tank and died. Both the indirect (vehicular) and the direct mortality by humans should be a consideration in the management of fishers. The increase in number of paved roads, and the increase in vehicle speeds, should be discouraged in areas where habitat is being managed for fishers. Wildlife underpasses should be considered an option in the development of new roads where fishers and other species could benefit. Finally, additional means should be instituted to warn hunters and trappers about the consequences of molesting or killing a fisher.

The relatively high mortality rates, especially of adult females, should be examined further. We recommend a modeling approach to simulate population growth in each study area that incorporates estimates of vital rates that have either come to light as a result of this meta-analysis (e.g. adult survival) or for which we can make reasonable guesses. Simplest among the options would be the creation of static age, or stage-based projection matrices (Caswell 1989). Such models require less data than spataially explicit models and can easily incorporate stochasticity (demographic, environmental, catastrophe) to simulate potential impacts on small populations. Only with additional modeling will we be able to predict the consequences to long-term viability of what appear to be relatively high mortality rates, especially in the most tenuous of the populations, the Southern Sierra.

REGION-SPECIFIC RECOMMMMATIONS

Our analyses have led to recommendations for the management of fishers and fisher habitat in each region. However, because each study is incomplete and final analyses specific for each region have yet to be concluded our recommendations should be viewed as preliminary.

Eastern Klamath study area

Fishers appear to exist in poorer quality habitat in this region than in the others. This conclusion is drawn not only from our analyses but by a comparison of the North Coast and eastern Klamath regions in the recent landscape analysis by Carroll and Zielinski (in prep.). Some of the difference may be climatic; inland forests receive less moisture and therefore have lower primary productivity than coastal forests (Sawyer and Thornberg 1977). However, it is clear from the history of timber harvest, and by aerial examination of the three study areas, that the eastern Klamath area has been subjected to more timber harvest -- and more by clearcutting -- than the other two areas. The recent institution of the Northwest Forest Plan and its protection of late-seral and riparian areas should help restore some of the habitat that has been degraded. However, more of the Late-Successional Reserves (LSRs) occur in the more humid northwestern portion of California than in the drier, inland forests.

North Coast study area

The North Coast study area benefits from being situated nearest to what appears to be the center of the highest-quality fisher habitat in northern California (Carroll 1997). Much of this is due to the fact that there has been less timber harvest in the Six Rivers National Forest than the Shasta-Trinity and the fact that the North Coast receives more rainfall, which produces greater forest biomass, than in the eastern Klamath.

Because a number of forest-dwelling vertebrates in addition to fishers also appear to exist in very high numbers in northwestern California (e.g., northern spotted owl [*Strix occidentalis caurina*] , California red tree *vole* [*Arborimus* *longicaudua*]), even in the face of substantial disturbance by timber harvest, it may be that some large-scale regional phenomenon favors their abundance. It has been speculated that the occurrence of schlerophyllus shrubs and trees (e.g., madrone, tan oak) which provide cover throughout the year, in combination with the overstory cover of conifers, may produce favorable conditions for species associated with closed-canopy forests in the region.

The larger Klamath region was also spared the marine inundation to which much of the surrounding mountains of the Northern Coast Ranges were subjected, resulting in a prolonged period for the development and diversification of its biota (Sawyer and Thornburgh 1977). It may be that this diversity of plants and animals, which now typifies most of northwestern California, provides an abundance of potential prey for fishers and other predators.

Regardless of whether the reasons are historical, contemporary or a combination, the mature forest cover in the North Coast study area appears to be in better condition than in the eastern Klamath. Only about 18% of the Six Rivers National Forest has been affected by timber harvest. The Northwest Forest Plan, which includes new approaches to forestry (including commercial thinnings in mid-mature stands), are certain to have less effect on fisher habitat than the clearcuts that characterized past management. Proponents even claim these prescriptions will accelerate the development of late-seral forest structure (Pilot Creek EIS 1996).

Most of the indicators of population and habitat quality for the North Coast study area provide no reason to suspect this population is declining. However, the suspected poaching of 2 animals indicates that additional attention to trapper and hunter education and law may be warranted. Although the North Coast study provides no reason for concern about fisher viability, this does not apply to the larger fisher population throughout its historic range in northwestern California. Currently fishers appear to occur no further south along the California coast than northern Mendocino county (Zielinski et al. 1995) whereas they once occurred as far south as Marin county (Grinnell et al. 1937).

Southern Sierra study area

Of greatest concern in this population is the high female mortality rate in combination with its isolation from fishers in northern California. Unfortunately, there are no comparable data on fisher mortality rates from populations that have neither been subject to trapping nor derived from recent reintroductions. However, the 39% annual mortality rate of monitored females is substantially higher than that reported for an untrapped marten population (Hodgman et al. 1997). The southern Sierra Nevada has been spared much of the habitat degradation by timber harvest that occurred in the northern Sierra (Franklin and Fites-Kaufmann 1996, McKelvey and Johnston 1992). However, many large-diameter trees, especially ponderosa pines and white firs, have been removed from west-side, mid-elevation Sierran forests. This harvest has simplified many stands, removing the conifer overstory and exposing the midstory of oaks and the rapidly regenerating shade-tolerant conifers that have been favored by fire suppression.

Fishers rest frequently in cavities in large and old oaks, but the long-term prognosis for the ability of these plant communities, which have been altered by high-grade logging and fire suppression, remains to be seen. The current use of hardwoods by fishers highlights the need to protect these elements in stands where conifers are scheduled to be harvested and to regulate their cutting for firewood. However, this is not to overemphasize the importance of oaks. While considerable use of oaks for both resting and denning was observed, fishers also extensively used large diameter conifers; recall that three of five natal dens were located in cavities of large white firs (two in snags and one in a live tree, Table 4). Management toward the recruitment of large, cavity-rich oaks should not be at the expense of maintenance and enhancement of large diameter conifers. Clearly large diameter conifers provide important resources for fishers in the Southern Sierra, and the long time required to recruit large-diameter conifers, particularly snags, must be appreciated.

High natural mortality rates and altered forest structure are risk factors that are compounded by the fact that fishers in the southern Sierra Nevada are separated from those in northern California by a distance of at least 400 km (Zielinski et al. 1995, L. Campbell, pers. comm.). Thus, the population will probably receive no immigrants to augment its genetic diversity or to rescue it from random events that could lead to its extirpation. Special consideration should be given to the effects of all land management activities on the short and long-term viability of this isolated population. In addition, the viability of the population in the southern Sierra should be examined in detail before it is considered a source of transplants for reintroduction in the northern Sierra Nevada.

Of the 3 study areas included in this meta-analysis, the southern Sierra study occurs where fire frequencies have historically been highest (McKelvey et al. 1996). In this region in particular, efforts should be made to return natural fire regimes and to encourage the development and retention of large-diameter conifers in the mid-elevation mixed conifer zone.

Finally, the Southern Sierra area is unique among the studies in that the fisher population coexists over a relatively broad elevation range with the American marten (*Martes americana*). Because the intensity of competition is predicted to be proportional to taxonomic relatedness, the fishers in the Southern Sierra may be subjected to an additional adverse factor to which the fishers in the northern California populations are not.

GENERAL RECOMMENDATIONS

Considered together, the habitat relationships described for fishers in this paper have important ecological and management implications. First, in the absence of Douglas-fir, fishers in the Southern Sierra Nevada appear to utilize a diverse array of tree species. Particularly noteworthy is the extensive use of black oaks, a species that tends to produce numerous cavities in Mixed Conifer forests. Whether this represents a local adaptation by fishers to conditions in the southern Sierra or simply reflects differences in habitat availability among regions is impossible to determine with currently available data. However, the small sample of natal and maternal dens found by the Southern Sierra study suggests the value of these oaks not only as suitable resting cover, but also as important structural elements to reproductive females.

Second, although extensive use of small diameter trees was observed on the Eastern Klamath study area, caution must be used when interpreting the importance of these results. Although platforms in small diameter trees may provide suitable resting habitat, such trees are likely of little or no value to reproductive female fishers. Research in the eastern US has stressed the importance of tree cavities as fisher natal dens (Paragi and Krohn 1996); natal den use in the southern Sierra supports this.

The prevalent use of platforms in small diameter trees on the Eastern Klamath study in conjunction with the relatively limited use of large diameter live trees and snags warrants further discussion. Extensive historic timber harvest within the Eastern Klamath study area has likely resulted not only in the conversion of mature forests to early seral stages (through clearcutting), but also in a decrease in the occurrence of large diameter living trees and, consequently, in the recruitment of large diameter snags and logs. At both Southern Sierra and North Coast study areas, large trees and snags appear to provide an important resource for fishers, and probably for their prey as well.

These data demonstrate the consistent use of large diameter trees on the North Coast and Southern Sierra study areas, and to a lesser extent on the Klamath study area. Although the observed patterns of rest site use are confounded by incomplete knowledge of structure availability, it is clear that fishers regularly use large diameter trees and logs. The availability of a diversity of structural elements across the landscape may play a crucial role in successful reproduction and recruitment of young.

Lastly, it is important to recognize the data presented here, although they have been collected from 3 ecological regions of California, reflect but a sample of the fisher's range in California. The Eastern Klamath study was located in the easternmost portion of the ecological region where the combination of climatic patterns and land management practices have apparently influenced fisher ecology. Whether this is true for the entire Klamath Mountains region is impossible to know at this time. Important questions remain about population dynamics within the spatially contiguous population occupying northwestern California. Likewise, the Southern Sierra study occurred in an area that may include the best remaining fisher habitat in the Sierra Nevada. Comparisons of our results with those that become available from ongoing research in the coastal redwood region (Klug et al., in prep) and a second study in North Coast Ranges (Higley et al., in prep) will help corroborate the results presented herein.

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This collaborative research would not have been possible without cooperation and support of numerous individuals and organizations. The California Department of Fish and Game provided funding to synthesize data from the three studies; in particular, we thank E. Burkett for helping secure funds through the Department's tax check-off funds and providing continuing support to each study. we thank R. Schlexer, G.

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Table 1. Climate data for weather stations within or in close proximity to three fisher studies conducted in California from 1992-1996.

