Conservation of Fishers *(Martes pennanti)* in South-Central British Columbia, Western Washington, Western Oregon, and California

2011

VOLUME II: Key Findings from Fisher Habitat Studies in British Columbia, Montana, Idaho, Oregon, and California

Recommended Citation:

Lofroth, E. C., J. M. Higley, R. H. Naney, C. M. Raley, J. S. Yaeger, S. A. Livingston, and R. L. Truex. 2011. Conservation of Fishers (*Martes pennanti*) in South-Central British Columbia, Western Washington, Western Oregon, and California–Volume II: Key Findings From Fisher Habitat Studies in British Columbia, Montana, Idaho, Oregon, and California. USDI Bureau of Land Management, Denver, Colorado, USA.

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USDI Bureau of Land Management, National Operations Center, Denver, Colorado

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PREFACE

The Interagency Fisher Biology Team produced 4 documents (Volumes I through IV) as part of the development of the Conservation Assessment (Assessment) and the Conservation Strategy (Strategy) for fishers (*Martes pennanti*) in south-central British Columbia, western Washington, western Oregon, and California (henceforth Assessment Area). Volume I (Conservation of Fishers [*Martes pennanti*] in South-Central British Columbia, Western Washington, Western Oregon and California–Volume I: Conservation Assessment) is a comprehensive review of best available information on fisher biology and habitat ecology based primarily on research conducted in the Assessment Area and adjacent regions. Volume I describes the current status of fisher populations and provides a broad overview of the physical and human environments in the Assessment Area. Volume II provides a detailed summary of results of fisher habitat studies from 27 study areas within the Assessment Area and adjacent regions. Volume II was developed as a supporting document for the primary syntheses of habitat associations presented in Volume I (Chapter 7), as well as a general reference to help orient practitioners to the body of available information for their geographic area of interest. Practitioners are strongly encouraged to reference the original literature pertinent to their region rather than rely exclusively on Volume II. Volumes I and II reference source materials produced and available in a document (i.e., progress or final report, thesis, dissertation, peer-reviewed paper, etc.) prior to 1 July 2008. Volume III (Conservation of Fishers [*Martes pennanti*] in South-Central British Columbia, Western Washington, Western Oregon, and California–Volume III: Threat Assessment) is an assessment of threats pertinent to fishers and fisher habitat within the Assessment Area. Volume IV (Conservation of Fishers in South-Central British Columbia, Western Washington, Western Oregon, and California–Volume IV: Conservation Strategy) was developed based on the information and syntheses in Volumes I through III to achieve the goal of "self-sustaining, interacting populations of fishers within their historical west coast range."

Larry R. Davis

ACKNOWLEDGEMENTS

We thank the many agencies and individuals that supported this multiyear effort to develop a fisher conservation assessment for British Columbia, Washington, Oregon, and California. We thank the Fisher Science Team for insightful discussions on fisher ecology. We thank many of the principal investigators identified in this volume for freely providing project documents and reviewing our syntheses of their work. This volume of key findings benefited greatly from comments and suggestions for improvement provided by the Fisher Science Team and 3 anonymous peer-reviewers. We also received many helpful comments from more than 20 biologists and resource managers associated with various state, federal, and provincial agencies, private industry, nongovernment organizations and independent consultants.
We thank the fisher researchers who generously provided their photographs for publication in this volume. The federal, state, and provincial agencies associated with members of the Interagency Fisher Biology Team provided support including time and travel for individuals to attend working meetings. The USDI Fish and Wildlife Service (Pacific Region), and the Interagency Special Status and Sensitive Species Program (USDA Forest Service Pacific Northwest Region and USDI Bureau of Land Management Oregon/Washington) provided additional funding to assist with costs. The map-based figure was capably produced by Dave LaPlante of Natural Resources Geospatial. Janine Koselak (USDI Bureau of Land Management, National Operations Center) capably managed the layout and publication process.

CHAPTER 1. INTRODUCTION

Numerous field studies have been conducted on populations of fishers in British Columbia, Montana, Idaho, Oregon, and California, most of which have focused on habitat associations at 1 or more spatial scales (Table 1.1; Fig. 1.1). We have tried to identify all available information on fisher habitat ecology (i.e., documented in a progress or final report, thesis, dissertation, peer-reviewed paper, etc.) from fisher habitat studies conducted west of the Rocky Mountains. We considered all literature available prior to 1 July 2008 in our review of habitat studies; new information that has become available since this date was not included in our review. We did not include studies that focused on other aspects of fisher ecology (e.g., food habits) or detection surveys that only documented presence of fishers in a study area. We also do not report on studies that describe the application of fisher habitat associations (e.g., models) to explore solutions to management issues. We review fisher habitat studies from 27 study areas within 8 distinct fisher populations. One to many individual studies have been conducted within each study area. Our review includes 3 study areas within which the habitat associations of recently translocated fishers were investigated (Beaver Valley, East Kootenay, and Cabinet Mountains). We report findings using the investigators' terminology with the exception of scale, which, in some cases, we were required to interpret based on our working definitions (Section1.1). We provide scientific names for each species after its first occurrence, and provide a complete list of English and scientific names in Appendix 1.1.

1.1 Scale and Habitat Associations

Fishers appear to use landscapes at different spatial scales for different behaviors and activities (Powell 1994, Weir and Harestad 2003). For example, fishers may establish home ranges at the landscape scale, forage at the site scale, and select habitat for resting or denning at the site and structure scales (Powell 1994, Powell and Zielinski 1994, Weir and Harestad 2003). There is no universally appropriate scale for investigating fisher habitat associations because the scale must match the questions being asked (Buskirk and Powell 1994, Powell and Zielinski 1994). Thus, studies on fisher habitat ecology have been conducted at various spatial scales (Fig. 1.2) depending on the behavior being investigated and the specific research objectives involved. Furthermore, scale is an important consideration when summarizing and comparing information among studies. Analyzing and interpreting data at a spatial scale that is not comparable to that at which the data were collected, or applying information derived from one scale to a different scale, may lead to incorrect conclusions (Buskirk and Powell 1994, Powell and Zielinski 1994).

Because of the complexity of available fisher habitat data at various spatial scales, and the availability of new data from several studies that have not been reported elsewhere, we used a novel approach to summarize information on fisher habitat associations. We developed a standardized template and summarized key findings from studies that investigated fisher habitat associations for each study area within a fisher population. Our approach facilitates comparison of key findings among studies and fisher populations and provides 1) a consistent format for organizing and summarizing available habitat data by fisher population, study area, and spatial scale; 2) documentation of underlying data used to summarize information on fisher habitat associations (Volume 1, Chapter 7); and 3) a reference tool that can be used by biologists and resources managers. This reference tool will enable users to easily identify where fisher habitat studies have been conducted, determine what type of information on habitat relationships was generated,

Table 1.1. Five spatial scales at which habitat data were collected during fisher studies in the Assessment Area (Study Areas 8–27) and adjacent regions (Study Areas 1–7) in western North America: landscape (L), home range (HR), stand (ST), site (SI), structure (SR). Only information that was available as of 1 July 2008 was included (blank cells denote no available information).

		Spatial scale				
Fisher population and study area no.	**Study year**	**L**	**HR**	**ST**	**SI**	**SR**
Western Plateaus and Valleys, British Columbia						
1. Williston	1996–2000	x	x	x	x	x
2. McGregor	2003–2005			x		
3. Chilcotin	2002–2003					
	2005–present			x		x
Cariboo, British Columbia						
4. Beaver	1990–1992	x	x	x	x	x
Southern Interior Mountains, British Columbia						
5. East Kootenays	1996–1999	x	x			
Northwestern Montana						
6. Cabinet Mountains	1988–1991	x	x			
North-central Idaho and West-central Montana						
7. Nez Perce National Forest	1985–1988	x	x		x	x
Cascade Range, Oregon						
8. Southern Oregon Cascades	1995–2001	x	x		x	x
Northern California-Southwestern Oregon						
9. Siskiyou National Forest	1997				x	
	2000–2001					
10. Green Diamond Resource Company	1994–1997	x		x	x	x
	2002–2003					
11. Redwood National and State Parks	2002	x		x	x	
12. Sacramento Canyon	1990–1995	x	x	x	x	x
13. Hoopa Valley Indian Reservation	1996–1998	x	x	x	x	x
	2004–present	x				
14. Shasta-Trinity National Forest	1992–1997	x	x		x	x
15. Shasta Lake	2003–2006	x				
16. Big Bar	1977–1979		x	x		
17. Pilot Creek, Six Rivers National Forest	1993–1997		x		x	x
18. Hayfork Summit	2005–2006					x
19. Coastal Northwestern California	1994	x			x	
20. Northern California Inventory	1991–1997	x			x	
21. Mendocino National Forest	2006	x		x	x	
Southern Sierra Nevada, California						
22. Sierra Nevada Fire and Fire Surrogate	2002–2005				x	
23. Kings River, Sierra National Forest	1995–2004	x	x		x	x
24. Sequoia-Kings Canyon	2002–2004	x			x	
25. Tule River	1994–1997		x		x	x
	2000–2001					
26. Sequoia National Forest Inventory	1991–1992	x			x	
27. Sierra Nevada Inventory and Monitoring	1996–present	x			x	

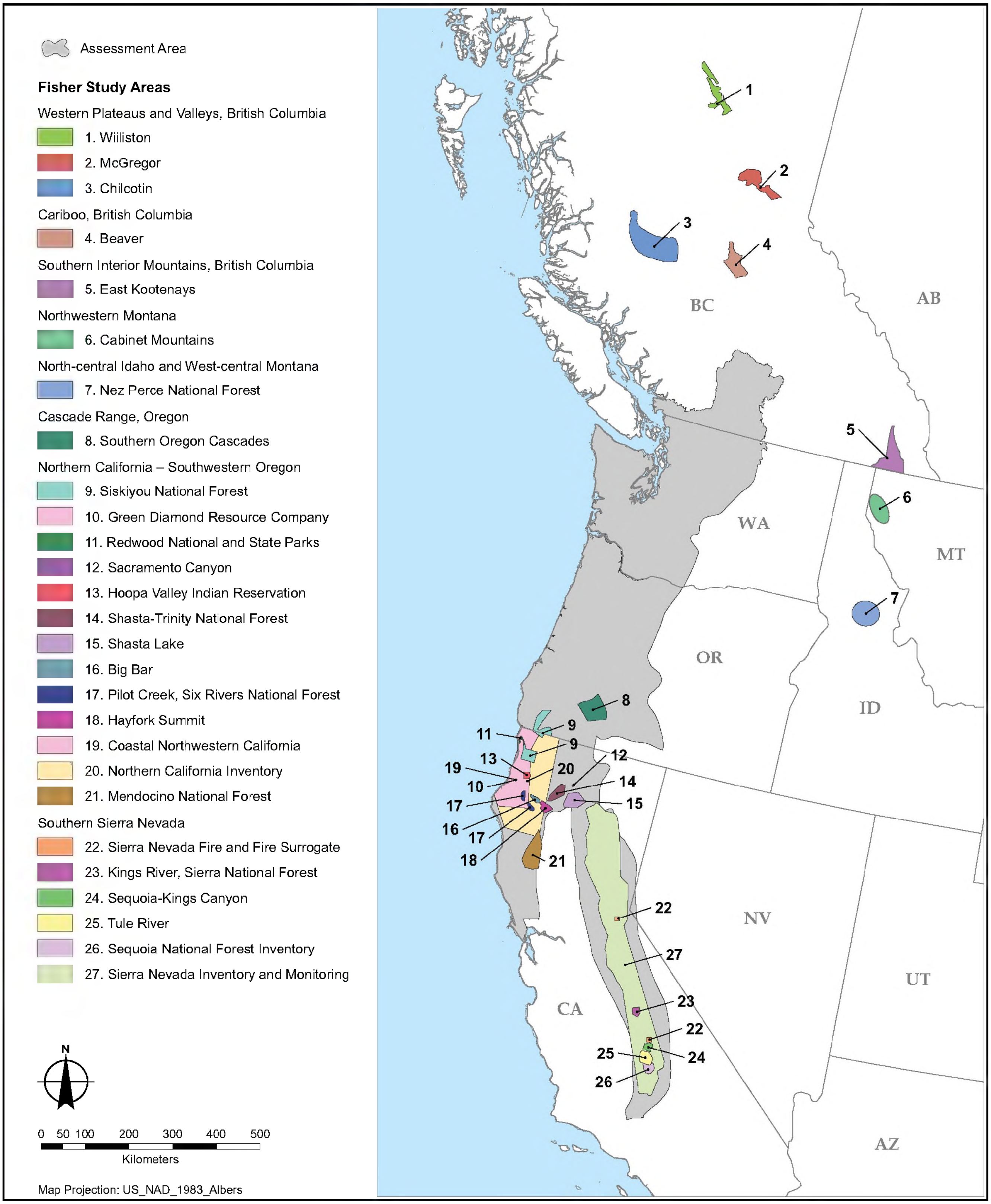

Figure 1.1. Fisher habitat study areas within the Assessment Area and adjacent regions in western North America.

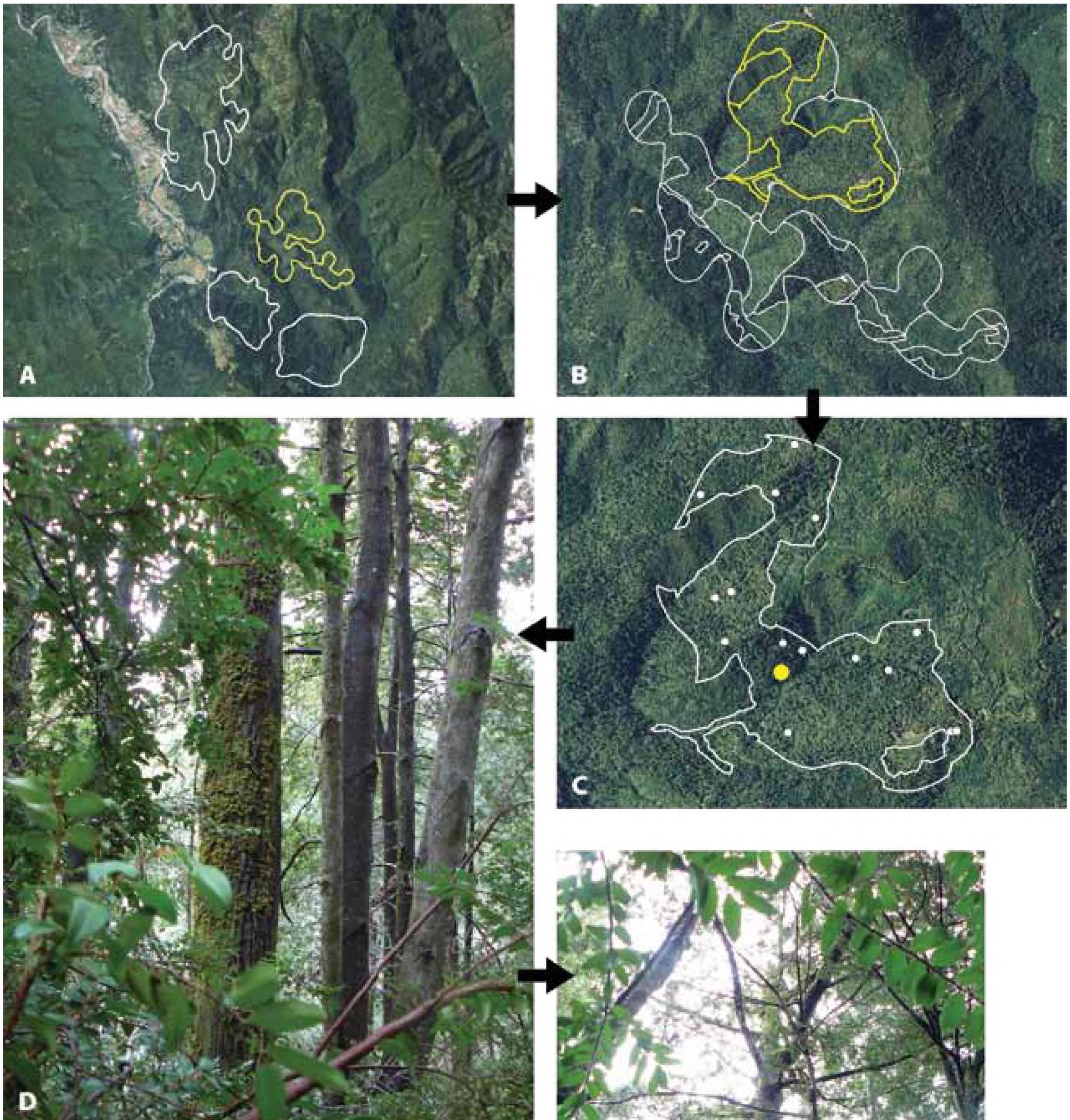

Figure 1.2. Examples of 5 spatial scales at which data are frequently collected when investigating habitat selection by fishers: the landscape scale (A; the graphic depicts a number of fisher home ranges within a population); the home range scale (B; the graphic depicts a fisher home range and the forest stand polygons within it); the stand scale (C; the graphic depicts a single stand within a home range and telemetry locations of a fisher within that stand); the site scale (D; habitat conditions in the immediate vicinity of a fisher telemetry location); and the structure scale (E; a tree in which a fisher denned). Photo and graphics courtesy of J. Mark Higley, Hoopa Tribal Forestry.

and review a detailed summary of the most important results (current as of 1 July 2008). However, this clearinghouse of information should be viewed as a starting point for practitioners, and we strongly encourage users to complement this compilation by reviewing the original sources of information (identified in the key findings for each study area) that apply to their area of interest. We have organized information in the Key Findings (Chapter 2, Sections 2.1–2.8) as follows:

1. *Study Area Meta-Data*–For each study area we have provided a summary of the study objectives, principal investigator(s), duration of the study(s), study area description, methods used to collect and analyze fisher habitat data, and any publications and reports generated from the study.