Climate Category	Variable	Study Area: Eastern Klamath	Study Area: North Coast	Study Area: Southern Sierra
Temperature				
	Mean Minimum (°C)			
	MAY - OCT	6.2	9.2	7.4
	NOV - APR	1.6	2.9	2.7
	Mean Maximum (°C)			
	MAY - OCT	29.2	30.1	19.3
	NOV - APR	12.6	14.6	7.6
	Weather Station Elev. (m)	623	180	2012

	Reporting period	1951-1997	1969-1997	1965-1994
Precipitation				
	MAY - OCT mean (cm)	12.8	2 2.4	13.3
	NOV - APR mean (cm)	77.0	133.7	91.6
	Annual mean (cm)	89.8	156.1	104.9
	Weather Station Elev. (m)	623	846	2012
	Reporting Period	1965-1997	1938-1997	1965-1994
Snowfall				
	Mean snow depth (cm)[1]	106.7	64.2	42.1
	Weather Station Elev. (m)	1890	1890	2012
	Reporting Period	1947-1997	1944-1997	1937-1983

[1] Mean snow depth recorded on 01 April. Although snow depth (cm) on April 1st is deepest for the Klamath study area, the reporting station was considerably higher than radio telemetry research; snow rarely covered the Klamath study area but was common on both the North Coast and Southern Sierra studies.

Table 2. Body mass (kg) and total body length (cm) measured from adult fishers captured in the Klamath, North Coast, and Southern Sierra regions of California, 1992-1996.

Variable	Study Area	Sex	n	$\bar{x}^*$	SD	Range	Med.	CV
Body Mass (kg)	Eastern Klamath	M	5	4.17A	0.335	3.70-4.55	4.20	8.03
	North Coast	M	11	3.75A	0.418	3.07-4.40	3.75	11.15
	Southern Sierra	M	7	3.24B	0.442	2.60-3.67	1.92	13.63
	Eastern Klamath	F	7	2.24A	0.248	2.00-2.65	2.11	11.06
	North Coast	F	18	2.02B	0.238	1.64-2.49	2.04	11.77
	Sequoia	F	18	1.93B	0.167	1.52-2.20	1.92	8.68
Body Length[1] (cm)	Eastern Klamath	M	4	102.25A	4.573	97.0-108.0	102.00	4.47
	North Coast	M	10	101.61A	4.486	96.5-112.0	100.25	4.41
	Southern Sierra	M	7	99.07A	4.092	93.3-105.0	99.50	4.13
	Eastern Klamath	F	7	92.14A	1.574	89.0-94.0	92.00	1.71

North Coast	F	18	89.34B	2.509	82.2-93.0	89.55	2.81
Southern Sierra	F	18	87.58B	3.387	81.5-95.0	88.00	3.87

[*] Means with the same letter were not significantly different ($P > 0.05$), based on one way Analysis of Variance conducted for each sex.
[1] Total body length (cm) measured from tip of the snout to end of the tail.

Table 3. Mortality sources and descriptions for fisher carcasses recovered on the Klamath, North Coast, and Southern Sierra study areas, 1992-1996. All individuals were categorized by field technicians as adult (A), Young Adult (YA), or juvenile (J) at the time of their initial captures; numbers in parentheses indicate age as determined by cementum annuli analysis following carcass recovery (Matson's Laboratory, Milltown, MT).

Study Area	Sex	Age	Date Recovered	Cause of Death
Eastern Klamath	M			Hit by car.
	M			Hit by car.
	M			Predation, coyote suspected.
	F			Unknown.
	F			Unknown.
	F			Predation, mountain lion suspected.

	F				Predation, coyote suspected.
North Coast	F	A	(3)	01 JUN 95	Unknown.
	F	A	(2)	04 SEP 95	Unknown, predation suspected.
	F	A		04 APR 96	Predation.
	F	A		26 AUG 96	Collar cut.
	F	YA		16 JAN 96	Collar cut and bloody.
	F	A		13 MAY 96	Unknown.
Southern Sierra	M	A		13 MAR 95	Unknown, predation suspected.
	M	YA	(2)	01 DEC 96	Head trauma, possible predation
	M	A	(4)	27 MAR 96	Head trauma.
	F	YA		13 FEB 95	Unknown.
	F	YA		09 MAR 95	Predation, raptor suspected.
	F	A	(5)	18 JUL 95	Exposure / starvation.
	F	A	(6)	25 SEP 95	Unknown.
	F	YA	(1)	22 NOV 95	Unknown.
	F	A	(3)	03 JUN 96	Head trauma.

F	J	25 ARR 95	Unknown.
F	J (0)	16 JAN 96	Predation, mammal suspected.

Table 4. Descriptions of natal and maternal dens and the surrounding habitat for female fishers in the Eastern Klamath, North Coast, and Southern Sierra regions of California. Natal dens refer to the site where parturition is assumed to have occurred while maternal dens refer to sites where an adult female was observed resting with one or more kit(s).

Study Area	Indiv.	Den Type	Tree Species	Tree Cond.	DBH	BA	Canopy Closure
Eastern Klamath	1	Maternal	PIPO	snag	78	59.4	70
	2	Maternal	QUKE	live	88	18.3	98
	3	Maternal	QUCH	live	52	59.4	75
	3	Maternal	QUCH	live	40	27.4	77
	3	Maternal	PSME	live			
North Coast	1	Maternal	CADE	live	105	101.6	97
	2	Maternal	PSME	live	138	78.5	98

	2	Maternal	QUKE	live	53	73.9	100
	3	Maternal	ABCO	log		120.0	72
	3	Maternal	PSME	live	99	50.8	99
	4	Maternal	ABCO	snag	125	166.3	96
Southern Sierra	1	Natal	ABCO	snag	148	32.1	94
	1	Natal	UNK	snag	112	64.3	96
	2	Natal	ABCO	live	82	64.3	96
	3	Natal	QUKE	live	99	59.7	93
	3	Natal	QUKE	live	76	114.8	97
	3	Maternal	QUKE	live	40	23.1	89
	3	Maternal	ABCO	live	146	27.7	93
	4	Maternal	QUKE	live	52	60.1	96

Table 5. Percent availability of California Wildlife Habitat Systems (CWHR) cover type, size class, and canopy closure for three fisher studies conducted in California 1992-1996. Data were summarized from existing Geographic Information Systems vegetation layers.

CWHR Attribute	Percent Occurrence		
	Eastern Klamath	North Coast	Southern Sierra
Cover Type[a]			
Shrub	1.48	1.07	9.30
Montane Hardwood	5.03	8.07	19.47
Montane Hardwood Conifer	22.93	23.50	0.00
Mixed Conifer	28.56	22.92	28.92
Douglas-fir	28.02	34.93	0.00
Pine	5.87	7.16	15.89
Other Conifer	0.52	1.14	22.33

Other	7.59	1.20	4.10
Size Class[b]			
Seedling	0.04	0.16	4.10
Sapling	2.45	6.32	0.59
Pole	86.46	64.65	48.21
Medium and Large	11.05	28.87	47.10
Canopy Class[c]			
Open	2.98	2.75	20.85
Sparse	10.36	10.98	11.17
Moderate	23.43	23.87	23.10
Dense	63.23	62.40	44.88

[a] Shrub = mixed chaparral, montane chaparral, and chamise-redshank chaparral
Mixed Conifer = Klamath mixed conifer and Sierran mixed conifer
Pine = Ponderosa pine, Jeffrey pine, and lodgepole pine
Other conifer = white fir, red fir, subalpine conifer, and closed-cone cypress
Other = wet meadow, barren, and undefined

[b] Size classes reported for tree dominated habitats only, based on average quadratic mean diameter. Size Class 1 = <1", Size Class 2 = 1-6", Size Class 3 = 6-12", and Size Classes 4, 5 = >12".

[c] Canopy class reported as percent closure for tree dominated habitats only. Sparse = 10 - 24%, Open = 25-39%, Moderate = 40-59%, Dense = 60-100%.

Table 6. Diameter at breast height (1.37 m) in centimeters for conifer and hardwood rest sites used by fisher on three study areas in California, 1992-1996.

Tree Type	Study Area	n	$\bar{x}$	SD	Range	Median
Conifer	Eastern Klamath	215	77.2	46.7	8-196	63.8
	North Coast	136	105.8	42.4	12-205	111.5
	Southern Sierra	176	111.7	49.7	28-433	106.0
Hardwood	Eastern Klamath	38	49.3	27.7	12-132	44.6
	North Coast	35	87.1	28.3	42-149	77.0
	Southern Sierra	141	65.0	21.6	30-145	63.0

Table 7. Habitat characteristics surrounding fisher rest sites located on three study areas in California from 1992-1996.

Variable	Study Area	n	$\bar{x}$	SD	Range	Median
Basal Area (m/ha^2)	Eastern Klamath	289	59.8	30.9	9.2-169.0	54.8
	North Coast	127	75.6	27.6	9.2-161.7	73.9
	Southern Sierra	285	62.6	26.1	9.2-129.3	64.7
Mean Tree DBH (cm)[a]	Eastern Klamath	293	46.2	28.2	6.8-236.4	39.5
	North Coast	127	118.3	35.6	40.2-198.7	119.2
	Southern Sierra	285	89.6	29.5	24.0-176.2	87.2
Canopy Closure (%)	Eastern Klamath	298	88.2	12.8	3.0-100.0	95.4
	North Coast	127	93.9	7.5	65.2-100.0	96.7
	Southern Sierra	291	92.5	9.1	39.7- 99.9	95.4

[a] Mean tree diameter at breast height (DBH, 1.37 m) calculated for the four largest trees at rest sites; the rest site tree was included if it was among the four largest.