2. *Study Area Key Findings*–For each study area, we organized findings on fisher habitat associations into 5 sections based on spatial scale: 1) landscape, 2) home range, 3) stand, 4) site, and 5) structure. For each spatial scale that had available habitat information, we summarized the key findings at that scale (including data summaries and tables when appropriate), and the investigators' interpretation of results at that scale. Publications and reports from most studies identified the spatial scale at which data were collected. For those that did not, we determined the appropriate spatial scales from information provided on the study design, sampling methods, and analyses.

We defined spatial scales, and included examples of information that might be investigated at each scale, as follows (see also Fig. 1.2):

1. *Landscape scale*–The broadest spatial scale including regional extents at which the population of interest and associated population-level processes occur (e.g., home-range establishment, breeding, dispersal, recruitment, etc.). The size of the landscape will vary depending on the geographic extent of the fisher population of interest. Based on McCullough (1996), we define a population as an interacting collection of individuals occupying a defined geographic area, the boundary of which can be determined in various ways including a geographic unit in which movement and interaction of animals are greater within than between adjacent units. Analyses at this spatial scale may include information such as the configuration and continuity of various vegetation types, distances between patches of the same vegetation type, and degree of connectivity, and how these various factors may affect the distribution and abundance of fishers. Habitat associations at the landscape scale have been studied using results from large-scale systematic surveys of fisher populations or extensive investigation of a population of radio-tagged fishers, and associated quantitative information on vegetation communities, forest age, and successional stages derived from classified satellite imagery, or vegetation data in geographic information systems (GIS).

2. *Home range scale*–Home range is typically defined as the area used by an individual animal for its normal daily movements (Burt 1943). Analyses at this spatial scale may include information such as vegetative composition, proportions of various habitat types, and configuration of habitat patches within individual fisher home ranges, and how these attributes may affect individual fitness. Typically, habitat associations at this spatial scale have been investigated using relocation data from radio-collared fishers and quantitative information on plant communities, forest age and successional stages derived from classified satellite imagery or other vegetation data in GIS.

3. *Stand scale*–A discrete area composed of relatively homogeneous vegetative characteristics (e.g., species composition and successional stage). Analyses at this spatial scale may include information such as the size of available stands and the vegetative characteristics, forest age, successional stage, and size of stands in which fishers denned, rested, or foraged, and how these attributes may affect individual fitness. Habitat associations at this spatial scale have been investigated using relocation data from radio-collared fishers and GIS or map-based polygon data delineating stands.

4. *Site scale*–The immediate vicinity around specific locations used by fishers for various behaviors such as resting, denning, or foraging. Analyses at this spatial scale may include information such as vegetative composition and forest structure (e.g., density of live trees, dead trees and logs, various measures of vegetation cover, etc.) in the immediate vicinity of resting, foraging, and denning locations, and how these attributes may affect individual fitness. Habitat associations at this scale have been investigated using relocation data from radio-collared fishers and detection survey data in conjunction with quantitative habitat data measured at points along transects or within relatively small-scale plots.

5. *Structure scale*–The type of structures used by fishers for resting and denning (e.g., the tree or log where a fisher was resting) as well as the associated microstructures (e.g., mistletoe broom, cavity). Analyses at this spatial scale may include information such as tree species, sizes of structures used, characteristics of associated microstructures, and how these attributes may affect individual fitness. Habitat associations at this scale have been investigated using walk-in telemetry methods to locate individual structures used by radio-collared fishers for resting or denning, and with return visits at a later date to collect detailed habitat measurements.

1.2 Interpreting Habitat Data

Fisher researchers have used many terminologies, sampling designs, and field-sampling methods to assess resource use and availability, making comparisons of results among studies difficult. We present a few general caveats to make the reader aware of some of the fundamental methodological challenges faced by those conducting research on fisher habitat relations. We do so to improve consistency of interpretation and application of these findings. We advise practitioners using this reference to refer to original literature whenever possible to better understand detailed field methods, results, and appropriate inferences.

1.2.1 Field Research Methods–Direct Versus Inferred Observation of Activity and Behavior

Studies of fisher habitat associations in British Columbia, Montana, Idaho, Oregon, and California have relied largely on 3 methodological approaches: 1) the use of radiotelemetry, where individual fishers are monitored and their behavior can be observed directly (visually or, in most cases, by isolating an animal's radio signal to a specific location or structure and determining whether they are foraging [e.g., observing prey remains], resting, or denning); 2) noninvasive survey methods (e.g., track-plate surveys, remote-camera surveys) where individuals are generally not identified and animal behavior is inferred (e.g., track-plate stations are visited by animals that are travelling or foraging); and 3) snow tracking where individuals may be identified using genetic methods (from hair or scat collected along tracks), and animal behavior can often be inferred (Plate 1.1). Studies based on snow-tracking are relatively rare for western fisher populations, and the majority of existing information comes from studies relying on other noninvasive techniques and radiotelemetry. Snow tracking has most often been used as a complementary field technique in radiotelemetry studies, particularly in northern studies where snow conditions are conducive to tracking.

Plate 1.1. Fisher habitat studies have relied primarily on three techniques: radio-telemetry (A); non-invasive techniques such as track plates (B); and snow-tracking (C).

Radiotelemetry research has often focused on describing the activity and behaviors of known individuals to investigate habitat and space use, habitat selection, and demographic measures. Such studies are effort intensive and may cover smaller spatial extents (e.g., 200–500 km^2 study areas, although some are much larger) than other types of studies, but are often data rich (although inferences may be limited by the number of focal animals monitored and the duration of the study). In addition to the number of animals monitored, the sex and age distribution of individuals monitored can influence analytical opportunities and scope of inference. For example, a radiotelemetry study that tracks male fishers for 1 field season can provide valuable insights into some aspects of fisher habitat ecology (e.g., rest structures used by male fishers for that season) but will not provide the insights of a multiyear study monitoring year-round habitat use by a large number of females and males. These factors should be considered when drawing inferences from existing research and integrating literature into land management planning. As study duration and number of individuals monitored increases, and the sex/age distribution more closely reflects that of the population, the strength of inference increases accordingly.

Studies relying on noninvasive sampling techniques typically do not collect information from known individuals; thus analyses of data from such studies may be limited. Recent advances in genetic sampling permit identification of individuals detected if hair or scat samples can be collected, potentially increasing the utility of such data. The scope of inference from analysis of detection data depends largely on the scale at which the study was conducted. Detection studies can be spatially intensive when sampling a small number of animals, or spatially extensive when sampling an entire population. Inferences should be drawn relative to the area included in the detection study. As with radiotelemetry studies, the temporal extent of detection studies should also be considered when interpreting results and drawing inferences.

Radiotelemetry and detection studies generally examine different aspects of fisher habitat ecology. Because sampling occurs at an individual level and each focal animal's gender is known, radiotelemetry studies can effectively investigate numerous aspects of fisher habitat such as den structure selection, den site selection, habitat associations of foraging animals, and home range size and composition. In the case of spatially extensive detection studies, the spatial arrangement of sampling units (track plates and cameras) affects the likelihood of detecting the same individual at 1 or more sampling units, and all detections are assumed to be indicative of "active" animals. Whether or not an animal is detected in habitat where it typically forages or is drawn into areas owing to the presence of bait or commercial trapping lure is unknown. Establishing sampling designs that minimize the likelihood that the same individual is detected at multiple stations and that include habitat types representative of the area being investigated generally increases the strength of inference from detection studies. Detection studies conducted to date have not identified fisher gender; this limits inference, particularly for short-duration studies in small areas. At large spatial scales, where sampling is consistent temporally and spatially (i.e., sites are sampled repeatedly over multiple years), and fishers are repeatedly detected, it can generally be assumed that certain life requisites are being met at smaller spatial scales within the overall area sampled.

1.2.2 Field Research Methods–Habitat Sampling

Fisher researchers investigating habitat associations are faced with the challenge of balancing field effort between collecting data on fisher populations and collecting habitat data. The need to quantify habitat conditions for assessment of habitat use and selection requires tradeoffs between the time needed to collect the data and the rigor of the collection technique.

Investigators typically collect habitat data to meet specific research objectives of their studies, rather than use standardized techniques that facilitate comparison of results across study areas. Resource practitioners using this reference must be aware of the habitat sampling methods used and how they influence results and conclusions, and should use caution when comparing results from studies using different habitat sampling techniques. Habitat sampling protocols often integrate multiple techniques to estimate a variety of parameters. For example, a study may use fixed-radius plots to sample small-diameter trees, plotless techniques (e.g., prism sampling) to estimate large-tree density, line-intercept methods to sample coarse down wood, and visual estimates to describe shrub cover. In this example, selection of plot size (e.g., 5-m radius vs. 25-m radius), selection of prism size (e.g., 20-factor prism vs. 40-factor prism), and length and orientation of line intercept transect may all influence observed results. Visual estimates are often subject to considerable inter-observer variability and are generally less repeatable than other techniques. Comparisons of absolute values may be appropriate when exact or similar field methods have been used, but can be inappropriate when habitat-sampling techniques differ substantially; in the latter situation, relative comparisons of habitat attributes may be more appropriate.

Estimates of canopy closure are widely used in descriptions of fisher habitat, but definitions of canopy closure and methods to quantify canopy closure often vary. Unless an author provides a description of the specific vegetative layer measured (e.g., canopy of overstory trees, shrub canopy, etc.), we use the term "canopy cover" to describe all vegetative cover (both foliar and structural) for all foliar forest layers that occur above breast height (1.4 m).

Forest complexity is often reported in fisher habitat studies although, as with canopy closure, there is no standardized definition of complexity or widely accepted technique to measure complexity. Some researchers use estimates of various canopy layers as an indication of complexity, whereas others may estimate vertical and horizontal complexity by measuring variation in the sizes of trees and logs. In addition to structural complexity, some researchers use floristic diversity as a measure of forest complexity.

1.2.3 Data Interpretation–Habitat Use, Preference, Selection, and Avoidance

Habitat use, preference, selection, and avoidance are fundamental concepts in establishing basic habitat associations for any species. These terms, however, are subject to misuse and misinterpretation, both in the literature and in the application of research findings. They have been the subject of extensive theoretical and applied research, and we provide only a rudimentary overview here. We refer the reader to a series of papers published in Journal of Wildlife Management (2006, Volume 70:2) for a review of current analytical approaches and numerous seminal references that address habitat selection theory.

Habitat use simply refers to the observation of an animal's occurrence in, or use of, a specific habitat type, and does not demonstrate any link, direct or implied, to individual fitness. Habitat selection, however, infers a direct link to individual fitness. Investigating habitat selection for specific types of behavior (e.g., denning, resting) generally improves the ability of investigators to demonstrate a link to fitness. However, we do not attempt to interpret the reporting of use versus selection in this volume; rather, we summarize habitat use and selection as was reported by the researchers. The fundamental difference between habitat use and habitat selection is the application of statistical techniques to demonstrate whether use of a habitat type or resource is greater than its availability. That is, within a specified area, a habitat resource is selected if its use is statistically greater than expected based on resource availability. Habitat selection and preference are often used synonymously. Conversely, a resource is considered avoided (and therefore assumed to have a negative effect on fitness) if it is used significantly less often than available to the individual or population.

We encourage practitioners to consider the following questions when interpreting habitat data:

1. How extensive and intensive was the study in terms of study area size, sample size of replicates (e.g., focal animals, rest structures, detection sample units), and what was the duration of the study?

2. How did the investigators define canopy cover, forest complexity, and other habitat variables?

3. Were canopy cover or other variables measured in the field (e.g., at a rest structure or track-plate station) or were they estimated remotely (e.g., generated from GIS vegetation data or aerial photography)?

4. Were canopy cover or other variables measured directly (e.g., spherical densiometer, moosehorn) or visually estimated?

5. Were habitat attributes measured as continuous or categorical variables?

6. Were sampling techniques appropriate for the parameter estimated (e.g., large, fixed-area plots used to estimate large-tree density), and were variables measured and reported at an appropriate spatial scale?

Rick Schlexer

CHAPTER 2. KEY FINDINGS

2.1. Western Plateaus and Valleys, British Columbia Fisher Population

2.1.1. Williston, Study Area 1

Study Objectives: This study examined habitat relationships, spatial organization, and behavior of fishers in an industrialized forest landscape near the northern edge of their range in central British Columbia.

Principal Investigator(s): R. D. Weir (Artemis Wildlife Consultants) and F. B. Corbould (Peace Williston Fish and Wildlife Compensation Program)

Duration: 1996–2000

Study Area: The Williston study was conducted on provincial crown land on the west side of Williston Reservoir in the Omineca region of British Columbia. The study area was located in the Rocky Mountain Trench approximately 70 km northwest of Mackenzie, British Columbia. It encompassed portions of the Manson, Omineca and Mesalinka River drainages. It was bordered on the east by a 300-km long hydro-electric reservoir (Williston Lake). The study area was 1,930 km^2 and was dominated by forested environments ranging in elevation from 670–1,100 m. The study was conducted within the Sub-boreal Spruce biogeoclimatic zone (Meidinger and Pojar 1991). Dominant vegetation types were sub-boreal mixed conifer and mixed wood (coniferous and deciduous). Riparian areas were dominated by mixed hybrid spruce (*Picea glauca x engelmannii*) and black cottonwood (*Populus trichocarpa trichocarpa*) stands. Annual precipitation ranged from 690–905 mm. Average snow depth was 40–50 cm throughout the winter. Mean annual temperature was 2° C and ranged from -47–36° C. The study area contained all or parts of 5 registered traplines and was heavily influenced by industrial forestry.

Methods: Weir and Corbould live trapped and radio-tagged 20 different fishers with radio-collars (1996–1997) or surgically implanted abdominal implant transmitters (1998–2000). Fishers were monitored with traditional VHF ground and aerial telemetry on a daily to weekly schedule throughout the year. Monitoring was more intensive in winter than other seasons, and was conducted almost exclusively during diurnal periods. Walk-in telemetry was used to locate resting and denning sites. Home range composition was evaluated using geographic information systems (GIS) with predictive ecosystem mapping data. Ground sampling at fisher locations and random locations included estimates of vegetative strata cover, tree mensuration data, and characteristics of forest structures posited to be important to fisher use of habitat. Sample sizes for habitat selection analyses varied by scale and ranged from 10 to 12 resident fishers.