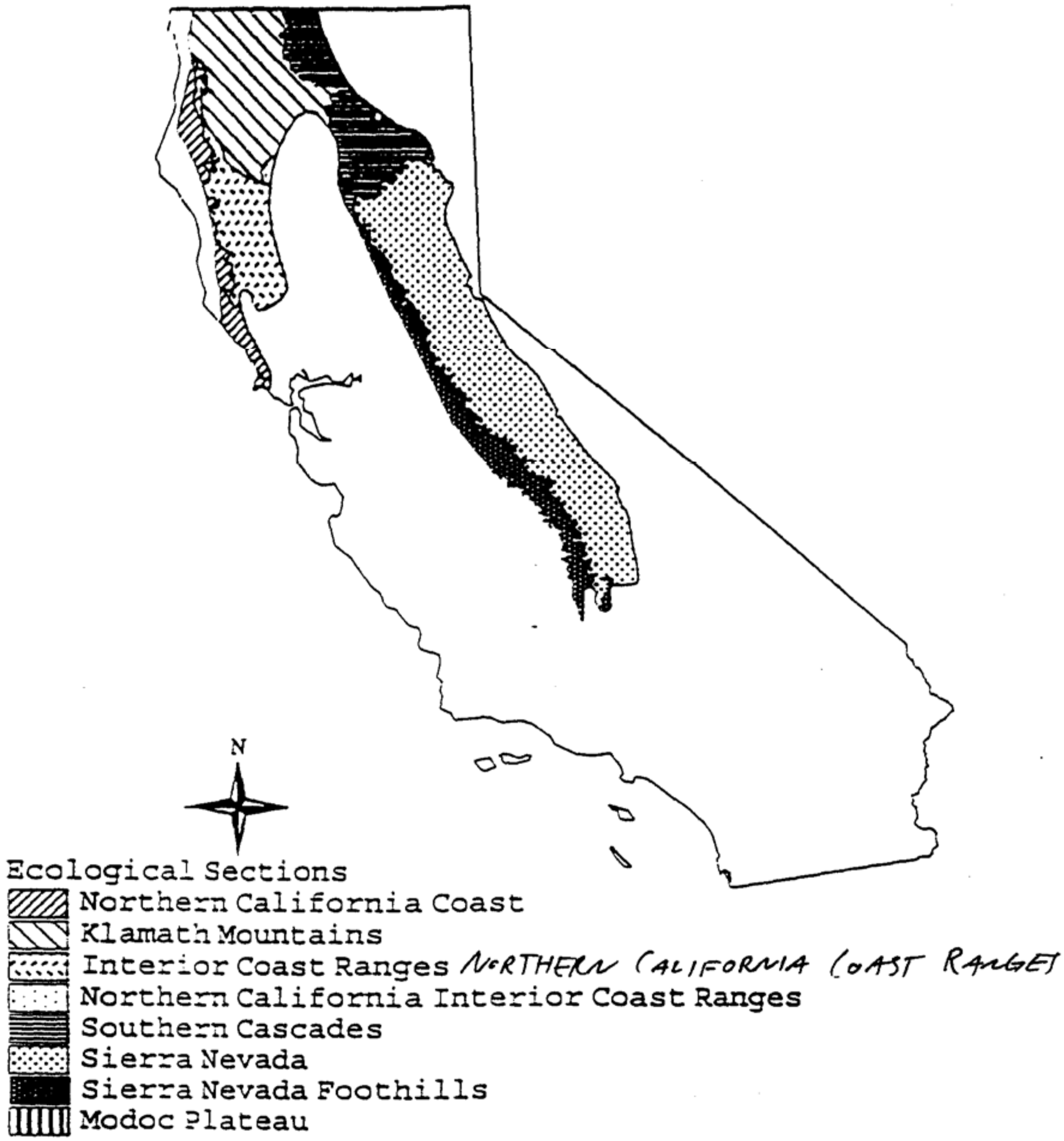

Figure 1 . Ecological sections (ECOMAP 1993) occurring within the historical distribution of the fisher in California as described by Grinnell et al. (1937).

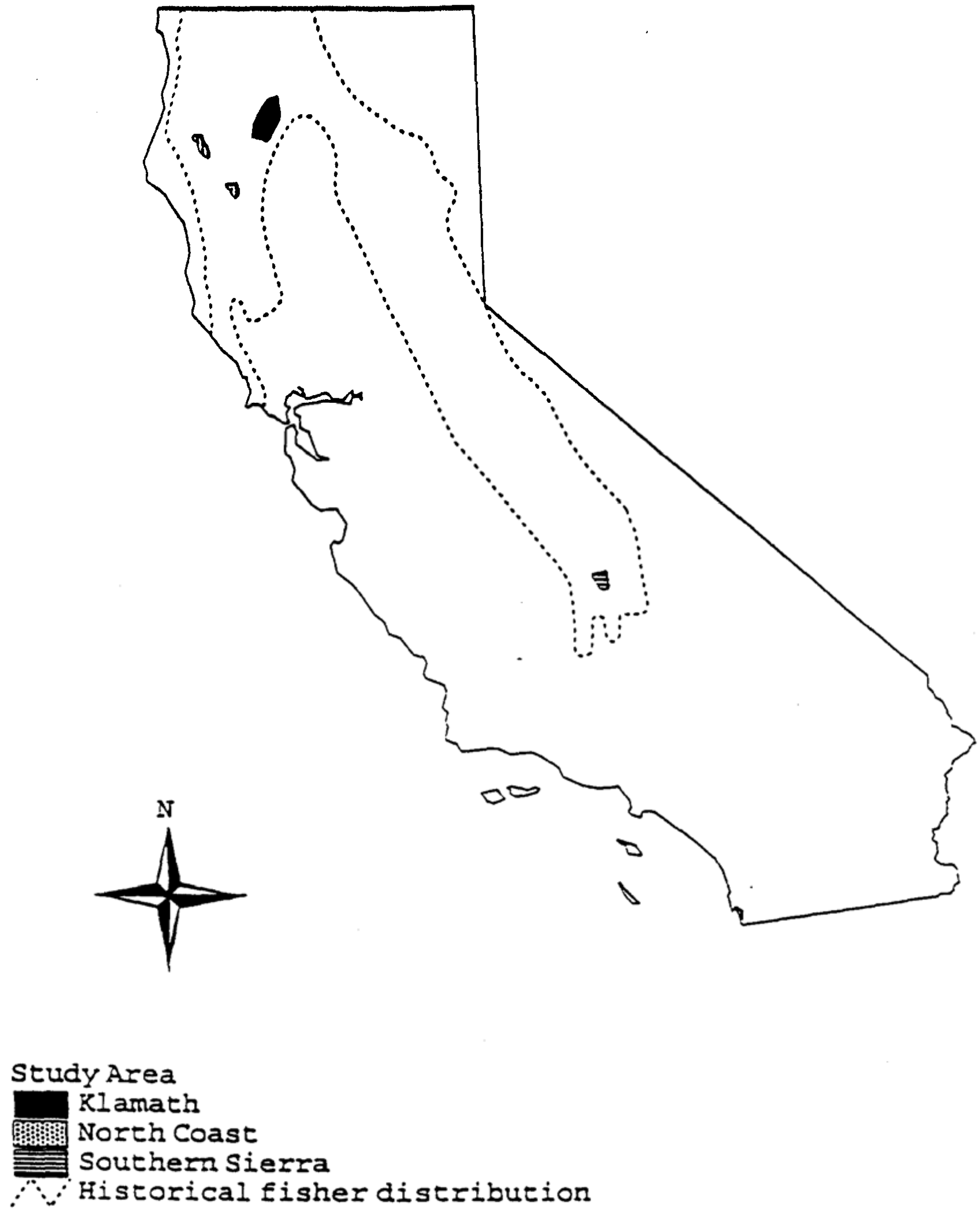

Figure 2. Location of three radio telemetry studies conducted in California From 1992 to 1996, plotted with the fisher's historical distribution as described by Grinnell et al. 1937.

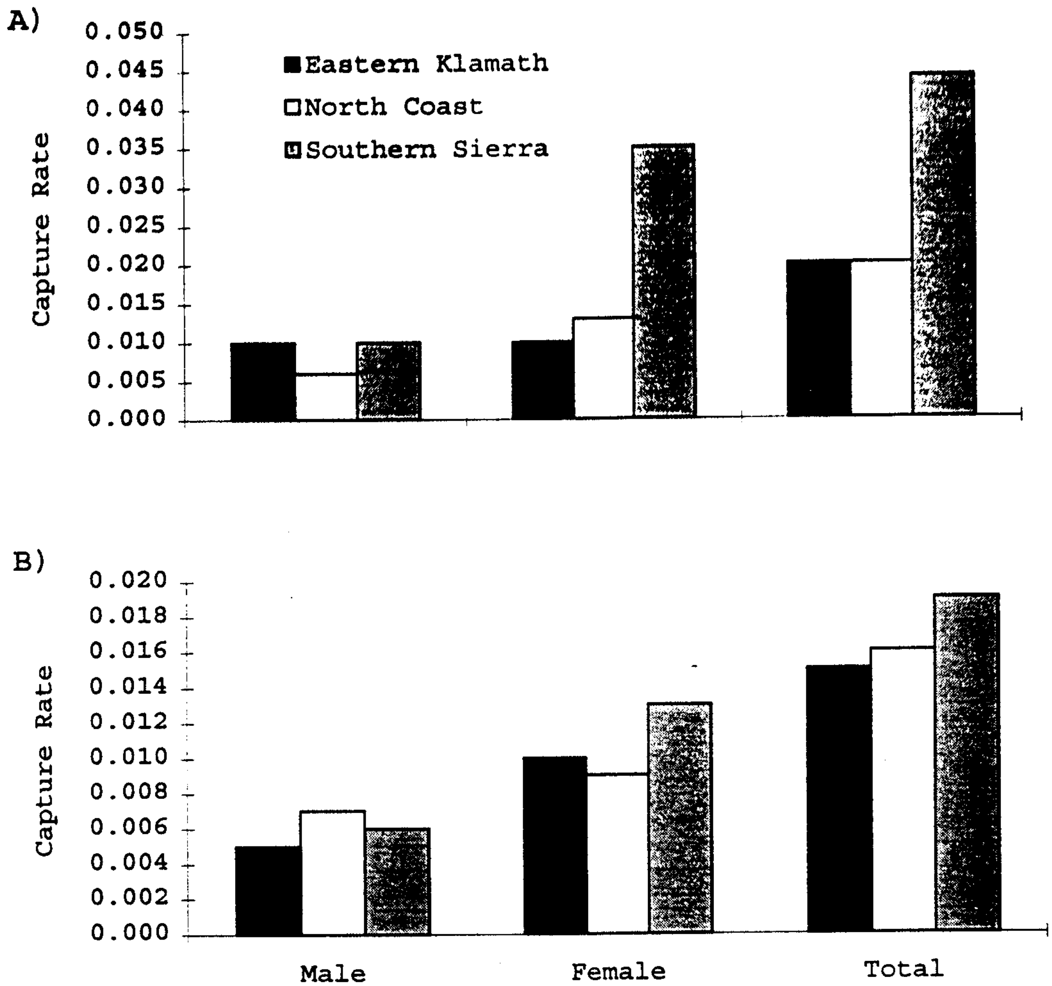

Figure 3. Initial (A) and overall (B) capture rates for fishers livetrapped in three regions of California, 1992-1996. Capture rate = no. fishers captured / total trap nights.