Weir and Corbould identified habitat features at a variety of scales which might influence fisher habitat selection, and developed predictive relationships between these and the probability of use by fishers. At the landscape scale they evaluated habitat selection by comparing features of home ranges occupied by radio-tagged fishers to features of potential (pseudo) home ranges that could occur within the landscape using interpreted predictive ecosystem mapping. Both 95% utilization distribution (fixed kernel) and minimum convex polygon home ranges were calculated for radio-tagged fishers. They conducted logistic regression analyses on 10 measured characteristics of fisher home ranges. At the stand scale Weir and Corbould compared features of stands used by 10 radio-tagged fishers to those available within their respective home ranges using logistic regression analyses. They used detailed 1:20,000 ecosystem mapping and associated stand attribute sampling as

underlying data for habitat analyses and developed predictive resource selection functions. They tested 14 a priori candidate models, using 20 variables in their analyses. Models were based on previous literature and suspected ecological relationships within their study area. At the site scale Weir and Corbould compared biotic and abiotic variables of sites (their patches) used by fishers to those of randomly selected sites contained within the same stand using logistic regression techniques. They examined 27 candidate a priori models to evaluate the influence of these variables on site selection by fishers for 3 behaviors. Fourteen resting site models, 5 whelping site models, and 8 models for active behavior were evaluated. Candidate models were constructed on the basis of previous studies of fisher ecology and suspected relationships within their study area. Population averaged models were generated for each candidate model and evaluated using quasi-likelihood information criteria. At the structure (their "element") scale Weir and Corbould (2008) evaluated selection by comparing structures associated with 68 precise radiolocations of 11 fishers to the features of structures located within the same site using similar analytical techniques as those for site scale selection. Candidate sets of models were analysed for 3 different fisher habitat attributes: arboreal rest sites, coarse woody debris (CWD) rest sites, and reproductive dens. Weir et al. (2004) evaluated the effect of ambient temperature on selection of structures used for resting by documenting structure scale selection from 86 resting sites. The data in Weir et al. (2004) are not mutually exclusive to the Williston study and are also discussed in the Beaver study area key findings.

Publications and reports: Several unpublished progress reports, 1 conference paper (Weir and Corbould 2000), 1 project completion report (Weir and Corbould 2008), and 3 peer-reviewed publications (Weir et al. 2004, Weir and Corbould 2006, Weir and Corbould 2007).

Results:

Landscape Scale

All information is from Weir and Corbould (2008).

Key Findings

- Characteristics of the home ranges of 10 resident fishers (2M, 8F) were compared to those of 162 pseudo home ranges (generated and analyzed independently for each fisher).
- The model which best explained the likelihood of occupancy of a home range by fishers was the percentage of the home range composed of open habitat (non-forested wetlands and recent logged areas; negative association).
- The next best model (24 times less likely) was the percentage of the home range with ≥ 30% overhead cover (positive association).
- The 95% confidence set of best models included 7 models (Table Williston 1).
- Parameterization of the best model suggested that a 5% increase in open areas within a potential home range decreased the probability of occupancy by 50%. A 25% increase in open areas reduced the relative probability of occupancy to essentially nil.

Table Williston 1. Variables included in the 7 best models explaining home range selection by fishers in the Williston Basin, British Columbia (modified from Weir and Corbould 2008).

Variable	Variable association
Open areas	Negative
Non-forested ecosystem associations	Negative
Forested ecosystem associations	Positive
Recent logging (0-12 yrs)	Negative
Stands ≥30% cover	Positive
Mature and old structural riparian	Positive
Habitat Suitability Index	Positive

Author's Interpretation

- Fishers selected home ranges based on avoiding open areas within their home range. This was apparently more important than inclusion of specific features of the landscape.

- Although other variables were part of alternate models, these had substantially less predictive power.
- Fishers were posited to behave in this fashion because of lower preferred prey densities associated with wetland and recently logged areas and increased mortality risk associated with predation.

Home Range Scale

All information is from Weir and Corbould (2008).

Key Findings

- There were no habitat association findings reported at this scale.
- Mean 95% utilization distribution (fixed kernel) home range size for females was 49.1 km^2 (SD = 16.3, n = 6) and for males was 218.8 km^2 (n = 2).
- Minimum convex polygon home ranges (100%) averaged 59.0 km^2 for females (SD = 33.2, n = 6) and 177.5 km^2 for males (n = 2).

Stand Scale

All information is from Weir and Corbould (2008).

Key Findings

- Data supported only 2 of the 14 models that predicted the selection of stands within the home range as being plausible. Both models were nearly equally supported by the data, and were 6,900 times more likely than other models within the candidate set.
- The best supported logistic model included ecosystem association as the only predictor. This model (based on 80% of data points collected) was demonstrated to work well to predict outcomes of the reserved 20% test data.
- The model indicated that fishers were 3.5 times less likely to use Spruce Dry over Spruce Zonal (mesic) ecosystems and 5.4 times as likely to use Spruce-Wet over Spruce-Zonal ecosystems (Table Williston 2).
- The data supported a second model almost as well which included several structural attributes of stands (Table Williston 2).
- Stand scale selection was positively related to high (2–10 m) shrub cover and volume of CWD >20 cm diameter and negatively related to deciduous tree cover and density of trees with spruce broom rust (*Chrysomyxa arctostaphyli*) or fir broom rust (*Melampsorella caryophyllacearum*).

Table Williston 2. Ninety-five percent confidence set of models that explained the selection of stands within the home range of radio-tagged fishers in the Williston region of north-central British Columbia, 1996–2000 (modified from Weir and Corbould 2008).

Model category	Predictors of probability of use of stands within home range
General	Ecosystem association
Resting, cover	Volume of elevated large CWD, density of trees with rust brooms, coniferous tree cover, deciduous tree cover, high-shrub cover

Author(s) Interpretation

- The supported models were complimentary to one another, and both were useful for interpretation and extension.
- Fishers selected stands within their home ranges on the basis of ecosystem association and structural attributes.
- Fishers were least likely to select Spruce-Dry ecosystems, most likely to select Spruce-Wet ecosystems and neutral with respect to other ecosystems found within home ranges. Other attributes of stands found to be useful predictors

of stand scale selection by fishers were volume of elevated large CWD, density of trees with rust brooms, and cover of coniferous trees, deciduous trees and high shrubs.

- Selectivity for Spruce-Wet ecosystems may have been related to environmental conditions found predominantly within them that were not evaluated within the context of these analyses (e.g. prey abundance). Use of these wet riparian forests ecosystems were 5.4 times as likely to be used as the next most commonly used ecosystems, consistent with the findings of other studies. Selection of structural features was related to fishers use of foraging and resting habitats.

Site Scale

All information is from Weir and Corbould (2008).

Key Findings

- Site scale comparisons (n = 141) were evaluated for 12 radio-tagged fishers within the study area (62 resting, 13 reproductive dens, and 66 sites with unknown activity; Table Williston 3).
- Fisher rest sites included 39 arboreal (9 cavities and 30 branch platforms or rust brooms), 11 CWD, 2 CWD piles, and 3 ground sites.
- The best candidate model to predict fisher selection of sites for resting was one which included density of trees with rust brooms and total length of logs with resting potential. The only other resting site model in the 95% CI of models included density of trees with rust brooms and volume of elevated large CWD as variables.
- Four models (including the null) were included in the 95% confidence set to explain selection of reproductive sites. The model variables included maximum dbh of trees, deciduous tree cover and density of cavity trees at the site. All relationships were positive.
- Five candidate models and the null model to predict fisher selection of sites for active behavior were included within the 95% confidence set. These models showed poor discriminatory power, thus they were unable to assess selection for habitat at this scale.

Table Williston 3. Characteristics of sites used by fishers in the Williston study (1996–2000) (modified from Weir and Corbould 2008).

Variable	$\bar{x}$	SD
Vegetation cover (%)		
Tree cover	15.3	13.0
Coniferous tree cover	12.2	11.9
Deciduous tree cover	3.9	7.3
High shrub cover	23.2	15.3
Coniferous shrub cover	8.1	10.9
Low shrub cover	27.0	18.6
Leaf-off cover[a]	20.7	11.4
Leaf-on cover[a]	58.5	22.5
Tree density (stems/ha)		
All trees	374.0	350.8
Trees >35 cm dbh	80.3	96.9
Trees with cavities	3.9	11.3
Potential den trees	2.0	6.4
Trees with rust brooms	13.5	36.5
Declining or dead trees[b]	44.0	95.4
Coarse woody debris		
Number of pieces/transect	14.8	9.5
Density (pieces/m)	0.4	0.6
Index of aggregation	2.1	1.2
Mean piece length (m)	7.4	3.6
Total volume (m^3/ha)	173.5	182.9
Hard[c] volume (m^3/ha)	119.5	170.0
Elevated[d] volume (m^3/ha)	80.7	135.7
Elevated large[e] volume (m^3/ha)	54.1	127.0
Total length with rest-site potential (m)	2.9	7.8
Total length suitable for travel (m)	1.4	2.1

[a] cover provided by trees and shrubs
[b] appearance codes 2-9 (British Columbia Ministry of Environment, Lands and Parks and British Columbia Ministry of Forests 1998*a*)
[c] decay classes 1-3 (British Columbia Ministry of Environment, Lands and Parks and British Columbia Ministry of Forests 1998*b*)
[d] piece suspended above ground at survey point
[e] pieces >20 cm diameter and suspended above ground

Author(s) Interpretation

- Site scale selection for resting was strongly affected by density of structures used for resting. Small increases in densities of trees with rust brooms, density of trees with cavities, or increases in the number of pieces of CWD with resting site potential resulted in large increases in the likelihood of these sites being selected over others within the same stand.
- The results were consistent with other fisher habitat selection studies and site selection may not be independent from structure selection (see below) due to the overlap in habitat features at these 2 scales.

Structure Scale

All information is from Weir et al. (2004) and Weir and Corbould (2008).

Key Findings

- Rest sites were located primarily in branches of live trees (57%), in tree cavities (19.8%), under CWD (18.6%), and in ground structures (4.6%).
- Branch rest sites were typically associated with abnormal growth structures such as spruce broom rusts. Fishers rested on tree branches or in cavities at warmer ambient temperatures and under CWD or in ground structures at colder temperatures.
- Selection for structure was evaluated at 13 reproductive dens (8 natal and 5 maternal), and 55 rest sites (39 arboreal, 11 CWD, 2 CWD piles and 3 ground sites).
- Fishers chose 2 structures when using arboreal rest sites; rust brooms in trees generally >50 cm dbh and cavities in black cottonwood and trembling aspen (*Populus tremuloides*). Arboreal rest sites were most often found in co-dominant hybrid spruce trees that were larger on average than others at the site.
- Other features of arboreal rest structures were not dissimilar to those of the site.
- The best supported model predicting fisher selection of arboreal structures included the presence of rust brooms, dbh and presence of *Populus* spp. Two additional models were included within the list of top models (Table Williston 4).
- Probability of selecting an individual tree was a function of dbh, presence of rust brooms and interactions between these 2 variables.
- CWD used by fishers for resting were exclusively decay classes 1–3 (sound to moderately sound) and were typically longer, larger diameter, and higher off the ground (and thus had more potential rest site space) than other pieces within the patch.
- The best supported model predicting selection of CWD for rest sites was based on length of estimated rest-site potential (i.e., length of pieces >35 cm in diameter with the lower surface 25–50 cm above the ground). The other 3 models in the 95% confidence set included only single variables: height above ground, diameter, and piece length. Multi-model parameterization of the variables in the 95% confidence set suggested that the probability of use of a piece of CWD for resting was positively related to all 4 variables.
- Female fishers used black cottonwood trees exclusively for reproductive dens. Weir and Corbould (2008) report den tree $\bar{x}$ dbh = 109.5 cm which was sub-stantially larger than unused trees within the same sites. Data limitations prevented logistic regression analyses.

Table Williston 4. Factors affecting selection of trees within patches in which fishers rested in the Williston region of north-central British Columbia, 1996–2000 (*n* = 39 used, 207 unused elements; modified from Weir and Corbould 2008).

Model category	Model variables
Tree size, pathogens	Presence of rust brooms in spruce, dbh of *Populus* with pathogens
Tree size, pathogens	dbh of spruce with rust brooms, dbh of *Populus* with pathogens
Pathogens	Presence of rust brooms

Author(s) Interpretation

- Fishers selected trees with rust brooms and branches on large trees for arboreal rest sites due to the security these features offer.
- CWD resting sites were used by fishers in winter (i.e., snow cover present) during cold weather and selection was influenced by piece size, length and height.
- At warmer temperatures, arboreal platforms (rust booms and branches) were used as rest sites.
- Weir et al. (2004) stated that fishers exclusively used subnivean CWD sites when temperatures were lower than -14.2° C. They also suggest that other factors such as wind and snow pack may be a factor in rest site selection. This is consistent with other research in cold environments.
- Fishers selected sites for reproductive dens in 1 species exclusively in this study area. This was influenced by the tree species present in the study area and the diameters they attain. The later condition is likely a factor of the state at which the age and decay of individual trees result in the development of suitable cavities and the size of cavity required by a female fisher with kits.
- Other than large-diameter cottonwood trees, no other factor appeared to affect den selection at the site scale. This may be because the selection for den sites was based on other characteristics that were not measured (e.g., presence and size of cavities), or because sample size was limited.
- Poor model performance and inability to identify a selection function was likely due to the models being generic, simple, and relying on ecological correlates to represent resources that fishers were thought to be sequestering while active. Different behaviors (e.g., foraging for snowshoe hares (*Lepus americanus*), foraging for red squirrels (*Tamiasciurus hudsonicus*), travelling) may have been driving the selection process for different active radiolocations.

2.1.2. McGregor, Study Area 2

Study Objectives: This study investigated the utility of using vegetation resource inventory maps to predict fisher use of habitat.

Principal Investigator(s): G. Proulx (Alpha Wildlife Research and Management)

Duration: 2003–2005

Study Area: The McGregor study was conducted on provincial crown land in the McGregor River watershed 100 km east of Prince George in the Omineca region of British Columbia. The study area was 1,818 km^2 and was contained within Canadian Forest Products Tree Farm License 30. Study area elevation varied from 600–1,700 m, however field testing was limited to sites <900 m. Study sites were limited to forest stands within the Sub-boreal Spruce and Interior Cedar Hemlock biogeoclimatic zones (Meidinger and Pojar 1991). White spruce (*Picea glauca*), subalpine fir (*Abies lasiocarpa*), lodgepole pine (*Pinus contorta*), and trembling aspen were common tree species within the former zone and western hemlock (*Tsuga heterophylla*) and western redcedar (*Thuja plicata*) were dominant in the latter zone. Within Tree Farm License 30 immature, young and mature stands comprised 34%, 6%, and 60%, of the landscape respectively. Climate was described as continental, with severe snowy winters and warm, moist summers. Temperatures during the study varied from -30–0° C and snow depth varied from 45–150 cm.

Methods: Proulx developed predictive maps of fisher habitat using data available from vegetation resource inventory maps. Proulx selected variables on the basis of their relevance to fisher biology and habitat use following an extensive literature review. Variables included in developing predictive habitat maps were: absence of disturbance, age class, structural stage, basal area, crown closure, shrub cover, and diameter at breast height.

Predictive values were assigned to map polygons (stands) based on an expert weighting system using the identified vegetation variables and each map polygon was assigned 1 of 4 ratings (low, medium, high, excellent). Proulx field tested predictive fisher habitat maps over 2 winters (2003/04 and 2004/05) by conducting snow track surveys on 43 randomly located 400-m transects. Proulx used univariate analyses to compare observed fisher track frequencies (per polygon rating) to that predicted based on the relative proportion of transects within each rating category.

Publications and reports: 1 peer-reviewed publication (Proulx 2006).

Results:

Landscape Scale

At this time no information is available at this scale.

Home Range Scale

At this time no information is available at this scale.

Stand Scale

All information is from Proulx (2006).

Key Findings

- Fisher tracks were significantly disproportionately distributed.
- Most fisher tracks ($\bar{x}$ = 84.3%, n = 2 yrs) were found within polygons (stands) rated high or excellent.
- Most tracks were encountered within coniferous forest stands (94%). Most (83%) were in stands ≥ 80 yrs of age with advanced structure, canopy closures of 30–60% and >20 m^2/ha basal area of trees >21 cm dbh.

Author(s) Interpretation

- Fisher winter habitats in this study area corresponded to structurally complex forest stands with high canopy closure and high basal area.
- Stands lacking these characteristics were used significantly less than predicted confirming findings of previous studies.
- Vegetation resource inventory data were valuable for predicting fisher winter habitat.

Site Scale

At this time no information is available at this scale.

Structure Scale

At this time no information is available at this scale.

2.1.3. Chilcotin, Study Area 3

Study Objectives: This study was designed to examine movement, home range, spatial organization, density and habitat selection of fishers in the central portion of their range in British Columbia.