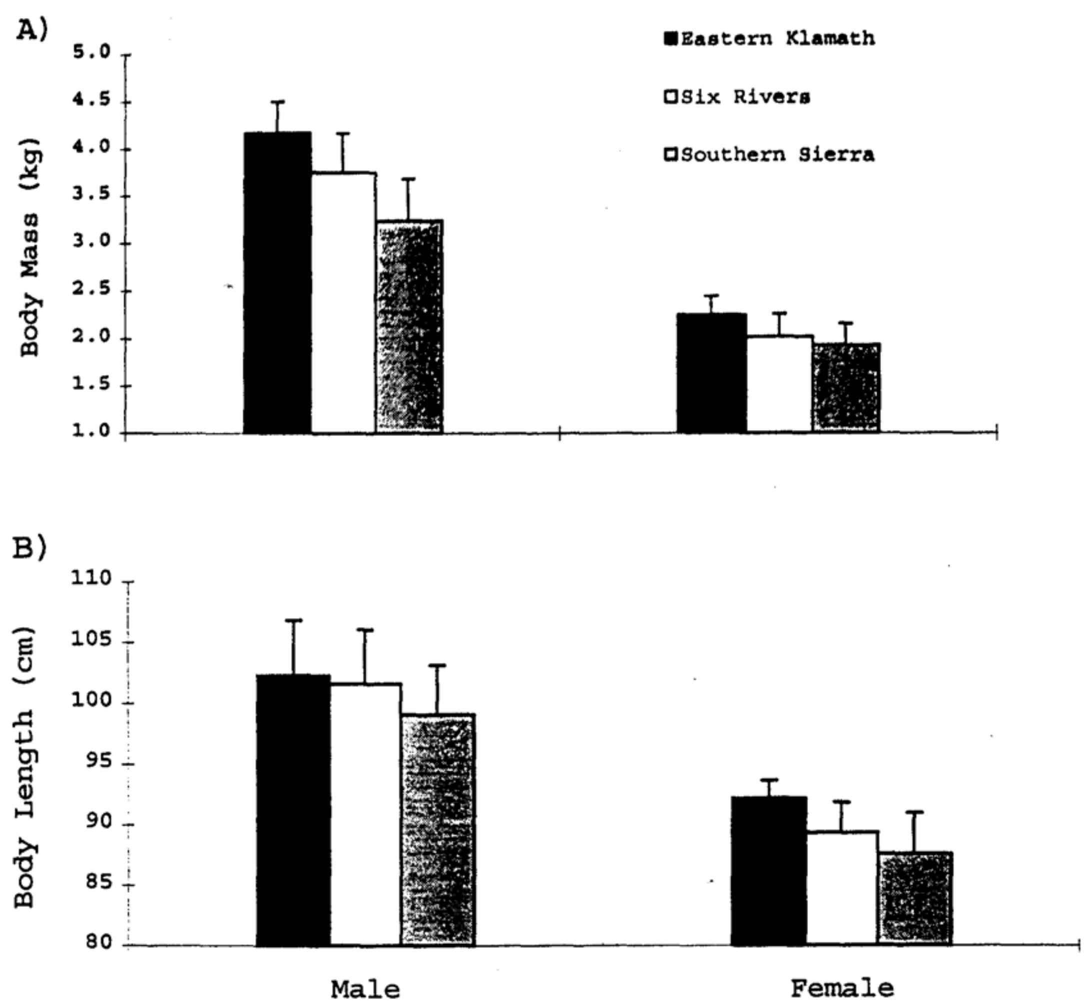

Figure 4. Average body mass in kg (A) and total body length in cm (B) for adult fishers captured in the Eastern Klamath (*n* = 5 male, 7 female), North Coast (*n* = 7 male, 11 female), and Southern Sierra (*n* = 7 male, 18 female) regions of California, 1992-1996. Error bars = 1 SD.

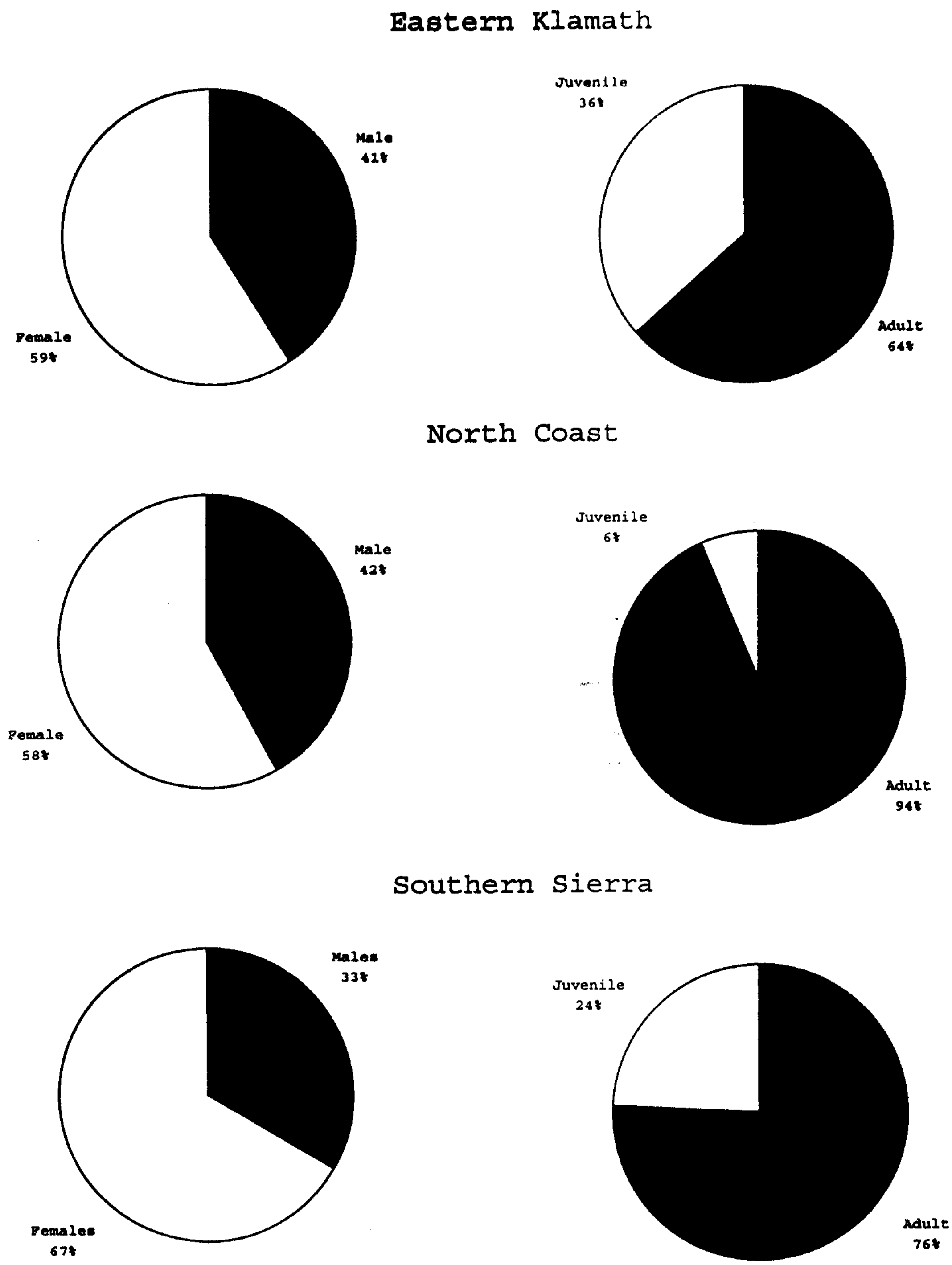

Figure 5. Sex and age ratios for fisher captured on the Eastern Klamath (n = 22), North Coast (n = 31), and Southern Sierra (n = 33) study areas in California, 1992-1996.

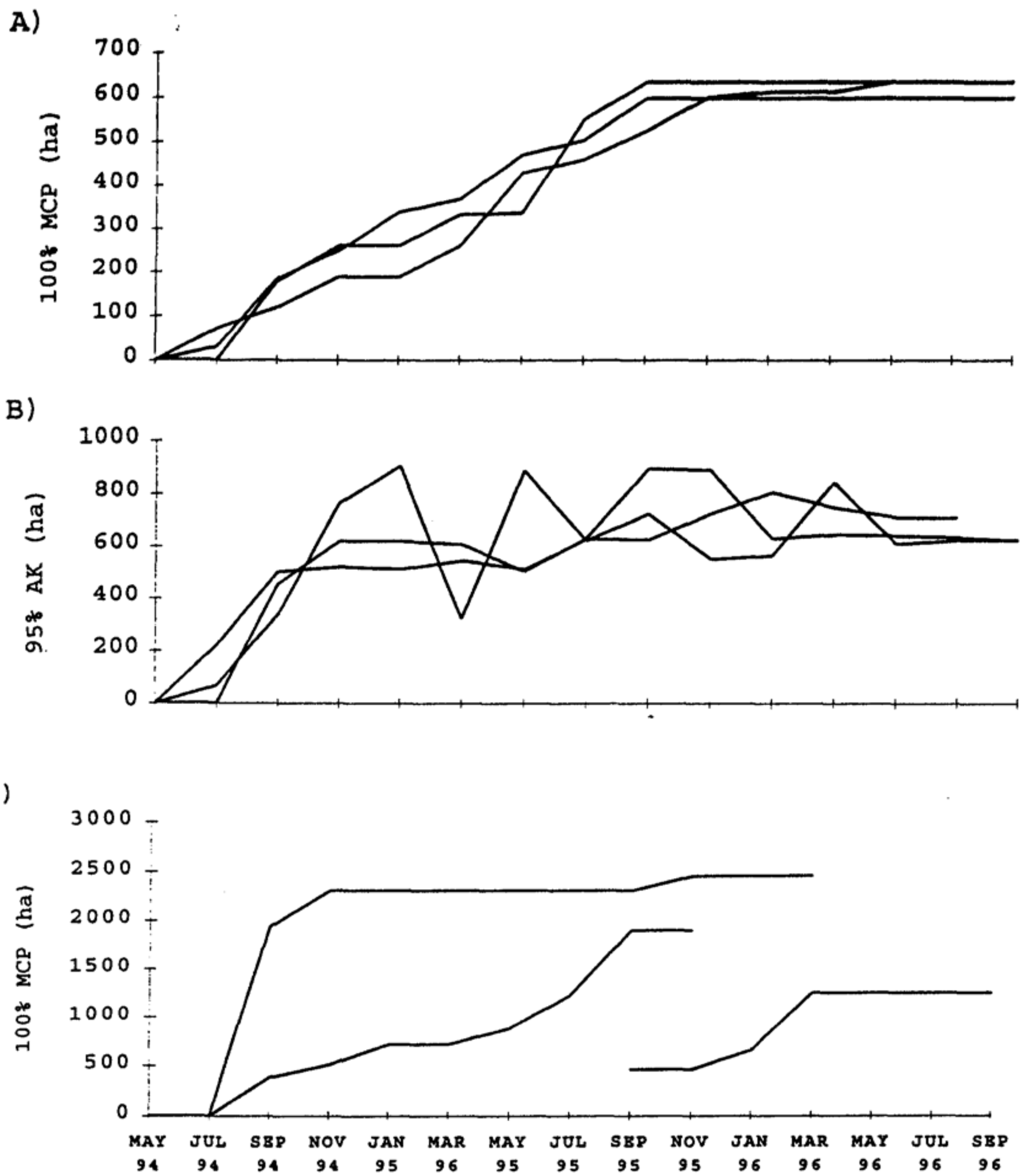

Figure 6. Bimonthly home range size estimates for (A) 100% Minimum Convex Polygons (MCP) for three females, (B) 95% Adaptive Kernels for the same three females, and (C) 100% MCP for three male fishers on the Southern Sierra study area, 1994-1996. Note: scaling of y axis differs among figures.