Principal Investigator(s): L. Davis (Davis Environmental Consulting) and A. S. Harestad (Simon Fraser University)

Duration: 2002–2003; 2005–ongoing

Study Area: This study was conducted on 2 study sites on provincial crown land in the Chilcotin Plateau region of British Columbia. The Anahim Lake study site (2,000 km^2) was located in the Chilcotin Plateau, approximately 300 km west of Williams Lake, British Columbia in the Sub-Boreal Pine Spruce (SBPS) and Montane Spruce (MS) biogeoclimatic zones (Meidinger and Pojar 1991). The Puntzi study site (3000 km^2) was also located in the Chilcotin Plateau in the SBPS, MS, and Interior Douglas-Fir (IDF) zones approximately 175 km west of Williams Lake. Elevations in the study area ranged from 1,000–1,500 m. Lodgepole pine was the leading tree species in much of the study area, with white spruce and trembling aspen the leading species in a minority of stands. Understory species included regenerating lodgepole pine, white spruce and trembling aspen, Soopolallie

(*Sherpherdia canadensis*), willow (*Salix* spp.) and common juniper (*Juniperus communis*). In the IDF part of the study area pure Douglas-fir (*Pseudotsuga menziesii*) stands were patchily located at lower elevations with mixed stands of lodgepole pine and Douglas-fir. Small stands of trembling aspen were locally abundant here and black cottonwood stands were patchily distributed in low-elevation riparian areas. Most of the study area was managed for forest harvesting.

Methods: Davis conducted track transects to determine relative intensity of prey activity and of fisher habitat use. Transects were stratified by stand age into young (<40 yrs old), mid-seral (40–80 yrs), and mature/old (>80 yrs). Approximately one half of young stands were a result of forest harvesting within the past 20 yrs. Vegetation and stand mensuration data were collected at the mid-point of each transect segment during summer. Davis used univariate chi-square analyses to evaluate selection of habitat as a function of stand attributes and logistic regression analyses, informed by Akaike Information Criteria (AIC), to evaluate potential stand type predictors of the occurrence of fishers within a systematic transect-based sampling regime. A priori models were refined on the basis of variables for which univariate analyses demonstrated significant associations. Stand and vegetation data were used as independent variables.

Davis live-captured and radio-tagged 24 different fishers with surgical abdominal implant transmitters. Fishers were monitored with traditional VHF ground and aerial telemetry on a daily to weekly schedule throughout the year. Monitoring was more intensive in winter than other seasons. Walk-in telemetry was used to locate resting and denning sites. Ground sampling at fisher locations and random locations included estimates of vegetative strata cover, tree mensuration data, and characteristics of forest structures posited to be important to fisher use of habitat. Only reproductive structure results were available for this summary.

Publications and reports: 5 unpublished project progress reports (Davis 2006*a, b*; 2007; 2008*a, b*) and 1 project completion report (Davis 2003).

Results:

Landscape Scale

At this time no information is available at this scale.

Home Range Scale

At this time no information is available at this scale.

Stand Scale

All information is from Davis 2003 for the Anahim Lake study site.

Key Findings

- Fishers demonstrated selection for transect segments with warm aspects, increasing slope (up to 30%), increasing volumes of coarse woody debris (CWD), increasing number of pieces of CWD, large pieces of CWD present, increasing number of snowshoe hare, red squirrels and grouse (*Bonasa* spp.) tracks, segments located within the Sub-boreal Pine-Spruce moist/cold (SBPSmc) biogeoclimatic subzone (over 2 other subzones) and older aspen, spruce and spruce/pine forests.
- Fishers used sedge meadows less than expected although these habitats represented a small percentage of transect segments.
- The best model of those candidates evaluated contained mature spruce/pine stands, old spruce stands, number of large pieces of CWD, and SBPSmc subzone as variables. Seven models were considered as top models (within 4 AIC units of the best model). These included, in addition to the above variables, trembling aspen habitats, and number of grouse tracks (Table Chicoltin 1).

Table Chilcotin 1. Top models predicting probability of detecting fishers (modified from Davis 2003).

Model	Variables
1	Mature hybrid spruce-lodgepole pine, old hybrid spruce, no. large pieces CWD, SBPSmc subzone
2	Mature hybrid spruce-lodgepole pine, old hybrid spruce, no. large pieces CWD, SBPSmc subzone, trembling aspen
3	Old hybrid spruce, no. large pieces CWD
4	Old hybrid spruce
5	Mature hybrid spruce-lodgepole pine, old hybrid spruce, no. large pieces CWD, grouse
6	Mature hybrid spruce-lodgepole pine, old hybrid spruce, no. large pieces CWD, trembling aspen
7	Mature hybrid spruce-lodgepole pine, old hybrid spruce, trembling aspen

Author(s) Interpretation

- Fishers preferred old spruce, mature mixed and mid-aged to mature aspen stand types.
- Snowshoe hare abundance strongly influenced the likelihood of fisher presence.
- Fishers appeared to be influenced by other prey species, as indicated by their selection for segments with higher densities of red squirrel and grouse sign.
- Warm, steeper aspects were selected for. This may be related to shallower snow depth associated with these conditions, resulting in reduced energy expenditure.
- Fishers selected for CWD, perhaps due to association with prey and as an element of resting habitat.

Site Scale

At this time no information is available at this scale.

Structure Scale

All information is from unpublished progress reports (Davis 2006*a*, *b*; 2007, 2008*a*).

Key Findings

- Fisher reproductive dens were located in lodgepole pine, trembling aspen and Douglas-fir, often (but not exclusively) in trees larger than those characteristic of the site (Table Chilcotin 2).

Table Chicoltin 2. Fisher den tree and plot characteristics at natal den sites. Animals with a "P#" ID are from the Puntzi study site and those with an "A#" are from the Anahim Lake study site. Values for wood condition figures are modal values (modified from Davis 2008*a*).

Den ID	Species	dbh cm $\bar{x}$ (range)	Height m $\bar{x}$ (range)	Wood condition[a]
P2 den tree	Lodgepole pine	35.5	14.5	4
P2 site	Lodgepole pine	20.7 (12.6–35.5)	11.6 (8.5–14.5)	3
P3 den tree	Lodgepole pine	33.8	11.2	4
P3 site	Lodgepole pine	22.7 (16.0–33.8)	10.8 (8.5–13)	3
P7 den tree	Douglas-fir	54.5	15.9	4
P7 site	Douglas-fir	63.6 (54.5–74.4)	24.0 (15.9–30.5)	2
P10 den tree	Lodgepole pine	34.0	1.5	4
P10 site	Lodgepole pine	19.3 (12.7–34.0)	8.9 (7.0–11.5)	1
A4 den tree	Trembling aspen	47.3	27.5	3
A4 site	Trembling aspen- lodge-pole pine-hybrid spruce	30.3 (13.1–48.2)	17.8 (6.0–28.0)	1
A1den tree	Trembling aspen	39.5	32	3
A1 site	Trembling aspen- hybrid spruce	25.3 (12.5–48.5)	20.1 (6.0–32.0)	1

[a] Wood condition 1: No decay, 2: deformities/possible decay inside, 3: Some decay but wood hard, 4: Some soft wood present, 5: Approximately half soft wood, 6: Approximately 60–90% soft wood, 7: All soft spongy wood, 8: Hollow shell/ outside wood hard.

Author(s) Interpretation

- No interpretations provided.

2.2. Cariboo, British Columbia Fisher Population

2.2.1. Beaver, Study Area 4

Study Objectives: This field study of fishers in British Columbia was initiated to examine movement, home range establishment and habitat selection of translocated fishers and movements and habitat selection of resident fishers. This work included a food habits study and a resting site selection study using data from a broader geographic area.

Principal Investigator(s): R. D. Weir and A. S. Harestad (Simon Fraser University)

Duration: 1990–1993

Study Area: This study was conducted primarily on provincial crown land in the Beaver Valley drainage in the Cariboo region of British Columbia, 65 km northeast of Williams Lake. The study area was 1,500 km^2 and was dominated by forested habitat ranging in elevation from 750–1,300 m. The study area was within the Sub-Boreal Spruce biogeoclimatic zone (Meidinger and Pojar 1991). Dominant vegetation types were sub-boreal mixed conifer and mixed wood (coniferous and deciduous). The study area was primarily managed for forest harvesting. Valley bottoms contained extensive agricultural conversion. Mean annual precipitation was 50 cm, 50% of which fell as snow. Mean annual temperatures in the study area ranged from 3.4–3.7° C.

Methods: Weir and Harestad live captured resident fishers and used primarily soft-release procedures for translocated fishers. The fisher sample for the study consisted of 15 translocated fishers (13F, 2M) and 9 resident fishers (7F, 2M). Fishers were radio-collared and monitored using traditional VHF ground and aerial telemetry on a daily to weekly schedule in winter, summer and fall seasons. Walk-in telemetry was used to locate resting and denning sites. Home range composition was evaluated using geographic information systems (GIS) with biophysical mapping data provided by the BC Ministry of Environment. Ground sampling at fisher locations included ocular estimates of vegetative strata cover, variable radius plots to assess tree characteristics and line intercept transects to describe coarse woody debris. Habitat availability was assessed by sampling at 1015 randomly generated sampling points within the study area. Home ranges were calculated as the 90% utilization distribution isopleth using adaptive kernel analyses. Landscape level selection was evaluated for both resident and transient fishers by comparing habitat type composition of home ranges to that available within the study area. Landscape level selection was also evaluated for transient fishers by comparing their use of stands within the landscape to availability within that overall landscape. Stand scale selectivity was examined on a seasonal basis for 9 fishers (8F, 1M). Stand selectivity analysis for the lone male fisher was limited by sample size requirements to the winter field season. Stand scale selection was measured by examining use of stand types available within the study area to those used by fishers with established home ranges. Structural attributes of stands fishers selected were compared to structure of stands at random points. Weir and Harestad examined site (their "patch") scale selection by comparing the characteristics of stands used by fishers (expected values) to the characteristics of sites used by fishers within these stands. They evaluated 217 locations of 18 radio-tagged fishers (15F, 3M). Structure (their "element") scale selection was evaluated from 32 resting sites and 5 reproductive dens by comparing characteristics of structures used by fishers for resting and whelping to characteristics of structures within the site (their "patch"). Selection analyses were conducted for summer, autumn and winter seasons. Weir et al. (2004) evaluated the effect of ambient temperature on selection of structures used for resting by documenting structure-scale selection from 86 sites within Beaver and Williston study areas. The data in Weir et al. (2004) are not mutually exclusive to the Beaver study and are also discussed in the Williston study area key findings.

Publications and reports: Several unpublished progress reports, 1 thesis (Weir 1995), and 4 refereed publications (Weir and Harestad 1997, Weir and Harestad 2003, Weir et al. 2004, 2005).

Results:

Landscape Scale

All information is from Weir (1995) and Weir and Harestad (1997).

Key Findings

- Landscape level selection was analyzed for 9 resident fishers (2F, 7M) and 15 transient fishers (13F, 2M) (translocated fishers prior to home range establishment).
- Fishers primarily used forested habitats dominated by Douglas-fir, lodgepole pine and hybrid white spruce with minor deciduous components of trembling aspen and black cottonwood.
- Transient fishers used primarily coniferous and mixed coniferous/deciduous stands but demonstrated landscape level selectivity only for coniferous stands, and avoided non-forested stands (primarily cultivated fields; Table Beaver 1). They also primarily used young and mature forest stands but demonstrated selection only for young forest seral stages and against herb-shrub and non vegetated seral stages (Table Beaver 2).
- As a study population, resident fishers did not demonstrate selection for any forest type or seral stage. Four individual female fishers did, however, demonstrate selection or avoidance of some types or stages, although this was inconsistent between fishers and across seasons (Table Beaver 3).

Table Beaver 1. Forest type selection by transient fishers (modified from Weir and Harestad 1997).

Forest type	Proportion available	Proportion used	Selection ($P<0.05$)
Non-forested	0.27	0.06	*
Deciduous	0.03	0.04	
Mixed coniferous-deciduous	0.38	0.33	
Coniferous	0.32	0.56	*

Table Beaver 2. Seral stage selection by transient fishers (modified from Weir 1995).

Seral stage	Stand age	Proportion available	Proportion used	Selection ($P<0.05$)
Non-vegetated	0	0.03	0.00	*
Herb shrub	1–10	0.23	0.06	*
Pole sapling	11–40	0.09	0.10	
Young forest	41–80	0.33	0.49	*
Mature forest	81–250	0.29	0.36	

Table Beaver 3. Forest type selection by resident female fishers (modified from Weir 1995).

Fisher	Season	Selection for	Avoidance of
F290	Summer	Coniferous	Deciduous, mixed coniferous-deciduous
F350	Summer	Mixed coniferous-deciduous	Coniferous
F770	Winter	Deciduous, non-forested	Coniferous, mixed coniferous-deciduous
F855	Autumn	Coniferous, non-forested	Mixed coniferous-deciduous

Author(s) Interpretation

- Weir (1995) and Weir and Harestad (1997) concluded that transient fishers' avoidance of non-forested habitats (non-forested and herb-shrub seral stages) and lack of use of non-vegetated seral habitats indicated a need for overhead security cover, as suggested by other authors. They also suggested that this reasoning explained their "avoidance of mixed forest stands while transient", however the analyses in Weir (1995) suggests that this is only the case with a limited number of habitats.

- Weir (1995) suggested that the lack of selection evident at the landscape scale in resident fishers was likely due to the "granularity" of the landscape and the likelihood that fishers were selecting resources at finer scales of resolution. He stated "… the study area was a 'fine-grained mosaic of stands' and, as such, unsuitable stands were likely a part of fisher home ranges as they accessed suitable habitat.". He also suggests that fishers within this study area may be selecting for a wide diversity of habitats.

Home Range Scale

All information is from Weir (1995).

Key Findings

- There were no fisher habitat association findings reported at this scale.
- Mean annual home range sizes (post establishment of home range) of fishers transplanted to his study area were 26.4 km^2 (SE 9.2) for females (n = 5) and 46.5 km^2 for males (n = 1).
- Seasonal home range sizes did not differ from annual home ranges for females (n = 3–8 for seasonal home ranges) but were larger for males (n = 1–2 for seasonal home ranges).
- Substantial overlap in female winter home ranges was reported.

Stand Scale

All information is from Weir (1995) and Weir and Harestad (2003).

Key Findings

- Fishers demonstrated selectivity for stands for all structural attributes examined with the exception of mean tree diameter. Fishers selected stands with moderate measures of most stand attributes evaluated. Stand scale selectivity varied by season (Table Beaver 4).

Table Beaver 4. Stand scale selectivity by fishers in the SBSdw biogeoclimatic subzone (1990–1993) (modified from Weir and Harestad 2003; A = Avoided; S = Selected).

Structural variable used to classify stands	Summer		Autumn		Winter	
	A	S	A	S	A	S
Structural stage	herb		herb		herb	
Forest phase[a]		MI		MI	MISL NF	
Total CWD (m^3/ha)	0	>200			0	
Volume hard CWD >20 cm diameter (m^3/ha)		1–25				>50
Volume elevated CWD (m^3/ha)		21–40				
Conifer canopy cover (%)						21–60
Deciduous canopy cover (%)	0	21–40				
High shrub (2-10 m) cover (%)						41–60
Low shrub (0-2 m) cover (%)	>80				>80	
Trees (stems/ha)	0				0	
Trees with rust brooms (stems/ha)		1–20		0,1–20		
Trees >40 cm dbh (stems/ha)				1–50		51–100
Aspen (stems/ha)		401–800			1–401	
Hybrid spruce (stems/ha)		401–800			401–800	

[a] MI = mixed conifer-deciduous forest, MISL = mixed conifer-deciduous selectively logged forest, NF = non-forested.

Author(s) Interpretation

- Weir and Harestad concluded that fishers primarily selected habitats at the stand scale for security cover, snow interception, foraging, and resting.
- Fishers selected for habitats with a mix of conifer and deciduous cover. These attributes were suggested to provide structural complexity and thus high quality habitat for primary prey.

- Fishers selected for moderate values of coniferous cover in winter and moderate values of deciduous canopy cover during summer and avoided herb structural stages in all seasons. In general, fishers selected stands with high volumes of CWD, elevated CWD and hard CWD >20 cm diameter and intermediate values of high shrub closure. Fishers avoided stands with extreme low shrub closure.
- Fishers selected stands in summer and autumn with at least some trees containing rust brooms.

Site Scale

All information is from Weir (1995) and Weir and Harestad (2003).

Key Findings

- Fishers selected for all attributes examined at the site scale except mean tree diameter.
- Site scale selectivity was most common when fishers used stands with extreme values for structural attributes (Table Beaver 5).
- Fishers selected sites with substantially more structure when using stands which had little to no structure recorded at random points. Similarly fishers selected sites within stands with less structure than expected values where stands had extremely high values for specific structural variables.

Author(s) Interpretation

- Fishers selected for habitats at the site scale for security cover, snow interception, foraging habitat, resting sites and denning habitat.
- When using stands where the values of structural attributes may have been low, fishers compensated by selecting sites within stands with higher than expected values for those structural attributes and vice versa. For example, fishers selected sites for security (overhead canopy cover) by using sites with greater values of over-story or shrub cover when in stands with typically low values for these attributes.
- Fishers also selected for sites which gave them access to habitats with moderate to high levels of structural complexity. These were interpreted to be valuable foraging habitat.