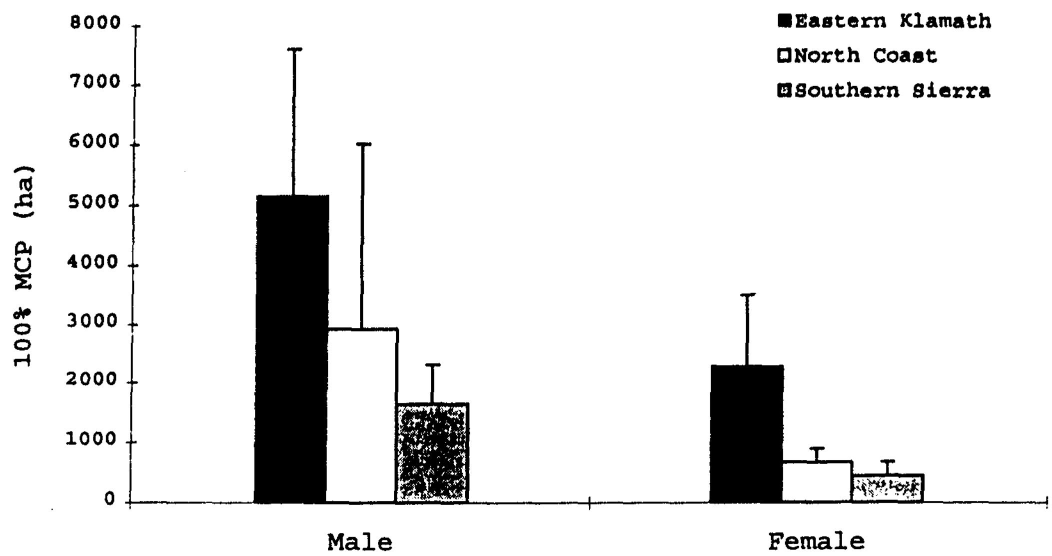

Figure 7. Average Minimum Convex Polygon home range estimates in ha (error bars = 1 SD) for adult fishers monitored a minimum of 9 months and located at rest sites at least 10 times for the Eastern Klamath (*n* = 6 male, 5 female), North Coast (*n* = 2 male, 5 female), and southern Sierra (*n* = 4 male, 7 female) study areas, 1992-1996.

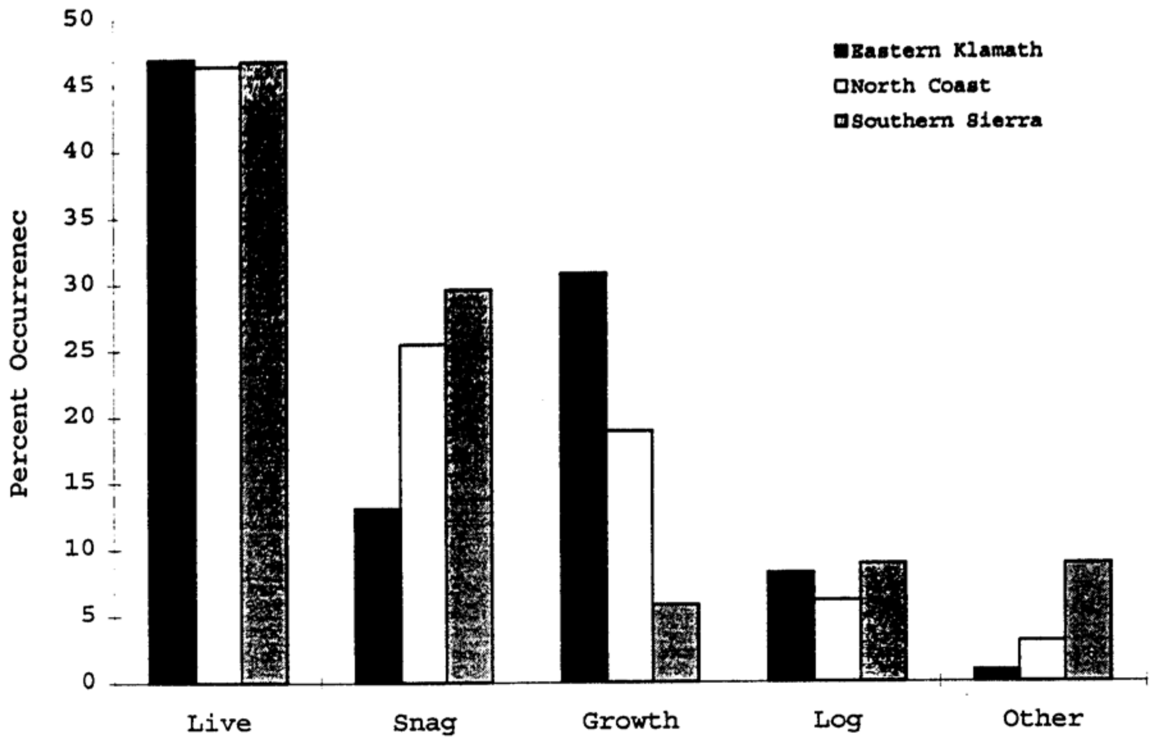

Figure 8. Rest site structures, aggregated into five functional groups, used by fisher in Eastern Klamath (*n* = 451), North Coast (*n* = 196), and Southern Sierra (*n* = 395) study areas, 1992-1996. Rest site structure categories were defined as follows: Live = in cavities, broken-tops, or on the limbs of living trees; Snag = in cavities or broken-tops of snags; Platform = in nests, mistletoe brooms, or other platforms; Log = in individuals logs or in log piles; Other = in rock piles, subnivean sites, or other ground cavities.

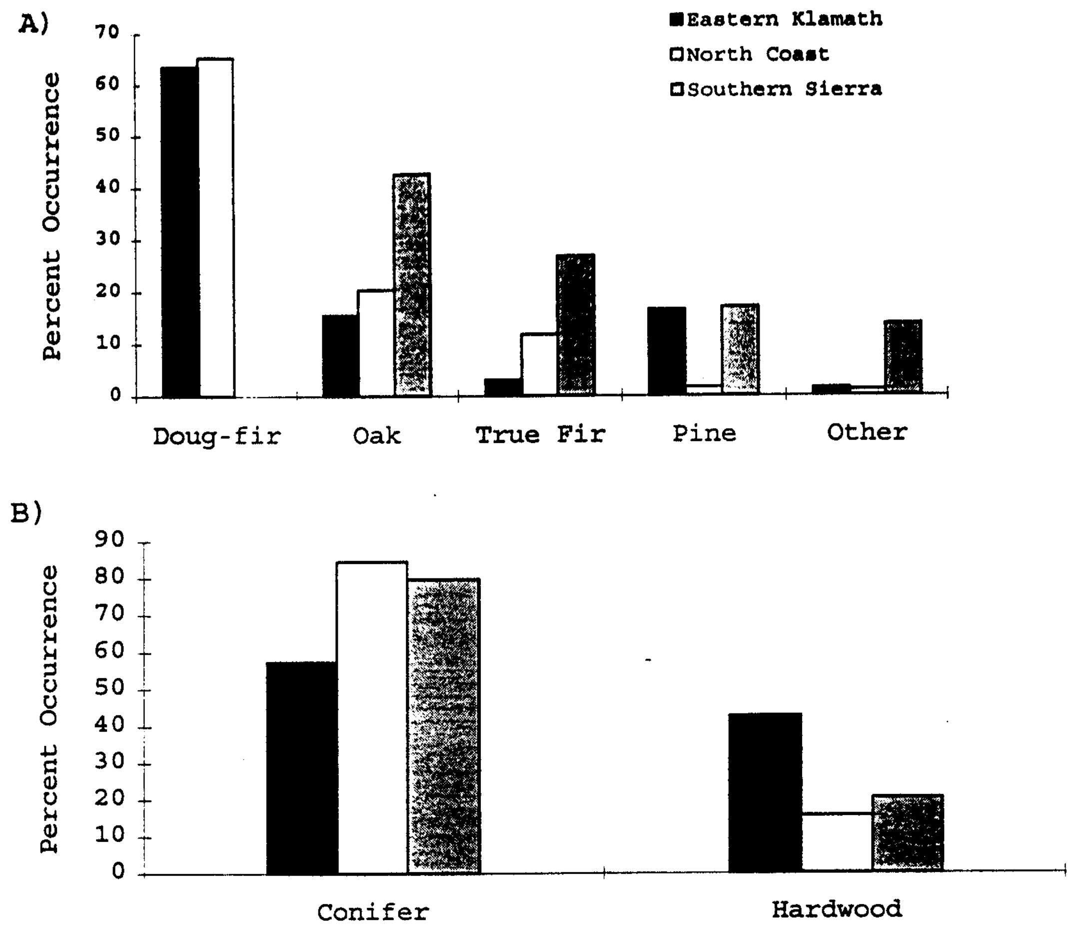

Figure 9. Rest site tree species, aggregated into (A) 5 functional groups and (B) 2 functional groups, used by fishers on the Klamath (n = 394), North Coast (n = 359), and Southern Sierra (n = 187) study areas, 1992-1996. Tree species were grouped as follows: Doug-fir = *Pseudotsuga menziesii;* Oak = Quercus spp., *Arbutus menziesii*, and *Lithocarpus densiflora;* True Fir = *Abies* spp.*;* other = *Sequoiadendron giganteum*, *Calocedrus decurrens*.

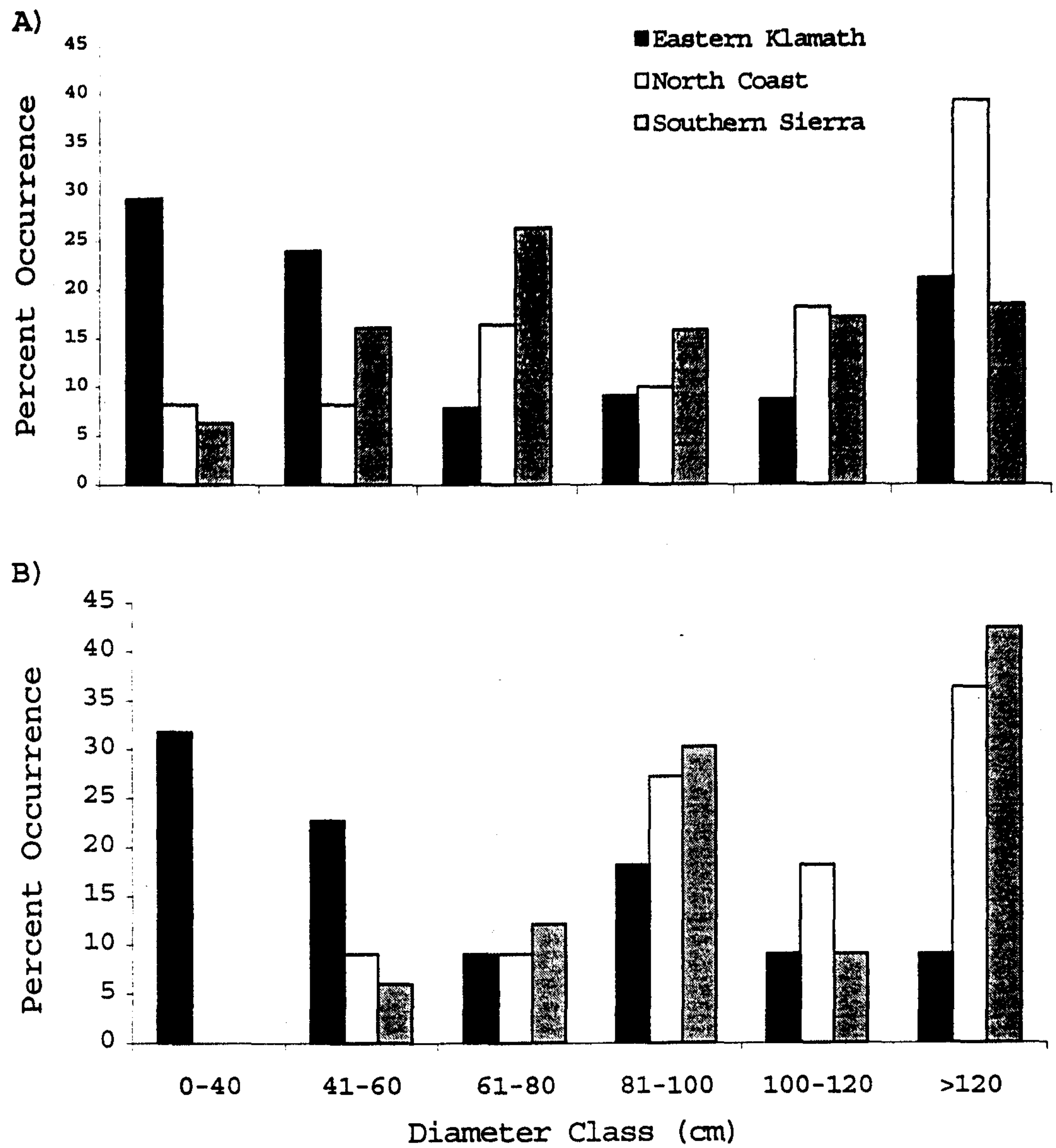

Figure 10. Distribution of (A) diameter at breast height (DBH) classes for trees and (B) maximum diameter for logs used as rest sites by fishers on the Klamath (*n* = 316 trees, 37 logs), North Coast (*n* = 171 trees, 12 logs), and Southern Sierra (*n* = 242 trees, 35 logs) study areas, 1992-1996.

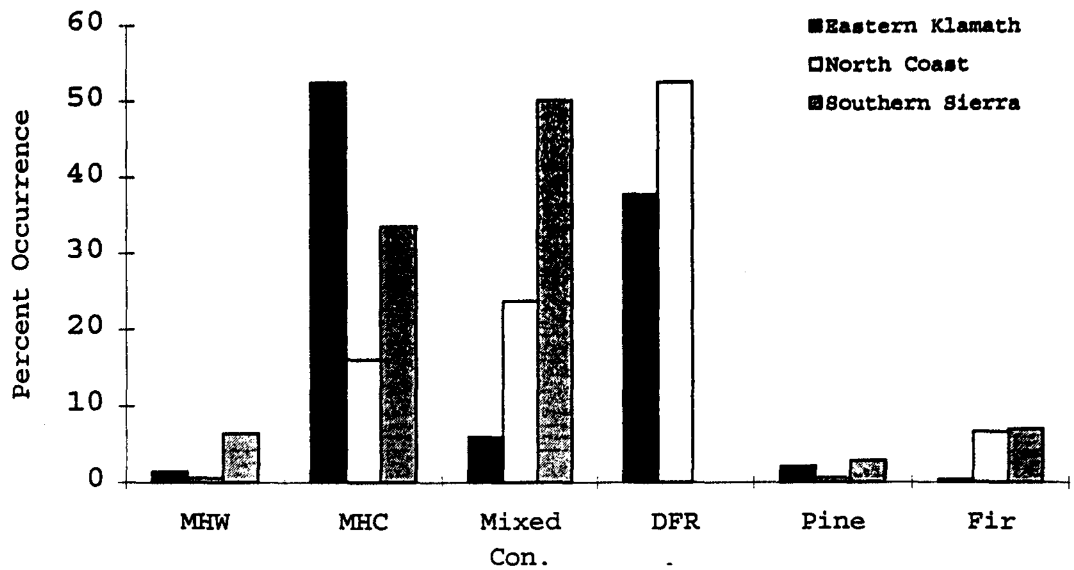

Figure 11. California Wildlife Habitats Relationship cover types visually assigned for habitat surrounding fisher rest sites on the Eastern Klamath (n = 286), North Coast (n = 181), and Southern Sierra (n = 387) study areas, 1992-1996. Habitat types are as follows: MHW = Montane Hardwood, MHC = Montane Hardwood-Conifer, Mixed Con. = Sierran and Klamath Mixed Conifer, DFR = Douglas-fir, Pine = Ponderosa Pine and Jeffrey Pine, and Fir = White Fir and Red Fir.

Appendix 1. Details of field methods used by fisher studies in California, 1992-1996.

VARIABLE	Southern Sierra Method	Eastern Klamath Method	North Coast Method
REST SITE DATA	Males Females	Males Females	Males Females
# of rest site locations	91 317	290 290	76 115
# of individuals with 0-9 rest sites	5 4	2 5	5 5
# of individuals with 10-20 rest sites	4 4	0 7	1 7
# of individuals with 21+ rest sites	0 5	6 2	1 1
LOCATION DATA			
Rest Site Location	UTM location recorded using either 7.5 minute USGS topo maps or GPS	UTM location from 1:24000 USGS topo map. Precision 1 and 2 locations used.	Same as Southern Sierra.
Rest Site Elevation	Elevation recorded in ft from USGS topos or GPS	Topographic map and altimeter	Same as Southern Sierra.
Location Precision	Rest site occupation confirmed either by 1) telemetry only 2) telemetry and direct confirmaion (visual or auditory), 3) telemtry and indirect confirmation (e.g., fresh snow tracks)	1) animal seen at rest site 2) structure of rest site known 3) immediate vicinity of rest site known	Same as Southern Sierra.

Appendix 1, cont.

VARIABLE	Southern Sierra Method	Eastern Klamath Method	North Coast Method
Date found	Recorded in DD - MMM - YY and later converted to Julian date	DD-MMM-YY	Same as Southern Sierra.
Rest site use	rest site, natal den, maternal den	description of activity and kit presence or absence	
STRUCTURE DATA			
Rest Site Structure (cont.)	Rest Sites are categorized into one of the following structure types: - LIVE: in an unknown location of a live tree - LTCA: in a cavity of a live tree - LTBT: in a broken top of a live tree - LTGR: in a live tree growth (mistletoe, witch's brom,...) - SNAG: in an unknown location of a snag - SNCA: in a cavity of a dead tree - SNBT: in a broken top of a dead tree - SNGR: in a dead tree growth (mistletoe, witch's broom...) - LOG: in a log (defined as single coarse woody debris with maximum diameter > 30 cm) - PILE: in a collection of coarse woody debris, a	Descriptive paragraph about the type of structure in which the animal was found. Often accompanied by a picture. Southern Sierra Method (cont) log pile - NEST: in a nest of a live tree or snag, including raptor nests, rodent nests, and accumulations of branches and litter - ROCK: in a rock pile, cliff, beneath a boulder - SNOW: in a subnivean site - SHRU: in a site completely covered by shrubs, generally in the roots or another ground cavity - OTHER: in a site not described by the above structure types	Same as Southern Sierra.

Appendix 1, cont.

VARIABLE	Southern Sierra Method	Eastern Klamath Method	North Coast Method
FOR LIVE TREES and SNAGS:			
Rest Site Species	Species identified when possible; coarser taxonomic identification provided when species identification not possible	Species identified.	Same as Southern Sierra.
Rest Site DBH	Diameter measured on uphill side of rest site tree (live trees, snags, and stumps) to the nearest cm. Diameter on uphill side of rest tree estimated to the nearest 5 cm.	Measured with DBH tape to nearest 0.1 cm on the upslope.	Same as Southern Sierra.
Height of rest site tree	Visual estimate of total tree height (m)	estimated total tree height (m)	Same as Southern Sierra.
Height of rest site	Visual estimate (m) when exact location of animal known or inferred from telemetry. Not recorded if exact resting location not known.	Height of animal from ground, data colllected since 9-93	Same as Southern Sierra.
Rest Site Condition Class	Condition class assigned as live, declining, dead, loose bark, clean, broken, decomposed, down material, stump (from Maser et al. 1979).	Live tree crowns categorized as normal, broken, dead, sparse, half crowned. Snags categorized according to WHR decay classification: sound, rotten, hollow.	Same as Southern Sierra.