Table Beaver 5. Characteristics of sites used by fishers when the structural characteristics of the stand were different than that expected based on date from random plots (modified from Weir and Harestad 2003). Structural variable values listed represent the values at sites which were significantly different from expected.

Structural variable	Characteristics of sites used when stand used had less structure than expected for the stand	Characteristics of sites when stand used had more structure than expected for the stand
Total CWD (m^3/ha)		0, 1–100, >200
Volume hard CWD >20 cm diameter (m^3/ha)		0, 1–25, 26–50
Volume elevated CWD (m^3/ha)		0
Conifer canopy (%)	41–60	0
Deciduous canopy (%)	21–40	0
High shrub (2–10 m) (%)	41–60	1–20
Low shrub (0.1–2 m) (%)	61–80	
Trees (stems/ha)	1,001–2,000, 2,001–3,000, 3,001–4,000	0
Trees with rust brooms (stems/ha)	>40	0
Trees >40 cm dbh (stems/ha)	>100	0
Aspen (stems/ha)	1–400, 401–800	0
Hybrid spruce (stems/ha)		0

Structure Scale

All information is from Weir (1995), Weir and Harestad (2003) and Weir et al. (2004).

Key Findings

- Fisher reproductive dens were exclusively in branch hole cavities in large diameter ($\bar{x}$ = 103 cm, SE = 12.9) declining black cottonwood trees (n = 5).
- Rest sites were located primarily in branches of live trees (57%), in tree cavities (19.8%), under CWD (18.5%) and in ground structures (4.6%).
- Branch rest sites were typically associated with abnormal growth structures such as spruce broom rusts or fir broom rusts.
- Resting sites were located in structures whose size and density were atypical of the surrounding site (Table Beaver 6).
- Selection of resting structure was also influenced by ambient temperature (Table Beaver 7). Fishers rested on tree branches or in cavities in warmer ambient temperatures and in CWD or ground structures in colder temperatures.

Table Beaver 6. Selectivity for characteristics of resting and fisher reproductive denning structures (modified from Weir and Harestad 2003).

	Structures used by fishers			Available structures			Selection
Structure	$\bar{x}$	SE	n	$\bar{x}$	SE	n	($P \leq 0.05$)
Resting sites							
Hybrid spruce[a]	46.3	3.9	17	32.1	2.0	66	*
Black cottonwood[a]	103.2	16.9	5	62.1	7.9	15	*
Douglas-fir[a]	111.0	21.4	3	44.8	4.7	29	*
Rust brooms[b]	3.2	0.7	17	0.2	0.1	66	*
CWD[c]	80.3	11.8	4	23.4	2.9	48	*
Reproductive dens							
Black cottonwood[a]	103.1	12.9	5	52.5	9.4	22	*

[a] diameter at breast height (cm) [b] number per tree [c] diameter (cm)

Table Beaver 7. Effect of ambient temperature on selection for resting structures by fishers (modified from Weir et al. 2004).

Type of structure	$\bar{x}$ (°C)	SE	Range (°C)	n	Contrast of means
Branch	2.4	1.1	-13.1 to -20.9	49	A
Cavity	1.3	2.0	-14.2 to 21.1	17	A
Ground	-5.7	2.2	-10.9 to 0.3	4	AB
CWD	-10.7	3.1	-29.4 to 3.2	16	B

Author(s) Interpretation

- Fishers have stringent requirements for structural elements to meet life requisites and select structures that are atypical of the site in which they are currently active.
- Trees and coarse woody debris used for resting were typically larger than those within the site, as were trees used for reproductive dens.
- Cold winter temperatures mediated rest site selection with fishers choosing to rest in subnivean and subterranean sites in periods of extreme cold. At warmer temperatures, branch platforms were used as rest sites.
- Fishers used exclusively subnivean sites when temperatures were lower than -14.2° C. Other factors such as wind and snow pack may be a factor in rest site selection.

2.3. Southern Interior Mountains, British Columbia Fisher Population

2.3.1. East Kootenay, Study Area 5

Study Objectives: To study the establishment and habitat use of a recently translocated population of fishers into an area hypothesized to be good fisher habitat.

Principal Investigator(s): A. Fontana and I. Teske (British Columbia Ministry of Environment)

Duration: 1996–1999

Study Area: This study was located in the East Kootenay Trench of British Columbia, south of Skookumchuck, east of Moyie Lake, west of Lake Koocanoosa and north of the Canada/United States border. The study area was within the Ponderosa Pine, Interior Douglas Fir, Interior Cedar Hemlock, Montane Spruce and Engelmann Spruce Subalpine Fir biogeoclimatic zones (Meidinger and Pojar 1991). Habitat was primarily mid-seral forests with scattered mature trees interspersed with regenerating stands resulting from forest harvesting. Elevation ranged from 1,067–1,981 m.

Methods: Fishers were live captured in winters of 1996–1998 in the Cariboo region, British Columbia and translocated to the East Kootenay region. Fishers were kept in a holding facility prior to release. Pregnant females were kept in the facility until after they had whelped and kits were 12 weeks old. Fishers were radio-collared and released into target areas based on assessed habitat capability (Apps 1995). Fishers were monitored using aerial telemetry 2–5 days post-release and every 7–14 days subsequently. Broad scale habitat characteristics, elevation and aspect were recorded at every location. Habitat characteristics were determined visually and by overlay on 1:50,000 forest cover maps. At each location leading tree species, age class (immature <40 yrs; in-growth 40–99 yrs; mature >100 yrs), and canopy closure (open habitats <25%; open forest 25–45%; closed forest >45%) were derived. Home ranges were calculated (100% minimum convex polygon [MCP] for fishers with <20 locations; 100% MCP and 90% adaptive kernel [ADK] for fishers with >20 locations) using CALHOME. Univariate tests of selection using Bonferroni confidence intervals were used to evaluate habitat selection by the study population as a whole during the winter and non-winter ("growing") seasons.

Publications and reports: 2 unpublished final reports (Apps, 1995, Fontana et al. 1999) and 1 extended conference abstract (Fontana and Teske 2000).

Results:

Landscape Scale

All information is from Fontana et al. (1999) and Fontana and Teske (2000).

Key Findings

- Mean elevation of fisher non-winter locations was 1,402 m (range = 823–2,073 m); mean elevation of fisher winter locations was 1,296 m (range = 912–1,738 m).
- Mean elevation of winter locations of female N98 (excluded from above data) was 2,167 m.
- Most fisher locations were within forested habitats (Table East Kootenay 1).
- Fishers did not demonstrate selection for any habitats (as indexed by leading tree species).
- Fishers were located in pine (37%), spruce-true fir (19%), western larch (*Larix occidentalis*) (16%), Douglas-fir (14%), deciduous (2%), shrub-dominated (2%) and whitebark pine (*Pinus albicaulus*) stands (1%).
- Forested habitats with >45% canopy closure were selected by fishers in both seasons, open habitats (burns, clearcuts, and wetlands) were avoided in

non-winter, and open forest habitats (subalpine forest, dry forested grasslands and regenerating burns) were avoided in winter.

- Fishers were located primarily in areas of forest in-growth (areas of dense conifer incursion into formerly open conifer forests, primarily in drier valley bottom habitats) (57% winter, 44% non-winter locations) and mature forests (29% winter, 36% non-winter locations).
- Fishers were located in immature and other forest types the remainder (15% winter, 20% summer locations).

Table East Kootenay 1. Number of fisher radio-locations by habitat type in the East Kootenays, British Columba (modified from Fontana et al. 1999).

Habitat type	Non-winter *n* (%)	Winter *n* (%)
Forest	124 (58)	31 (48)
Open forest	36 (17)	8 (13)
Riparian	28 (13)	10 (16)
Open subalpine	3 (1)	9 (14)
Forested burn	0	5 (8)
Burn	8 (4)	1 (2)
Clear-cut	13 (6)	0
Wetland	1 (1)	0

Author(s) Interpretation

- Findings of this study were consistent with those of relevant studies in Montana and British Columbia.

Home Range Scale

All information is from Fontana et al. (1999).

Key Findings

- Fishers established home ranges 2.1–2.7 months post-release depending on the year.
- Home ranges (90% ADK) for 2 female fishers with >20 locations were 38.2 and 16.5 km^2, and for 1 male was 59.1km^2.
- Home “areas” for other female fishers (*n* = 3) with >10 and <20 locations averaged 36.4 km^2 and for 1 male was 60.9 km^2.

Stand Scale

At this time no information is available at this scale.

Site Scale

At this time no information is available at this scale.

Structure Scale

At this time no information is available at this scale.

2.4. Northwestern Montana Fisher Population

2.4.1. Cabinet Mountains, Study Area 6

Study Objectives: Primary objectives were to establish a re-introduced population of fishers, examine the activities and movements of reintroduced fishers, identify mortality factors related to reintroduced animals, examine temporal trends in movement, habitat use, activity, and spacing patterns of reintroduced fishers, and compare the effects of hard versus soft releases of reintroduced fishers.

Principal Investigator(s): L. Metzgar, K. Foreman, K.D. Roy, and K.S. Heinemeyer (University of Montana).

Duration: 1988–1991

Study Area: The Cabinet Mountains study area was located in Lincoln and Sanders Counties, Montana within the Kootenai National Forest, in northwest Montana. The Cabinet Mountain wilderness area formed the core of the 381.8 km^2 study area. The East and West Cabinet Mountains are divided by the Bull River Valley. Elevations ranged from 610–2,680 m. Pacific maritime air masses influenced the weather and resulted in short warm summers and wet, snowy winters. Temperatures ranged from -31–40.5° C and precipitation, coming mostly as snow, ranged from 100 cm in the Bull River Valley to over 500 cm at higher elevations. Average snowfall varied from 500 cm in the valley to over 1,800 cm at higher elevations. Vegetation in the valley was characterized by open, wet meadows and riparian shrubfields interspersed with grand fir (*Abies grandis*), western redcedar, western hemlock, black cottonwood, and trembling aspen. At low and mid-elevations, ponderosa pine (*Pinus ponderosa*) and Douglas-fir were common. Mixed stands of subalpine fir, Engelmann spruce (*Picea engelmanii*), and mountain hemlock (*Tsuga mertensiana*) were common above 1,500 m on northern exposures and above 1,800 m on southern exposures to timberline.

Methods: Fishers were live-trapped in Minnesota (*n* = 32) and Wisconsin (*n* = 80) (2 died pre-release) and were released on the study area between 1988 and 1991; 51 (32 in 1988/89 and 19 in 1990) were fitted with radio collars and 6 received intra-peritoneal implant transmitters. Soft releases were used on 45 fishers and the remaining fishers were hard released. Monitoring was both aerial and ground-based with attempts to locate animals at least weekly. Causes of mortalities were determined by backtracking in snow and necropsies. Movements were monitored using "standard relocations" (3–5-day intervals between locations) and classified as transient or dispersal, temporary residency, or permanent residency. Adaptive kernel home range estimates using CALHOME were calculated for 32 fishers using 1,313 radio telemetry locations between May 1990 and August 1991. Permanent home ranges were defined as the area an animal occupied for the duration of the monitoring, or, if the animal had died, the area it had occupied for at least 4 months. Seasonal (winter, breeding, and post-breeding) home ranges were estimated for animals that remained in the area for the duration of the season and had at least 12 locations during the period. Habitat variables for elevation, aspect, slope, distance to water, and distance to various types of water were derived from USGS Digital Elevation Models and hydrology models using the geographic information system (GIS) program PAMAP. Animal locations (*n* = 1,087) from 26 translocated animals (2 from the 1989 and 24 from the 1990 release) were compared to 473 random points. Habitat selection was evaluated by comparing elevation, slope, aspect and distance to water at fisher relocations to random locations.

Publications and reports: 3 theses (Roy 1991, Heinemeyer 1993, Vinkey 2003).

Results:

Landscape Scale

All information is from Roy (1991) and Heinemeyer (1993).

Key Findings

- Fishers selected mixed conifer and cedar/hemlock forests and avoided subalpine and hardwood stands.
- During the post-release and winter periods fisher selected for mid-elevations and avoided high elevations. During and after breeding season fishers strongly selected low elevations and avoided high elevations. Resting animals selected elevations from 600–1,200 m and active animals selected habitats from 600–800 m.
- During winter, fishers selected steep (31°–40°) and extremely steep (>40°) slopes; they selected flat areas during breeding and post-breeding season.
- North facing slopes were selected throughout the year.
- During winter, breeding, and post-breeding seasons, fishers selected habitats within 200 m of water and avoided areas 200–600 m from water. Fishers used habitat >600 m from water in proportion to availability.

Author(s) Interpretation

- Fishers selected dense, mixed-conifer and cedar/hemlock stands of young to medium age.
- Reintroduced fishers selected wet, forested habitats on lower, north-facing slopes with shallow gradient which were close to water.

Home Range Scale

All information is from Roy (1991) and Heinemeyer (1993).

Key Findings

- No habitat association findings were available at this scale.
- Fourteen fishers (9F, 5M) had sufficient locations to estimate winter home range size. Median home range sizes were 17.8 km^2 (females) and 18.3 km^2 (males) (range = 1.8–38.6 km^2).
- During the breeding season, 2 males (1 adult, 1 juvenile) had sufficient locations to estimate home ranges. The adult male's home range was 99.3 km^2 and the juvenile's 28.4 km^2. Seven females (3 adults and 4 juveniles) had sufficient locations to estimate home range (median = 10.3 km^2; range = 5.3–81.6 km^2.
- Post breeding home range sizes were estimated for 9 females and 3 males. Median home range size for females was 14.4 km^2 (range = 10.8–41.8 km^2) and for males was 77.2 km^2 (range = 25.6–99.3 km^2).

Author(s) Interpretation

- Reintroduced female fishers in Montana appeared to have home range sizes comparable to females in Maine.
- Intraspecific and intrasexual competition for few patches of "high quality" habitat may have contributed to the smaller home ranges maintained by females in Montana.

Stand Scale

At this time no information is available at this scale.

Site Scale

At this time no information is available at this scale.

Structure Scale

At this time no information is available at this scale.

2.5. North-central Idaho and West-central Montana Fisher Population

2.5.1. Nez Perce National Forest, Study Area 7

Study Objectives: Primary objectives were to describe fisher habitat use patterns and evaluate habitat selection at 3 scales (macrohabitat, microhabitat, and fine-scale), investigate fisher movements and food habits, determine population productivity to place habitat data in an ecological context, and assess current status of fishers in the study area.

Principal Investigator(s): O. Garton, and J. L. Jones (University of Idaho)

Duration: 1985–1988

Study Area: The study area was located in north-central Idaho on the Nez Perce National Forest in Idaho County, Idaho. The study area was bounded by the South Fork of the Clearwater River on the south and west, the Selway River on the north, and Meadow Creek on the east. The core study area, defined by 13 radio-collared fishers was approximately 1,010 km^2 and elevations ranged from 1,006–2,165 m. Primary forest types were grand fir and subalpine fir (Cooper et al. 1987). Annual mean maximum and minimum temperatures were 13° C and -3° C, mean annual precipitation was 85 cm, and mean annual snowfall was 353 cm.

Methods: Fishers were captured in live traps placed at 3–15-km intervals along random traplines between 1 September and 15 April. Trapped fishers were fitted with traditional VHF radio-collars and monitored from the air and ground (only ground locations were used for habitat analyses). The objective was to locate each animal twice per week and obtain ≥30 locations of each animal per season. Home ranges were calculated with harmonic mean estimates using program HOME RANGE. Fisher habitat use patterns and home range sizes were investigated using aerial and "walk-in" radiotelemetry techniques and back-tracking on snow to locate rest sites and hunting locations. Fishers approached to within 10 m were considered resting and error polygons were generally ≤0.05 ha. Active animals were approached to within 80 m during summer resulting in error polygons generally ≤1 ha. Around each use site, 3 nested, circular plots were used to sample vegetation structure and species composition (40.5 m^2, 376 m^2, and 0.10 ha). Two replicates of the 3 circular, nested plots were sampled, one 50 m north and one 50 m west of plot center to evaluate habitat availability. One of 6 successional stages was assigned (Thomas et al. 1979; grass-forb, shrub-seedling, pole-sapling, young forest, mature forest, old-growth) based on dominant and co-dominant tree heights, tree size classes, stand decadence, presence of snags and logs. Number of canopy layers was subjectively determined and height of average canopy level was measured with a clinometer. Overhead canopy cover was measured with a spherical densiometer. Habitat availability was determined on the broad-scale by measuring randomly distributed points throughout the study area.

Publications and reports: 1 thesis (Jones 1991), and 1 peer-reviewed manuscript (Jones and Garton 1994).

Results:

Landscape Scale

All information is from Jones (1991) and Jones and Garton (1994).

Key Findings

- The geographic area covered by 13 radio-collared fishers during the 1985–1988 study was 1,010 km^2 (minimum convex polygon for all fisher observations).
- Mean elevations used were 1,372 m and 1,378 m for females and males respectively.

- Fishers significantly shifted use of cover type seasonally, from mature forests in summer to young forests in winter. There was no difference in cover type use between sexes (5M, 4F) during summer; both sexes selected mature and old-growth forests and avoided non-forest, pole/sapling, and young forest cover types. During winter fishers selected the young forest cover types (highest densities of 11.4–34.3 cm dbh trees, 14.0–34.3 cm dbh snags, high density of 14.0–24.1 cm logs, and the highest understory cover of deciduous shrubs).

Author(s) Interpretation

- The seasonal shift in use of successional stages was supported by analyses indicating microhabitat structure and composition differed between summer and winter habitat use.
- Fishers selected habitats with a higher availability of large-diameter trees, snags, and logs relative to sites 50 m distant, even during winter when they selected young forests.
- Fishers used a more diverse array of cover types during winter and were less selective of habitats than during summer.
- Fishers tended to seek out areas in young forests that had at least 1 remnant large tree, snag, and/or log that survived a stand replacing fire.
- Snow conditions did not seem to affect habitat selection by fishers in north-central Idaho.
- Fishers selected forested riparian habitats.
- The shift in habitat use between summer and winter was likely due to shift in prey use between seasons.

Home Range Scale

All information is from Jones (1991) and Jones and Garton (1994).

Key Findings

- Male home ranges were nearly twice as large as female home ranges (median home range sizes were 82.6 km^2 for males [n = 6] and 40.8 km^2 females [n = 4] respectively).
- Home range sizes for fishers in northern Idaho were larger than anywhere else reported in North America.
- There was no significant relationship between the estimated size of home ranges and the proportion of mature or old-growth forest, or the amount of mature or old-growth forest, the preferred topographic types (draw bottoms and concave slopes), or canopy densities ≥60%.
- The presence of human activity appeared to have little influence on fisher movements.

Author(s) Interpretation

- Availability of large logs appeared to be important for winter habitat selection.
- Preferred resting habitat and prey were likely more available along drainage courses, which were the most commonly traveled by fishers, based on observations.
- Prey availability may have been lower in north-central Idaho resulting in larger fisher home ranges to obtain food resources.
- Fishers avoided drier (ponderosa pine, Douglas-fir, upland subalpine fir, and xeric grand fir), stands with pole-size or smaller trees, and open (≤40% crown cover) habitats.

Stand Scale

At this time no information is available at this scale.

Site Scale

All information is from Jones (1991) and Jones and Garton (1994).

Key Findings

- Fishers selected the ≥61% canopy cover class for resting and seemed to select the densest (≥81%) canopy cover class for foraging.
- Log rest sites were used more frequently during winter; 67.7% of the 24 observations of log use were in winter.
- During summer, fishers selected sites that had greater availability of Engelmann spruce ≥21.6 cm dbh, Douglas-fir >47.0 cm dbh, and Pacific yew (*Taxus brevifolia*) 11.4–21.6 cm dbh. Large diameter Douglas-fir was 431% more abundant and Pacific yew (11.4–21.6 cm dbh) was approximately 400% more abundant at use sites than random sites.
- Summer and winter use sites selected by fishers were in later-seral stages than plots 50 m away from plot center. Canopy cover, density of large diameter trees, snags, and availability of logs was greater at plot center than at plots 50 m away.
- Fisher use sites were 50% closer to water than plots 50 m away.
- Pacific yew and subalpine fir were important to fishers choosing winter sites.

Author(s) Interpretation

Fishers selected forested riparian habitats.

Structure Scale

All data are from Jones (1991) and Jones and Garton (1994).

Key Findings

- Fishers were primarily found resting in live trees (Table Nez Perce 1).
- Logs were used by fishers as rest sites proportionately more during winter.
- When resting in trees, fishers rested in Engelmann spruce (n = 85), grand fir (n = 43), Douglas-fir (n = 5), and subalpine fir (n = 1) trees.
- Mean rest tree dbh was 56.1cm and mean observed resting site height was 16.4 m.
- Brooms were resting substrate in 67.9% of tree rest sites.
- Rest sites in snags were in grand fir (n = 12) and Douglas-fir (n = 1), all but 1 had broken tops.
- Mean dbh of snags used for rest sites was 86.4 cm.
- Median diameter of the small end of logs used for rest sites was 53.3 cm.

Table Nez Perce 1. Fisher use of resting structures by season (modified from Jones 1991).

	Rest structure use (n)		
Season	**Trees**	**Snags**	**Logs**
Summer	94	9	9
Winter	40	4	16

2.6. Cascade Range, Oregon Fisher Population

2.6.1. Southern Oregon Cascades, Study Area 8

Study Objectives: To investigate the ecological relations of fishers with emphasis on determining 1) den and rest site characteristics and associated habitat types, 2) home range size and habitat composition, and 3) food habits. Additional objectives were to determine whether fishers occurring in the southern Oregon Cascades represented a reintroduced or native population, and to determine the current distribution and conservation status of fishers in Oregon.

Principal Investigator(s): K. Aubry and C. Raley (USDA Forest Service, Pacific Northwest Research Station)

Duration: 1995–2001

Study Area: The study area was located primarily in the Upper Rogue River basin on the Rogue River National Forest, Jackson and Douglas Counties, Oregon. The study area was on the west slope of the Cascade Range in southern Oregon, but also extended across the crest to some areas on the east slope of the Cascade Range. The study area was 2,437 km^2 and elevation ranged from 610–2,134 m. Average annual precipitation was about 107 cm (but varied depending on elevation) and snow persisted throughout the winter above about 1,219 m. The study area was primarily within the Mixed-Conifer Zone (Franklin and Dyrness 1988) which included forested habitats of Douglas-fir, true fir, ponderosa pine, sugar pine (*Pinus lambertiana*), and incense cedar (*Calocedrus decurrens*). Lands within the study area were primarily managed by the U.S. Forest Service, but also included U.S. Bureau of Land Management, U.S. National Park Service, and private industry lands.

Methods: Fishers were live trapped and fitted with radio-collars. Collared fishers were tracked year-round and located about 2 times per week by walking in and isolating their radio signal to a single structure (den or rest structure) or to an area <0.4 ha in size for active animals (i.e., foraging or traveling). Home ranges were estimated using 95% minimum convex polygons (MCP). At the site scale, each time a resting or active fisher was located, observers visually determined general forest conditions within a 0.4-ha site around the animal's location. Detailed habitat data were collected in 0.1-ha and 0.4-ha fixed-area plots at all den sites and a subset of rest sites to describe forest composition and structure including density of live trees, snags, and logs. At den and rest sites, and at each of 373 random points distributed across a 1,210-km^2 core sampling area, 4 measurements of overhead canopy cover were collected using a concave spherical densiometer (1 measurement in each cardinal direction 9 m from plot center). Availability of potential den and rest structures were also sampled at the 373 random points within the 1,210 km^2 core area. At each random point, the nearest 3 live trees, 3 snags, and 3 logs were sampled: 1 each that was 25–50 cm in diameter, 51–100 cm in diameter, and >100 cm in diameter. Structures sampled also had to meet specific height, length, and decay condition criteria. All data were summarized using descriptive statistics.

Publications and reports: Several unpublished reports (Aubry and Raley 2002*a*, 2006), a peer-reviewed note (Aubry and Raley 2002*b*), and 5 peer-reviewed manuscripts (Aubry and Lewis 2003, Drew et al. 2003, Aubry et al. 2004, Wisely et al. 2004, Aubry and Jagger 2006).

Results:

Landscape Scale

All information is from Aubry and Raley (2006).

Key Findings

- The geographic area occupied by 19 fishers radio-collared during the 1995–2001 study was 2,437 km^2 (100% MCP of all radiotelemetry locations). Fishers primarily used forested habitats below 1,525 m.
- Although detailed results from analyses on fisher habitat associations at this scale are not yet available, fishers primarily used mixed-conifer forests comprised of Douglas-fir, true fir (white fir-grand fir species complex), ponderosa and sugar pines, and incense cedar. Other common tree species in mixed-conifer forests used by fishers included western hemlock, western white pine, golden chinquapin (*Castanopsis chrysophylla*) and, at the higher elevations, Shasta red fir (*Abies magnifica*), mountain hemlock, and Engelmann spruce.

Author(s) Interpretation

- Preliminary analyses of adult fisher home ranges indicated that the Rogue River - Highway 62 corridor (a fifth-level watershed river and a 2-lane highway that run parallel to each other across the western portion of the study area) may influence spatial use and distribution of fishers. Radio-collared adult fishers established home ranges on one side or the other of the corridor. However, males regularly crossed the corridor during the breeding season, and the corridor did not appear to impede juvenile dispersal.

Home Range Scale

All information is from Aubry and Raley (2006).

Key Findings

- Fishers began to exhibit breeding season behavior in February; consequently, 1 February thru 31 January of the following year was considered to represent 1 annual cycle.
- Mean annual 95% MCP home range size for 7 adult females was 25 km^2.
- Because male fishers typically made wide-ranging movements during the breeding season, separate estimates of home range size were calculated for the breeding season (1 February–30 April) and the non-breeding season (1 May–31 January).
- Mean 95% MCP breeding season home range size for males was 147 km^2 (n = 3) and was >2 times larger than their non-breeding season home range ($\bar{x}$ = 62 km^2, n = 4).
- Additionally, male home ranges were much larger than those of females: male non-breeding season home ranges were >2 times larger than female annual home ranges.

Author(s) Interpretation

- Although the Rogue River-Highway 62 corridor appeared to influence where individual fishers established their home ranges, other geographic and man-made features (e.g., smaller rivers, creeks, paved county roads) did not appear to influence home range establishment or daily movements. For example, 1 male's home range encompassed the outskirts of a small rural community, portions of a 9-mile long water canal system, and he frequently crossed the South and Middle Forks of the Rogue River (fifth- and sixth-level watersheds, respectively).

Stand Scale

At this time no information is available at this scale.

Site Scale

All information is from Aubry and Raley (2006).

Key Findings

General habitat conditions at telemetry locations

- When active or resting, female fishers used patches of unmanaged forest more frequently than males (Table South Oregon Cascades 1). In contrast, males were found in a broader array of habitat conditions and used patches of managed second-growth forest and non-forested habitats more frequently than females (Table Southern Oregon Cascades 1).

Table Southern Oregon Cascades 1. Visual assessment of general habitat conditions within a 0.4-ha area around radiotelemetry locations of 12 female and 8 male fishers in the South Oregon Cascades study area, 1995–2001 (modified from Aubry and Raley 2006).

	% of female locations		% of male locations	
Habitat condition	Active $n = 274$	Resting $n = 489$	Active $n = 260$	Resting $n = 342$
Unmanaged: no evidence of past timber harvesting	40	63	25	25
Managed: some harvesting but original forest not replaced				
1–33% of overstory trees removed	6	8	8	5
34–66% of overstory trees removed	9	6	6	7
>66% overstory trees removed	17	8	13	14
Managed second-growth: original forest replaced by second generation growth				
10–25 cm dbh trees	5	4	6	23
26–50 cm dbh trees	21	10	36	23
51–75 cm dbh trees	1	<1	0	1
Non-forested habitat (e.g., wet meadows, upland shrub)	1	1	6	2

Detailed habitat characteristics at rest sites

- Habitat measurements in fixed-area plots at 130 rest sites for 12 females and 88 rest sites for 7 males revealed that both sexes used mixed-conifer forests with relatively high overhead vegetation cover (on average ≥82% canopy cover).
- Tree species composition at rest sites was primarily true fir, Douglas-fir, western hemlock, incense cedar, ponderosa, sugar and white pines, and golden chinquapin. On average, deciduous tree species comprised <4% of the total live tree basal area.
- Sites used by females for resting had greater basal areas of large (51–100 cm dbh) and very large (>100 cm dbh) live trees, and greater densities of snags and logs (all size categories) than sites used by males (Table Southern Oregon Cascades 2).
- Mean overhead canopy cover at 373 random points was only 67% compared to 84% and 82% at sites used by female and male fishers for resting, respectively (Table Southern Oregon Cascades 2).

Detailed habitat characteristics at den sites

- Natal dens (*n* = 13) were defined as sites used by adult females for giving birth to and nursing kits until weaning at 8–10 weeks of age.
- Maternal dens (*n* = 18) were defined as sites used for ≥2 days after the kits were weaned but while they were still dependent on the adult female for food (from about 2 months of age to 4 months of age).
- Forest composition and structure at natal and maternal den sites were similar, and they were relatively similar to those at sites used by females for resting (Table Southern Oregon Cascades 2). All den sites were in mixed-conifer forests and, on average, had ≥80% overhead vegetation cover and a live tree basal area of ≥49 m^2/ha.
- However, snag densities were about 1.5 times greater at natal and maternal den sites than at sites used by females for resting (Table Southern Oregon Cascades 2).
- Mean overhead canopy cover at 373 random points was only 67% compared to 80% and 88% at natal and maternal den sites, respectively (Table Southern Oregon Cascades 2).

Table Southern Oregon Cascades 2. Mean values (SD) for habitat characteristics measured at den and rest sites for 12 female and 7 male fishers, 1995–2001 (modified from Aubry and Raley 2006).

	Den sites		Rest sites	
Habitat characteristic	Natal *n* = 13	Maternal *n* = 18	Female *n* = 130	Male *n* = 88
Canopy cover (%, average of 4 readings at each site)	80 (22)	88 (11)	84 (16)[a]	82 (20)[a]
Basal area all live trees (m^2/ha)	49.0 (29.4)	51.0 (19.1)	48.8 (20.3)	43.5 (18.6)
Basal area deciduous trees (m^2/ha)	0.02 (0.07)	0.23 (0.80)	0.23 (0.93)	1.57 (3.11)
Basal area live evergreen trees 51–100 cm dbh (m^2/ha)	21.6 (22.5)	16.8 (15.0)	19.4 (15.7)	12.3 (10.5)
Basal area live evergreen trees >100 cm dbh (m^2/ha)	9.8 (11.2)	11.3 (13.5)	10.1 (9.9)	5.0 (8.0)
Snag density; 26–50 cm dbh and decay classes 1–4 (no./ha)	19.0 (15.7)	23.1 (23.3)	13.9 (11.9)	11.1 (10.9)
Snag density; ≥51 cm dbh and decay classes 1–4 (no./ha)	15.2 (14.9)	15.3 (9.7)	10.2 (9.3)	6.5 (7.3)
Log density; averaging 26–50 cm in diameter and in decay classes 1–3 (no./ha)	51.5 (38.9)	68.9 (33.9)	54.6 (51.2)	38.5 (42.6)
Logs density; averaging ≥51 cm in diameter and in decay classes 1–3 (no./ha)	31.5 (28.2)	27.2 (28.0)	33.3 (31.4)	26.7 (30.3)

[a] Canopy cover was measured at 235 rest sites for females and 171 rest sites for males.

Author(s) Interpretation

- Proportional use of various habitat conditions at the site-scale by female fishers was different than proportional use by males (Table Southern Oregon Cascades 1). However, frequent locations of active or resting female fishers in patches of 'unmanaged' forest may merely reflect the abundance of this habitat condition within female home ranges compared to male home ranges. Also, the paucity of locations of females or males in patches of managed second-growth forest with trees averaging 51–75 cm dbh probably reflected the scarcity of this habitat condition in the study area.
- Differences in the densities of large live trees, snags, and logs between female and male rest sites may be due to differences in available habitat conditions within the home ranges of male and female fishers. Some males had home ranges that encompassed second-growth forests which typically had smaller diameter trees and fewer snags than other forested habitats within the study area. Also, because females use large live and dead trees and logs for denning, they may establish their home ranges in areas that have higher densities of such structures.
- Both natal and maternal den sites had greater densities of snags than sites used by female fishers for resting. Females typically used cavities in dead or dying trees for denning; thus, during the denning period they may use sites that have a greater abundance of potential structures to select from.

Structure Scale

All information is from Aubry and Raley (2006).

Key Findings

Rest structures

- 378 rest structures were identified for 12 radio-collared female fishers and 275 rest structures were identified for 7 radio-collared male fishers.