Appendix 1, cont.

VARIABLE	Southern Sierra Method	Eastern Klamath Method	North Coast Method
Cavity Presence	Recorded for certain structure types (e.g., LTCA, SNCA). Description of structures may provide additional information about cavity presence when the rest site was not know to be in a cavity.	Presence / absence.	Same as Southern Sierra.
STRUCTURE DATA CONTINUED			
FOR LOGS:			
Log Species	Species identified when possible; coarser taxonomic identification provided when species identification not possible	Species identified when possible. Species can be aggregated into pines, oaks, Douglas fir, other.	Same as Southern Sierra.
Log Maximum Diameter	Maximum log diameter visually estimated (cm)	Maximum diameter estimated (cm)	Same as Southern Sierra.
Log Decay Class	Log decay class assigned according to the guidelines in Maser et al. (1979) Five classes from sound to rotten.	WHR decay classification: sound, rotten, hollow.	Same as Southern Sierra.
FOR OTHER STRUCTURE TYPES:	description and drawing of rest site provided	description and drawing of rest site provided	Same as Southern Sierra.
VEGETATION DATA	Plotless sampling method for trees, 0.04 ha plot sampled using 2 perpendicular line intercept transects centered at the rest site. A random azimuth was used to determine the placement of the transects.	0.04 ha circular plot for all variables except basal area (see below).	Same as Southern Sierra.

Appendix 1, cont.

VARIABLE	Southern Sierra Method	Eastern Klamath Method	North Coast Method
Basal Area	Basal area recorded for live trees and snags using a 20 BAF American scale prism.	Basal area recorded for live trees and snags using a 20 BAF American scale prism.	Same as Southern Sierra.
Tree DBH	Recorded for all trees "in" the prism sweep.	Recorded for the 4 largest trees on the plot.	Same as Southern Sierra.
WHR Habitat Type	WHR habitat type estimated for the area immediately surrounding the rest site (not limited to the plot) according to the guidelines in Mayer and Laudenslayer (1988). WHR TYPES include: SMC, MHC, MHR, WFR, MRI, RFR, MCP, PPN	WHR habitat classification for plot. WHR TYPES INCLUDE: BAR, DFR, KMC, MHC, MHW, PPN	WHR TYPES INCLUDE: DFR, KMC, MHC, WRF, RFR, AGS, MHW
WHR Habitat size class	WHR size class estimated for the area immediately surrounding the rest site (not limited to the plot) according to the guidelines in Mayer and Laudenslayer (1988)	WHR SIZE CLASS: SEEDLING TREE, SAPLING TREE, POLE TREE, SMALL TREE, MED/LG TREE, MULTI-LAYERED TREE	Same as Southern Sierra.
WHR Habitat canopy class	WHR canopy class estimated for the area immediately surrounding the rest site (not limited to the plot). WHR CLASSIFICATIONS: SPARSE COVER, OPEN COVER, MODERATE COVER, DENSE COVER	CLASSIFIED AS: DOMINANT, CODOMINANT, SUPPRESSED, EMERGENT	Same as Southern Sierra.
Canopy Cover	Concave spherical densiometer used to measure canopy closure at the rest site structure, and at the 4 transect ends.	Spherical densiometer used to measure closure at 4 cardinal directions, each at 5 m from rest site.	Same as Southern Sierra.
Tree Species Present	Dominant 3 tree overstory and understory species recorded. Additional species recorded if in the prism sample.	Inventory of dominant species, understory, overstory.	Same as Southern Sierra.

Appendix 1, cont.

VARIABLE	Southern Sierra Method	Eastern Klamath Method	North Coast Method
VEGETATION DATA (CONT.)			
Overstory Canopy Cover	Visually estimated (5% increments).	Visually estimated for each species recorded in inventory.	Same as Southern Sierra.
Understory Canopy Cover	Visually estimated (5% increments).	Visually estimated for each species recorded in inventory.	Same as Southern Sierra.
# of Logs	Not directly recorded.	Count of logs > 10cm.	Same as Southern Sierra.
% Log Cover	Recorded using line intercept transects for all coarse woody debris > 7.5 cm maximum diameter..	Not recorded.	
Log size	Maximum diameter recorded for all coarse woody debris > 15 cm maximum diameter which crosses transects.	Maximum diameter estimated for all logs > 10 cm on the plot.	Same as Southern Sierra.
Log decay	Log decay class assigned according to the guidelines in Maser et al. (1979) Five classes from sound to rotten.	Decay class (WHR) recorded for all logs > 10 cm on the plot	Same as Southern Sierra.
# of Snags	Snags sampled using prism method.	Count of snags > 12 cm on plot.	Same as Southern Sierra.
Snag Diameter	DBH (cm) measured for all snags in prism sweep.	DBH estimated for all snags on plot.	Same as Southern Sierra.
Snag Ht	Height visually estimated (m) snags in prism sweep.	Height recorded for all snags on plot.	Same as Southern Sierra.
Snag Decay	Decay class assigned (Maser et al. 1979) for all snags in prism sweep.	Decay class recorded for all snags on plot.	Same as Southern Sierra.
ABIOTIC DATA			
Slope	% slope averaged across uphill and downhill clinometer readings.	% slope recorded using a clinometer	Same as Southern Sierra.
Aspect	Aspect recorded based on local	Compass on major slope	Same as Southern

Appendix 1, cont.

VARIABLE	**Southern Sierra Method**	**Eastern Klamath Method**	**North Coast Method**
	topographic features (microslope) and general landscape topography (macroslope)	axis.	Sierra.
Topographic Position	Topographic position of rest site categorized as (Ridgetop, convex slope, bench, concave slope, and draw bottom).	Categorical: ridge, drainage, slope.	Same as Southern Sierra.
Distance to Nearest Water	Estimated if within 100 m, otherwise distance to water will be obtained from GIS.	Description and distance.	Same as Southern Sierra.
Distance to nearest Road	Not recorded in the field. Distance to nearest road will be obtained from GIS.	Description and distance.	Same as Southern Sierra.
Temperature	Temperature recorded with a thermometer when site was found.	Temperature recorded with a sling psychrometer.	Same as Southern Sierra.
% Cloud Cover	Visually estimated in increments of 10%.	Ocular estimate.	Same as Southern Sierra.
Precipitation	Categorized as: 0) no precipitation 1) light or intermittent rain 2) moderate, steady rain 3) heavy rain 4) light snow 5) moderate snow 6) blizzard	Descriptive.	Same as Southern Sierra.
HABITAT AVAILABILITY DATA	Male n=57; Female n=136 Habitat availability data sampled within the home ranges of 12 focal animals (4 male, 8 female) by generating 20 random UTM locations within each animal's home range. Each of these served as the basis of a pair of points, one located at random and one centered on a tree or log meeting minimum size requirements based on observed	n=100 Random plots were assigned to the study area by randomly generating UTM coordinates. The location was located using a 1:24000 topo map. Once the coordinates were located, the center of	No habitat availability sampling has yet occurred at North Coast.

Appendix 1, cont.

VARIABLE	Southern Sierra Method	Eastern Klamath Method	North Coast Method
	rest site use prior to June 1996. Briefly, the theoretical UTM coordinates were located in the field using map and compass, then random points were located by generating a random azimuth and distance between 10 and 50 m. Habitat data were then collected at the random site. From the random site, an intermediate log or tree meeting minimum size requirements was located (at least 12.5 m from the random point). From this intermediate point, another tree or log was located and served as plot center the structure-centered point. data was collected at random points and structure-centered points using the same methods as at rest sites with the following exceptions: 1) Line intercept transect distances were estimated, not measured along a tape. 2) Logs were counted and assigned to one of 4 maximum diameter classes: 0-30 cm, 30-60 cm, 60-90 cm, > 90 cm.	the plot was placed 22.6 m north of this location.	

Appendix 1, cont.

VARIABLE	Southern Sierra Method	Eastern Klamath Method	North Coast Method
TRACK PLATE DATA	One survey placing track plates at 2 km intervals throughout the study area was conducted during the from July - November 1995. Each track plate was checked once per week, each station was run for 3 weeks, chicken used as bait Habitat data was collected at track plate stations in the same fashion as described for habitat availability, but logs were not tallied along the transects. **83 stations**	Fowler and Golightly 1994, Linear spatial arrangement, stations serviced every other day. Riparian areas selected in 4 surveys. 22 days / survey. Chicken wings used as bait. Stations placed 50-100 m from roads. Habitat data collected was collected at 191 stations in the same fashion described for rest sites, with the following exceptions: - WHR habitat classification was provided for 119 stations, descriptions of habitat provided for 72 - Tree density for 3 size classes (<13 cm , 13-40 cm, and >40 cm dbh) calculated by species for the plot - Count of snags on the plot were categorized into 3 diameter classes (<15", 15-30", and >30") - snags were also categorized according to WHR decay classes (sound, rotten, hollow) **8 Surveys, 191 stations, 96 Survey nights, 6143 Survey Nights.**	

Appendix 1, cont.

VARIABLE	Southern Sierra Method	Eastern Klamath Method	North Coast Method
MORPHOLOGY and CAPTURE DATA			
# of individuals captured	Male n=11, Female n=22	Male n=9, Female n=13	Male n=13, Female n=18
# of trap nights during initial trapping in a distinct geographic area	n=315 Total recorded for initial trapping in the Camp Nelson and Mountain Home State Forest area.	N=851 Total recorded for trapping when an individual was not targeted or when trapping a new area for the first time.	Total recorded for initial trapping in the Pilot Cr. area and in the Cedar Gap area.
total number of individuals captured during initial trapping	Male n=3, Female=11	Male n=7, Female n=10	
total number of trap nights	n=1744 Total recorded for all trapping conducted during the study	n=1807	Same as Southern Sierra.
total number of captures	Male n=23, Female n=55 Total number of captures for the entire study.	Male n=22, Female n=21 Same as Southern Sierra	
# of individuals radiocollared	Male n=8, Female n=15	Male n=8 Female n=14	Male n=14 Female n=8
# of carcass recoveries	Male n=2, Female n=8 Total number of recoveries where part or all of a carcass, as well as the radio collar, was recovered.	Male n=2, Female n=4 Same as Southern Sierra	Male n=1, Female n=2 Same as Southern Sierra.

Appendix 1, cont.