- Both female and male fishers primarily used live trees for resting (225 and 195 rest sites, respectively). Live-tree rest structures were relatively large and females appeared to use larger trees ($\bar{x}$ = 88 cm dbh) than males ($\bar{x}$ = 64 cm dbh). Mistletoe brooms were the most frequently used microsite by both sexes (Table Southern Oregon Cascades 3).
- Females used a greater proportion of snags for resting (20% of 378 rest structures) than males (6% of 275 rest structures). Both sexes typically used cavities or hollows in large snags that had been created by advanced stages of heartwood decay, and use of various tree species was similar between sexes (Table Southern Oregon Cascades 4).
- Both sexes used logs equally for resting (16% of 378 female rest structures and 16% of 275 male rest structures). Both sexes used relatively large logs (Table Southern Oregon Cascades 4) and primarily used hollows or cavities created by late stages of heartwood decay.
- Mean size of 11 cull piles (slash from timber harvest operations) used by fishers for resting was 19.3 m long, 13.1 m wide, and 2.5 m in height.
- Other types of structures used infrequently for resting by female and male fishers (2% and 4% of all rest structures, respectively) included dense brush, natural debris piles, rock outcrops, and unknown structures under the snow.

Table Southern Oregon Cascades 3. Characteristics of live trees used by 12 female (*n* = 225) and 7 male (*n* = 195) fishers radio-collared during the 1995–2001 study. Confirmed microsite = fisher was seen; suspected microsite = fisher was not seen but the microsite was the only possible resting location. Percentages of confirmed and suspected microsite use are exclusive (modified from Aubry and Raley 2006).

			% of live-tree rest structures where microsite was confirmed and (suspected)				
Sex	Primary tree species[a]	$\bar{x}$ dbh cm (range)	Mistletoe broom	Limb cluster or platform branch	Rodent nest	Cavity	Other
Female	Douglas-fir western hemlock true fir	88 (26–185) *n* = 138	31 (44)	7 (2)	3 (1)	4 (1)	6 (1)
Male	Douglas-fir western hemlock true fir	64 (18–201) *n* = 121	21 (33)	9 (3)	24 (3)	<1	7 (1)

[a] True fir = white-grand fir complex and some red fir. Other tree species used for resting included lodgepole, ponderosa and white pine, Engelmann spruce, incense cedar, golden chinquapin, madrone (*Arbutus menziesii*), and Pacific yew.

Natal and maternal dens

- 13 natal and 18 maternal dens were identified for 6 reproductive female fishers.
- Females used large live or dead trees as natal dens (Table Southern Oregon Cascades 5) with openings that accessed hollows created by heartwood decay. Most (8/13) of the cavity openings used by female fishers were created by pileated woodpeckers (*Drycopus pileatus*); other openings included natural cracks or knot holes in the bole. The mean height of the cavity opening used was 16.2 m (range = 4–47 m; *n* = 10 measured).
- For maternal dens, females primarily used cavities in the lower bole or butt of large live

Table Southern Oregon Cascades 4. Characteristics of snags and logs used by 12 female (n_{snags} = 76; n_{logs} = 53) and 7 male (n_{snags} = 17; n_{logs} = 43) fishers for resting during the 1995–2001 study (not all rest structures were measured; modified from Aubry and Raley 2006).

	Snags			Logs		
Sex	Primary tree species used[a]	$\bar{x}$ dbh cm (range)	$\bar{x}$ height m (range)	Primary tree species used[a]	$\bar{x}$ large end diameter cm (range)	$\bar{x}$ length m (range)
Female	Douglas-fir true fir incense cedar sugar pine	114 (29–196) *n* = 47	16 (1–60) *n* = 47	Douglas-fir true fir incense cedar sugar pine	105 (48–182) *n* = 43	21 (4–52) *n* = 43
Male	Douglas-fir true fir pines	121 (62–196) *n* = 7	21 (8–62) *n* = 7	Douglas-fir true fir incense cedar pines	108 (52–160) *n* = 32	21 (5–46) *n* = 32

[a] True fir = white-grand fir complex and some red fir. Other tree species used included ponderosa and white pine, Engelmann spruce, and golden chinquapin.

Table Southern Oregon Cascades 5. Sizes of live trees, snags, and logs used by 6 reproductive female fishers for natal dens (sites used for giving birth to and nursing kits until weaning at 8-10 weeks of age) and maternal dens (sites used after kits were weaned and until about 4 months of age) during the 1995–2001 study (modified from Aubry and Raley 2006).

	Natal dens		Maternal dens		
Structure	Live trees *n* = 7	Snags *n* = 6	Live trees *n* = 8	Snags *n* = 5	Logs *n* = 5
$\bar{x}$ dbh or large end diameter (cm) (range)	92 (62–138)	89 (61–136)	97 (35–137)	132 (90–250)	105 (56–166)
$\bar{x}$ height or length (m) (range)	40 (25–54)	26 (10–52)	38 (19–57)	16 (3–27)	15 (5–27)

or dead trees, or hollows in large logs (Table Southern Oregon Cascades 5). Other microsites used included mistletoe brooms and rodent nests in live trees (2 and 1 dens, respectively) and 1 den in a cavity formed between the bole and sloughing bark of a snag.

- Four natal dens were in incense cedar trees; 3 natal dens each were in true firs and white pine, 2 in golden chinquapin, and 1 in Douglas-fir. Trees, snags, and logs of Douglas-fir were used most frequently for maternal dens (9/18); 5 maternal dens were in incense cedar and 4 were in true fir.

Availability of potential rest and den structures

- Less than 10% of all available live trees measured at random points had mistletoe brooms. However, larger trees had more brooms than smaller trees. Mistletoe brooms were present in 12% of 183 very large trees (>100 cm dbh), 10% of 330 large trees (51–100 cm dbh), and only 6% of 362 medium-size trees (26–50 cm dbh).
- Available live trees with cavities were rare but larger trees had more cavities than smaller trees. Cavities were present in 4% of the very large live trees measured, <1% of the large live trees, and no cavities were present in medium-size trees.

- Available snags with cavities were relatively uncommon, but larger snags had more cavities than smaller snags. Cavities were present in 33% of 109 very large snags measured, 19% of 242 large snags, and only 10% of 299 medium-size snags.
- Available logs with hollows or cavities were also relatively uncommon, but larger logs had more potential microsites than smaller logs: 23% of 142 very large logs were hollow at ≥1 end and 27% had cavities; 20% of 328 large logs were hollow at ≥1 end and 17% had cavities; only 6% of 356 medium-size logs were hollow at ≥1 end and 6% had cavities.

Author(s) Interpretation

- Use of various tree species for resting by female and male fishers was probably related to the presence of potential microsites. Mistletoe infections in Douglas-fir and western hemlock create more substantial broom structures than those created by infections in incense cedar. Also, platform branches were most characteristic of large Douglas-fir trees.
- The large size of snags and logs used by fishers for resting was probably related to the species of live trees in the study area that were most susceptible to infection by heart-rot decay fungi and had a tendency to form large hollows. Also, older (thus larger) live trees are typically more susceptible to infection than younger (thus smaller) trees.
- Although male fishers used rodent nests for resting more than females, specific habitat conditions occurring in the home ranges of 1–2 males may account for the differences.
- The species and large size of live trees, snags, and logs used by reproductive females for denning were probably related to the species of live trees in the study area that were most susceptible to infection by heart-rot fungi and had adequate time to form cavities large enough to accommodate a female with kits.
- The height of cavities used as natal dens may be important for protecting kits from potential predators.
- Available structures with the types of microsites used by fishers for denning and resting were relatively uncommon in the study area. However, larger live trees, snags, and logs appeared to provide more potential fisher den and rest sites than did smaller (26–50 cm dbh or diameter) structures.

2.7. Northern California and Southwestern Oregon Fisher Population

2.7.1. Siskiyou National Forest, Study Area 9

Study Objectives: The primary objective was to gather new information on the distribution and habitat ecology of American martens (*Martes americana*). However, historical information on the distribution of fishers indicated that both fishers and martens occurred in the southern portion of the Oregon coast range. Consequently, a secondary objective was to determine the distribution of fishers in coastal Oregon and the habitat characteristics where fishers were detected.

Principal Investigator(s): K. Slauson and W. J. Zielinski (USDA Forest Service, Pacific Southwest Research Station)

Duration: 1997; 2000–2001

Study Area: The study area was located in the Illinois River Valley on the Siskiyou National Forest in southwestern Oregon, primarily on the Siskiyou National Forest in Curry and Josephine Counties, Oregon. The study area was within the Central Pacific Coastal Forest and Klamath-Siskiyou Forest ecoregions (Ricketts et al. 1999). The western portion of the Siskiyou National Forest was dominated by Douglas-fir and western hemlock associations, whereas the drier eastern portion was Douglas-fir and mixed conifer-hardwood associations. The southern portion had unique habitat types and greater botanical diversity due to serpentine soils. Elevation within the study area ranged from 600–2,900 m. Winters were mild with heavy precipitation, and the summers were warm and dry. Lands within the study area were primarily managed by the U.S. Forest Service.

Methods: The investigators used the National Forest Inventory vegetation monitoring grid as the template for selecting grid points to survey martens and fishers. At each selected grid point, a sample unit of 6 sooted track-plate stations was established: 1 track plate station was located near the grid point and the other 5 were arranged in a circle about 500 m out from the grid point. For microhabitat sampling, a combination of variable-radius plot and transect methods were used to estimate vegetation composition and structure at each track plate station in each sample unit. Vegetation composition and structure was visually estimated using variable-radius plot methods. Two 25-m line transects were used to tally logs and visually estimate shrub cover. Using a spherical densiometer, 4 canopy closure measurements were collected (1 in each cardinal direction) at the track plate station and at the end of each 25-m transect.

Publications and reports: 2 unpublished reports (Zielinski et al. 2000, Slauson and Zielinski 2001).

Results:

Landscape Scale

At this time no information is available at this scale.

Home Range Scale

At this time no information is available at this scale.

Stand Scale

At this time no information is available at this scale.

Site Scale

All data are from Zielinski et al. (2000) and Slauson and Zielinski (2001).

Key Findings

- In 2001, 25 sample units were surveyed on the Illinois Valley Ranger district in the southeastern part of the Siskiyou National Forest. Fishers were detected in 16% (4/25) of the sample units.
- All fisher detections were south of Highway 199. Three of the 4 sample units where fishers were detected were adjacent to Oregon Caves National

Monument; the fourth was along the border of the Siskiyou National Forest and the Smith River National Recreation Area.

- 1 fisher was detected at 1 track plate station in a sample unit located about 18 km from the Oregon Coast during a previous survey in 1997.
- Summaries of habitat data were based on detections at 7 track plate stations (1 from 1997 and 6 from 2001) and represented ocular estimates of plot variables.
- Fisher detections were on average 50.6 km from the Oregon coastline (SD = 20), and at mean elevation 880 m (SD = 341).
- All 7 stations detecting fishers were in non-serpentine forest habitat: 4 stations were in Douglas-fir, and 1 station each was in montane hardwood-conifer, Klamath mixed-conifer, and white fir forest types. Mean basal area was 46.5 m^3/ha (SD = 19.0, range = 9.1–64.2).
- Mean total canopy cover was 86.4% (SD = 13.1, range = 70–95); mean overstory canopy closure was 53.6% (SD = 27.8, range = 10–90); mean understory canopy closure was 34.3% (SD = 28.8, range = 5–85); and mean shrub cover was 50% (SD = 39.5, range = 0–100).

Author(s) Interpretation

- All 7 stations detecting fishers had a high conifer component and were dominated by Douglas-fir in the overstory and hardwoods in the understory (primarily tanoak [*Lithocarpus densiflorus*] and chinquapin).
- Shrub cover was variable but on average lower than at stations detecting martens.
- 5/7 stations detecting fishers occurred in the most mesic macro-aspects sampled (270–90 degrees).
- Sample units detecting fishers were >2 times the distance from the coast than those detecting martens.

Structure Scale

At this time no information is available at this scale.

2.7.2. Green Diamond Resource Company, Study Area 10

Study Objectives: Assess the distribution, relative abundance and habitat associations of fishers within 3 vegetation types and at coarse and fine scales on Green Diamond Ownership (formerly Simpson Timber) in northwestern California. The authors used systematic surveys to compare habitat characteristics (stand level attributes) of sites with and without fisher detections. They also used radiotelemetry to locate and describe habitats used for fisher resting and denning sites.

Principal Investigator(s): L. Diller (Green Diamond Resource Co.), R. Klug (Humboldt State University/ Green Diamond Resource Co.), and K. Hamm and J. Thompson (Simpson Resource Company)

Duration: 1994–1995; 1996–1997; 2002–2003

Study Area: The Green Diamond Study Area was located on Green Diamond Timber Lands in the California North Coast Ecoregion in Humboldt and Del Norte Counties, CA. It encompassed approximately 1,500 km^2, mostly within 30 km of the Pacific Ocean with an elevation range of 5–1,400 m. Most of the study area was within the following 4 watersheds: Klamath River, Redwood Creek, Mad River, and Eel River. The climate of the study area was generally considered maritime. Significant snowfalls occurred at elevations above 500 m with persistent accumulations above 1,000 m. Temperatures became less moderate with more seasonal variation as elevation and distance from the coast increased.

Methods: The investigators used sooted track-plate surveys to evaluate presence of fishers among 3 forest vegetation types (1994–1995). Primary surveys consisted of 238 and 233 stations in 1994 and 1995, respectively. Each year following the primary survey, a secondary survey was repeated at 48 stations. Habitat attributes were measured at each track-plate station. Vegetation types sampled were characterized by predominant overstory vegetation of 1) redwood (*Sequoia sempervirens*), 2) redwood-Douglas-fir mix and 3) Douglas-fir. These represented a transition from coastal low elevation forests to inland and higher elevation forests. Six track plate stations were placed at approximately 1-km intervals within each segment (sample unit) and each sample unit was separated by 5 km. Forty sample units were surveyed annually in Jan–June of 1994 and 1995. Habitat data were reported at 3 different scales: microsite (0.04 ha circular plot) characteristics of the station; vegetative characteristics of the stand in which the station was located; and vegetation type in which the sample unit was located. Thompson et al. (2007) used logistic regression techniques to further evaluate the influence of various habitat variables on fisher presence. In 1996–1997, a radio telemetry study was undertaken to investigate den and rest site selection. Twenty-four fishers (10M, 14F) were captured and 12 (6F, 6M) fishers were radio-collared and tracked from the ground using hand-held Yagi antennas. Triangulation followed by observer walk-in was used to locate den or rest sites. Den or rest tree species, size and structures were recorded. Den and rest sites data have not been published but some descriptive information on structures used by fishers was included in Simpson Resource Company (2003) and Thompson et al. (2007).

Publications and reports: 1 thesis (Klug 1997), 1 preliminary report to USFWS (Simpson Resource Company 2003), 1 unpublished report (Thompson 2008), 1 peer reviewed manuscript (Hamm et al. 2003), and 1 conference proceeding (Thompson et al. 2007).

Results:

Landscape Scale

All information is from Klug (1997).

Key Findings

- A mean detection ratio of 0.195 was reported for the primary surveys and fishers were detected on 26/40 sample units (65%) during 1994 and 1995.
- Detection ratios differed between the 3 vegetation types at the landscape scale in both years and when combined (Table Green Diamond 1).
- Fishers were detected more frequently than expected in the Douglas-fir type in 1994, 1995, and in both years combined.
- They were detected less frequently than expected in the redwood type in 1994, 1995 and the combined analysis.
- In the mixed redwood-Douglas-fir type they were detected more than expected in 1994 and in the combined analysis and less than expected in 1995.

Table Green Diamond 1. Detection ratios for stations located in 3 vegetation types surveyed in 1994 and 1995 during primary surveys on Green Diamond lands in the California north coast region, Humboldt Co., CA (modified from Klug 1997).

	Detection ratio of primary surveys (*n*)	
Vegetation type	1994	1995
Redwood	0.09 (91)	0.06 (91)
Redwood-Douglas-fir mix	0.25 (44)	0.19 (44)
Douglas-fir	0.24 (100)	0.37 (98)

Author(s) Interpretation

- Although fishers used all vegetation types within the study area, they were detected significantly more often than expected in areas with Douglas-fir either as a predominant or co-dominant component, at higher elevations, and at greater distances from the coast.
- This trend might be explained by the increase in hardwoods, especially tanoak and madrone at the higher inland sites.
- Conversely, alder (*Alnus* spp.) was the major hardwood species at lower elevation and closer to the coast.