VARIABLE	Southern Sierra Method	Eastern Klamath Method	North Coast Method
MORPHOLOGY and CAPTURE DATA (CONTINUED)			
# of collar only recoveries	Male n=1, Female=0 Total number of collar recoveries where in part of a carcass was recovered.	Male n=0, Female n=1 Same as Sequoia	Male n=1, Female n=4 Same as Southern Sierra.
estimated age	categorized as juvenile, young adult, and adult based on tooth wear, sagittal crest development (males) , and general body condition	categorized as juvenile, less than 22 months. Age class determined by tooth wear and sagittal crest development.	
weight	measured to the nearest 0.05 kg using a 3 kg Pesola scale for females and a 10 kg Pesola scale for males	to the nearest 0.1 kg	Same as Southern Sierra.
total length	measured in cm from the tip of the nose to the end of the last vertebrate	tip of the snout to the end of the tail bone	
tail length	from the base of the tail to the end of the last vertebrate	from the base of the tail to the end of the last vertebrae	
neck circumference	measured around neck, behind the ears	measured around neck, behind the ears	
Hind foot length	length of hind foot measured from posterior portion of foot to anteriormost toe	pad length measured	

Appendix 1, cont.

VARIABLE	Southern Sierra Method	Eastern Klamath Method	North Coast Method
sagittal crest	description of sagittal crest provided, no measurements taken	length; height	
dose	initial and subsequent injection volumes recorded in cc	initial and subsequent injection volumes recorded in cc	
body temperature	recorded with a rectal thermometer ~every 2 minutes during handling	recorded with a rectal thermometer ~every 2 minutes during handling	
mortality sources		Animal x-rayed, soft tissue necropsy when possible	

Appendix 2. Summary of methodolgical comparisons for variables described in Appendix 1.

VARIABLE	Possible Analysis Scenarios and/or Comparability
REST SITE DATA	
LOCATION DATA	
Rest Site Location	Comparable for the purposes of home range estimation. However, each rest site locations for each study area has a different absolute accuracy of rest site location: North Coast has GPS'd > 80% of all rest sites found, Southern Sierra has GPS'd ~20 % of rest site locations, and Eastern Klamath has GPS'd none of rest site locations. This discrepancy will not preclude home range analysis, but must be considered in interpreting home ranges. Strategies for assessing the absolute and / or relative accuracy of rest site locations should be discussed.
Rest Site Elevation	Comparable when converted to a common metric (m). However, accuracy of rest site elevation will be contingent on accuracy of rest site location and ./ or altimeters.
Location Precision	Comparable with slight crosswalking between study areas: EASTERN KLAMATH precision 1 rest sites = SOUTHERN SIERRA and NORTH COAST rest sites confirmed by site or sound EASTERN KLAMATH precision 2 rest sites = all other SOUTHERN SIERRA and NORTH COAST rest sites (structure known, but animal's presence not confirmed) EASTERN KLAMATH precision 3 rest sites = SOUTHERN SIERRA and SIX RVERS Stand Locations of precision 3 (immediate vicinity of rest site known, see "California Fisher Studies: Variable Definitions…" document for details)
Date Found	Seasons can be defined based on date found if calendar seasons are used.
STRUCTURE DATA	
Rest Site Structure	All 3 study areas can be categorized into: - LIVE TREES - SNAGS - LOGS - NESTS / GROWTHS in Live trees and snags - OTHER

Appendix 2, cont.

VARIABLE	Possible Analysis Scenarios and/or Comparability
FOR LIVE TREES AND SNAGS:	
Tree Species	Directly comparable, though aggregates of species may be required within study area if Chi Square analyses are used. Due to large scale differences in vegetation type, comparisons between study areas will be limited to a coarse level of taxonomic resolution. For example, comparison of proportion of rest sites in Pines vs others may be possible, but comparison of Pines vs. Douglas-fir vs. others will not be possible due to the absence of Douglas-fir at Southern Sierra. Frequency of tree spp. use per study area will be interesting qualitative comparison.
Tree DBH	Comparable with no adjustments
Tree Ht	Comparable, but because height has been estimated it will be subject to observer error.
Rest Site Ht	Comparable but subject to observer error. If we assume observer error was consistent at a site, we can variable describing the relative height of the rest site within the tree (rest ht / total tree height)
Rest Site Condition Class	Condition of live tree crowns does not seem comparable between study areas. Decay classes for snags:sound=stage 3-stage 5. Rotten and hollow=stage 6-stage 9.
Cavity Presence	Comparable.
Log Species	Directly comparable, though aggregates of species may be required within study area if Chi Square analyses are used. Due to large scale differences in vegetation type, comparisons between study areas will be limited to a coarse level of taxonomic resolution. For example, comparison of proportion of rest sites in Pines vs others may be possible, but comparison of Pines vs. Douglas-fir vs. others will not be possible due to the absence of Douglas-fir at Southern Sierra.
Log Maximum Diameter	Comparable, though subject to observer error.
Log Decay Class	sound=log class 1 and 2. rotten=log class 3 and 4 hollow=class 5.
OTHER STRUCTURE TYPES	Comparison of structure type distributions.

Appendix 2, cont.

VARIABLE	Possible Analysis Scenarios and/or Comparability
VEGETATION DATA	
Basal Area	Comparable with no adjustments
Tree DBH	Comparable if 4 largest DBH trees are used for North Coast and Southern Sierra, this can be compared to 4 largest DBH trees for Shasta t. Pilot studies on S-T suggest that plot size does not have a significant effect on this parameter (for plots > 0.02 ha).
WHR Habitat Type	Directly comparable (at least qualitatively), though subject to observer error.
WHR Size Class	Directly comparable (at least qualitatively), though subject to observer error.
WHR Canopy Class	Directly comparable (at least qualitatively), though subject to observer error.
Canopy Cover	Comparable though results must be interpreted with caution due to the difference in proximity of densiometer readings relative to rest site (5 m for Eastern Klamath vs. 12.5 m for North Coast and Southern Sierra)
Tree Species Present	Comparable, though limited to the 3 dominant species in the overstory and understory. Subject to observer error.
Overstory Canopy Cover	Comparable when totaled across all species inventoried for Eastern Klamath; Southern Sierra and North Coast recorded a single estimate for total overstory canopy.
Understory Canopy Cover	Comparable, though definitions of understory may vary between study areas. Further discussion of methods will help determine comparability.
# of Logs on plot	Not directly comparable. Shasta inventoried the entire plot while Southern Sierra and North Coast sampled the plot using line intercept methods.
% log cover	Not directly comparable. Shasta inventoried the entire plot while Southern Sierra and North Coast sampled the plot using line intercept methods. Number of logs and log cover will likely be limited to qualitative comparisons.
Log Size	Comparable when limit to logs > 15cm maximum diameter.
Log decay	Comparable. See structure description.
# of Snags	Not directly comparable; snags counted on plot for Eastern Klamath but sampled using prism for Southern Sierra and North Coast. Comparisons between study areas will be limited to qualitative comparison.

Appendix 2, cont.

VARIABLE	Possible Analysis Scenarios and/or Comparability
	Not directly comparable; snags counted on plot for Eastern Klamath but sampled using prism for Southern Sierra and North Coast. Comparisons between study areas will be limited to qualitative comparison. Additionally, snag diameters measured for North Coast and Southern Sierra while estimated for Eastern Klamath.
Snag Ht.	Not directly comparable; snags counted on plot for Eastern Klamath but sampled using prism for Southern Sierra and North Coast. Comparisons between study areas will be limited to qualitative comparison. Comparisons between study areas will be limited to qualitative comparison. Hts subject to observer estimation for all study areas.
Snag Decay	Not directly comparable; snags counted on plot for Eastern Klamath but sampled using prism for Southern Sierra and North Coast. Comparisons between study areas will be limited to qualitative comparison.
ABIOTIC DATA	
Slope	Comparable, though subject to observer error. A technique to control for observer error would be to obtain slope estimates from DEMs, though this requires comparable accuracy of rest site location between study areas. Comparison of field measurement seems more appropriate considering possible differences in rest site accuracy.
Aspect	Comparable, though subject to observer error. A technique to control for observer error would be to obtain slope estimates from DEMs, though this requires comparable accuracy of rest site location between study areas. Comparison of field measurement seems more appropriate considering possible differences in rest site accuracy.
Topographic Position	Comparable if Southern Sierra and North Coast aggregate 5 topographic position classes into 3: EASTERN KLAMATH Ridge Tops = Six / Southern Sierra Ridge Tops EASTERN KLAMATH Slopes = Six / Seq Convex, Bench, and Concave slopes EASTERN KLAMATH Draw Bottoms = Six / Seq Draw Bottoms. The definitions of each of the topographic positions needs to be discussed; all categorization will be subject to observer variation.
Distance to nearest water	Limited comparability between study areas using field estimations; again GIS may be a better method.
Distance to nearest road	Data not recorded in the field for Southern Sierra / North Coast and must be obtained from GIS.

Appendix 2, cont.

Variable	Possible Analysis Scenarios and/or Comparability
Temperature	Comparable, though different methods used.
% Cloud Cover	Comparable.
Precipitation	Comparable when Eastern Klamath descriptions are crosswalked to Southern Sierra categories. It may be possible to define "snow" and "snow free" seasons for further comparisons of rest site use. A definition of snow vs. snow free season may be developed.
HABITAT AVAILABILITY DATA	Direct comparisons between study areas will be of limited value due to different methods used and lack of data for North Coast.
TRACK PLATE DATA	Direct comparisons between study areas will be of limited value due to different methods used.
MORPHOLOGY and CAPTURE DATA	
estimated age	Comparable if reduce age classes to two for North Coast and Southern Sierra, juvenile and reproductive age adult.
weight	Directly comparable.
total length	Directly comparable.
tail length	Directly comparable.
neck circumference	Directly comparable.
hind foot length	Not comparable; different methods used between Eastern Klamath and Six / Seq.
Sagittal crest	Not comparable; size measured for Eastern Klamath, described for North Coast and Southern Sierra.
dose	Comparable.
Body temperature	Comparable, though subject to a variety of uncontrolled factors (ambient temperature...)
TRAPPING DATA	Some of the parameters related to trapping may be comparable (e.g., capture rate, total number captured, area surveyed), although further discussion of sampling approaches will be necessary.
# trapped	
# trap nights	

Appendix 2, cont.

Variable	Possible Analysis Scenarios and/or Comparability
ADDITIONAL DATA	
mortality sources	directly comparable
survivorship	
rest site use	rest site, natal den, maternal den
home range size	Minimum convex polygon, adaptive kernel