- Tanoak and madrone both produce mast which could provide substantial food for potential fisher prey species. In addition, these hardwoods might provide suitable rest sites and den sites.

Home Range Scale

At this time no information is available at this scale.

Stand Scale

All information is from Klug (1997) and Thompson et al. (2007).

Key Findings

- Stand analysis was completed for 1994, 1995, and both years combined. In 1994, univariate comparisons of 13 stand level variables indicated significant differences between stands with fisher detections and those that did not have fisher detections (Table Green Diamond 2).
- Significant differences were found for vegetation type, percent hardwood basal area, and residual trees/ha (redwood [*Sequoia sempervirens*]). Klug, however, found that only percent hardwood was selected by the logistic model. In 1995 and both years combined vegetation type was the only variable selected by the logistic model.
- Univariate results for 1995 and both years combined were similar to the 1994 results except that residual trees/ha (fir), basal area young growth redwood, and residual (amount of noticeably larger remnant trees) were added in 1995, and basal area young growth fir was added for the combined analysis to the list of significant differences.
- Fishers were detected significantly more often at higher elevations, and in Douglas-fir dominated stands with greater amounts of hardwood.

Table Green Diamond 2. Means of habitat variables measured from Simpson Timber Company GIS database in stands with fisher detections and stands without fisher detections in 1994 and 1995 combined, in Humboldt and Del Norte Counties, California (modified from Klug 1997).

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

- Fishers were detected in stands ranging in age from 6 yrs to old-growth. No significant differences in fisher detections by stand age were apparent.

- Thompson et al. (2007) reported that on the basis of logistic regression analyses, fisher detections were best predicted by increasing elevation, greater volume of logs, less basal area of trees 52–90 cm dbh, more moderate slopes, and greater distance to the coast.

Author(s) Interpretation

- There was no relationship between fishers and old-growth or late seral forest identified in this study. However, only 2% of the study area was composed of small isolated stands of old-growth or late seral forest making it difficult to detect any relationships between fishers and old-growth.

- Fishers were detected in young stands (as young as 6 yrs of age) and there was no difference between age of stands with detections and age of stands without detections. This may be attributed to the rapid growth of stands in the study area and the potential that fishers are less selective during foraging and travel than during resting and denning.

- Vegetation grows rapidly within the California north coast region due to moderate temperatures and abundant precipitation. Therefore, within 5–7 yrs after clearcut harvest, it is possible to have a nearly "closed canopy" providing over head cover (of dense brush and seedling and sapling trees) for fishers. The young brushy stands also may provide a high density of potential prey such as, woodrats (*Neotoma* spp.) and chipmunks (*Tamias* spp.).

Site Scale

All information is from Klug (1997).

Key Findings

- Stations with fisher detections differed significantly from those without detections in all 3 comparisons (1994, 1995, and combined years).

- Stations with detections were higher in elevation and a greater distance from the coast. They had a greater basal area of hardwood with dbh of 13–27 cm, greater basal area of hardwood with dbh >52 cm, and also had a greater total basal area of hardwoods (dbh >13 cm).

- There were no differences in percent canopy cover (mean of 5 spherical densiometer measurements), number of logs, slope position, number of snags, distance to gap, basal area conifer of all size classes, basal area of hardwood with dbh between 28–51 cm, and total basal area of all trees.

- Results of logistic regression analysis were similar for 1995 and the combined data and included more variables in the final model than the 1994 analysis alone. Only elevation and volume of logs were included in the 1994 analysis while elevation, volume of logs, basal area of conifer (52–90 cm), percent slope, and distance to the coast were included in the 1995 and combined analysis.

Author(s) Interpretation

No interpretation provided.

Structure Scale

All information is from Simpson Resource Company (2003) and Thompson et al. (2007).

Key Findings

- A total of 9 dens were found for 5 of 6 females (4 natal, 5 maternal [temporary refuge sites for the kits]).

- Natal dens were in tree cavities in tanoak (2), Douglas-fir snag (1) and chinquapin (1) with a $\bar{x}$ dbh = 76.5 cm (SD = 15.6, range = 62.5–95.3).

- Maternal den trees had $\bar{x}$ dbh = 112.0 cm (SD = 45.8, range = 62.5–184.4) and were in cavities of tanoak (2), Douglas-fir snags (2) and 1 western red cedar snag.
- Thirty five rest sites were found in a variety of tree species and structures. The most common structures used were dwarf mistletoe clumps in hemlocks (10), lateral branches and/or nests in Douglas-fir trees (7) and cavities in cedars (6).

Author(s) Interpretation

Den trees tended to be the largest trees on plots measured around each den.

2.7.3. Redwood National and State Parks, Study Area 11

Study Objectives: This study was conducted to determine the distribution of martens and fishers in Redwood National and State Parks. Additional objectives were to identify habitat characteristics at several spatial scales and associations of various anthropogenic features, such as roads and trails, at sites where martens and fishers were detected.

Principal Investigator(s): K. Slauson and W. J. Zielinski (USDA Forest Service, Pacific Southwest Research Station)

Duration: 2002

Study Area: The study area was located along the northern California coast, from the Smith River just northwest of Crescent City south to Redwood Creek near Orick, CA. The study area was about 425 km^2, and was within a temperate rainforest ecosystem dominated by coast redwood and Sitka spruce (*Picea sitchensis*). Upstream areas in Redwood Creek were dominated by white oak (*Quercus alba*), black oak (*Quercus kelloggii*), and Douglas-fir. Elevation ranged from sea level to 945 m. Mean temperatures ranged from 7.2° C in winter to 20.5° C in summer. Average annual precipitation was 175 cm. Lands within the study area were managed by the U.S. National Park Service and California State Parks.

Methods: Systematic surveys (SSU), based on 23 grid points spaced at 5-km intervals, were conducted using track plate stations to detect martens and fishers in the study area. Road-based surveys (RBS) using track plate stations were also conducted in a separate but smaller inland area near Rock Creek. At each grid point, 1 sample unit was established consisting of 6 track plate stations: 1 at the grid point and 5 arrayed in a pentagon around the grid point using 0.5-km spacing. For SSU, habitat sampling was conducted at 3 spatial scales: compositional (comparable to this document's definition of landscape scale), stand, and microhabitat (comparable to this document's definition of site scale). For the compositional analyses, habitat variables were derived from a GIS vegetation coverage using a 2.5-km radius circle (21.25 km^2) placed around each of the 23 sample units. Variables analyzed at this spatial scale included number of stands >3 ha, amount of riparian habitat, amount logged, amount of old growth redwood and other conifer types, and relative amount of logging between 1948–1960 and 1961–1980. Habitat characteristics were summarized using descriptive statistics. At the stand scale, investigators assessed size of second growth stands and year of last harvest activity from a GIS vegetation layer. Investigators only assessed characteristics of second growth forests at this spatial scale because distinct stand types for old growth forests were not identified in the available GIS vegetation coverage. Second growth stands were considered used if a fisher was detected at ≥1 track plate station in the stand. Observed and expected patterns for fisher detections were analyzed using Chi-squared goodness of fit tests. For microhabitat sampling, a combination of variable-radius plot and transect methods were used to estimate vegetation composition and structure at each track plate station in each sample unit. Variable-radius plots (using a 20-factor prism sweep) were sampled to describe vegetation composition and structure including basal area, species diversity, and abundance and size of trees at each track plate station. Logs, stumps, and snags were sampled along 4 25-m long transects (varying in width from 5–10 m) radiating from each track plate station. Canopy layers, shrub species composition, and shrub cover were visually assessed within 0.49-ha plots. Four canopy closure measurements were collected using a spherical densiometer at each of 5 points (center and end of each 25-m transect). Various other site variables (e.g., elevation, slope, etc.) were also collected. Microhabitat variables were summarized using descriptive statistics.

Publications and reports: 1 unpublished report (Slauson and Zielinski 2003).

Results:

Landscape Scale

All information is from Slauson and Zielinski (2003).

Key Findings

- Fishers were detected at 7/23 (30%) of the SSU sample units and at 21/138 (14%) of all the track plate stations within the 23 sample units.
- 4 of the 7 SSU's where fishers were detected were in second growth (35–100 yrs old), 2 were on the edge of old growth and second growth, and 1 was in old growth.
- Within the 2.5 km area surrounding each sample unit, the 7 units where fishers were detected had, on average, fewer stands that were ≥3 ha in size, less riparian habitat, slightly less old growth redwood, a greater relative percentage of forest that was logged between 1948–1960, and a lesser relative percentage of forest that was logged from 1961–1980 (Table Redwood 1).

Table Redwood 1. Mean (SD) values of GIS-derived habitat variables within a 2.5-km radius circle (1,960 ha) centered on 23 surveyed sample units where fishers were detected or not detected in 2002, Redwood National and State Park study area (modified from Slauson and Zielinski 2003).

Variable	Detected (*n* = 7)	Not detected (*n* = 16)
No. stands ≥3 ha	37 (24)	48 (30)
Riparian (ha)	1.5 (3)	37 (84)
% logged	60 (29)	51 (29)
% old growth redwood	32 (24)	43 (26)
% old growth conifer	7 (15)	4 (8)
Amount logged (ha) 1948-60	369 (243)	248 (270)
Amount logged (ha) 1961-80	256 (292)	484 (385)
Amount logged (ha) years unknown	151 (187)	92 (140)
Relative % logged (ha)1948-60	70 (22)	40 (31)
Relative % logged (ha) 1961-80	30 (22)	60 (31)

Author(s) Interpretation

- There were fewer stands ≥3 ha in size where fishers were detected; however, this was due to overall larger stand size in these sample units compared to sample units where fishers were not detected.
- Detections of fishers in sample units and at track plate stations suggested that fishers used second growth redwood habitats more than old growth redwood habitat. However, the analysis also showed that on average 33% of the area around sample units where fishers were detected was old growth.

Home Range Scale

At this time no information is available at this scale.

Stand Scale

All information is from Slauson and Zielinski (2003).

Key Findings

- Fishers were detected at 7/23 (30%) of the SSU sample units and at 21/138 (14%) of all the track plate stations within the 23 sample units. However, because analyses at this scale only included second growth forests, only a subset of the detection results were used.

- 41 unique second growth stands were identified in the SSU areas sampled.
- Fishers were detected more than expected in second growth stands that were logged 44–55 yrs ago and less than expected in second growth stands logged 26–41 yrs ago (X^2 = 8.47, df = 1, probability of X^2 >8.47 = P <0.005).
- Second growth stands where fishers were detected were larger in size ($\bar{x}$ = 262.3 ha, SD = 282) than those where fishers were not detected ($\bar{x}$ = 183.9 ha, SD = 247).

Author(s) Interpretation

- Within second growth redwood forests, fishers were detected in the oldest stand ages.
- Stands were larger where fishers were detected, consistent with results from landscape scale analysis (i.e., at the landscape scale, areas around fisher detections had fewer number of stands due to larger stand size).
- Although fishers were most frequently detected in second growth stands, many of the stands were near patches of old growth redwood. However, additional research would be needed to determine if patches of old growth redwood are important to fishers at this scale.

Site Scale

All information is from Slauson and Zielinski (2003).

Key Findings

- Fishers were detected at 7/23 (30%) of the SSU sample units and at 21/138 (14%) of all the track plate stations within the 23 sample units.
- 4 of the 7 SSU where fishers were detected were in second growth (35–100 yrs old), 2 were on the edge of old growth and second growth, and 1 was in old growth. In the 2 SSU that were on the edge of second and old growth, 5/5 stations where fishers were detected were in second growth.
- When all track plates stations in old growth were pooled (n = 69) and those in second growth were pooled (n = 69), fishers were detected less than expected at stations in old growth (n = 4) and more than expected in second growth (X^2 = 8.42, df = 1, P <0.005).
- Track plate stations in old growth that detected fishers had >2 times the density of large (>90 cm) logs and stumps, lower overstory canopy, and no hardwoods compared to old growth sites where fishers were not detected (Table Redwood 2).
- Track plate stations in second growth that detected fishers were dominated by redwoods, whereas stations in second growth that did not detect fishers were dominated by Douglas-fir.
- Within second growth forests, sites detecting fishers had greater shrub cover, greater basal area of conifers and snags, lower basal area of hardwoods, and greater densities of medium-sized logs, and all sizes of snags and stumps compared to sites that did not detect fishers.

Author(s) Interpretation

- Authors assumed that fishers visited track plate stations while foraging and habitat characteristics at these sites represented the types of areas used for foraging, but could not make any assumptions about other life history needs (e.g., suitable resting habitat).
- It is not known how bait or olfactory lure affect fishers and the decisions they make about which habitats or sites to visit. Thus, results represented the types of sites fishers were willing to visit.
- Overhead cover (tree and tall shrub cover combined) was >75% at all 138 track plate stations; thus, differences between sites where fishers were and were not detected should reflect associations with prey populations or habitat characteristics important for resting and denning.

Table Redwood 2. Mean (SD) values for microhabitat variables measured at 138 track plate stations (6 stations in each of 23 SSU sample units) describing characteristics in old or second growth forests where fishers were and were not detected in 2002, Redwood National and State Park (data are subset of microhabitat results from various tables in Slauson and Zielinski [2003]).

	Old growth		Second growth	
Variable	Detected ($n = 4$)	Not detected ($n = 65$)	Detected ($n = 17$)	Not detected ($n = 52$)
Overstory canopy cover (%)	27.8 (25)	47.0 (17)	54.6 (25)	51.2 (32)
Total shrub cover (%)	86.2 (10)	89.0 (16)	58.1 (27)	41.2 (29)
Basal area (m^2/ha)				
Conifers	330 (140)	336 (134)	242 (135)	144 (88)
Hardwoods	0 (0)	17 (38)	43 (64)	77 (74)
Snags	60 (69)	50 (52)	23 (28)	12 (18)
Density (No./ha)				
Logs, large (>90 cm)	55.0 (57)	26.0 (25)	12.0 (13)	17.0 (20)
Logs, medium (30–90 cm)	53.0 (34)	53.0 (43)	90.0 (65)	55.0 (51)
Snags, large (>90 cm)	11.0 (13)	9.1 (10)	4.3 (8)	1.7 (4)
Snags, medium (30–90 cm)	5.0 (5)	4.3 (8)	6.2 (9)	3.1 (5)
Stumps, large (>90 cm)	7.5 (15)	0.1 (1)	31.0 (24)	22.0 (19)
Stumps, medium (30–90 cm)	0 (0)	0.1 (6)	8.7 (13)	4.2 (6)

- In second growth redwood forests, fishers were detected at sites that had the most structurally complex microhabitat conditions, most of which were consistent with older stand age. Structural complexity and diversity may be associated with a greater diversity and abundance of prey populations. Large logs and snags also provide resting and denning habitat.
- Shrub species provide food for fishers.
- Although shrub cover was greater at second growth sites where fishers were detected than at sites where they were not, all sites had moderate shrub cover.

Structure Scale

At this time no information is available at this scale.

2.7.4. Sacramento Canyon, Study Area 12

Study Objectives: These studies used telemetry techniques to determine landscape and stand features important to martens and fishers. Attributes measured included: home range size and stability, individual home range overlap, identification of features used within stands for resting, landscape-level habitat change over the past 50 yrs, and fisher use of managed forests at stand, home range and landscape levels. Specific objectives included the following: determining home range size, stability, and overlap between individuals, determining seasonal habitat selection within home ranges, testing habitat suitability index (HSI) and wildlife habitat relationship (WHR; Mayer and Laudenslayer 1988) models of fisher habitat selection, and identifying and describing fisher rest site selection. Self and Callas (2006) documented presence of fishers within their study area, described home ranges and reproductive status of adult female fishers, identified natal and maternal dens and characterized their habitat, and documented disease status of fishers in their study area. Their project was also conducted on the Hayfork study area.

Principal Investigator(s): S. Self (Sierra Pacific Industries), S Kerns (Wildlife Resource Managers), and R. Callas (California Department of Fish and Game)

Duration: 1990–1995; 2006; 2008

Study Area: The Sacramento Canyon study area occurred in 95.9 km^2 of the Castle Creek watershed, Shasta County, CA. The study area was located primarily on Sierra Pacific Industries lands immediately south of and including a portion of Castles Crags State Park. Elevation ranged from 615–2,154 m. Forest types were primarily Klamath mixed conifer, ponderosa pine and sugar pine and at lower elevation riparian types, montane hardwood and chaparral. Reno et al. (2008) also report associations with black oak, canyon live oak (*Quercus chrysolepsis*), madrone, and tanoak. Annual precipitation ranged from 152–178 cm with the majority falling as snow. Reno et al. (2008) reported that their study occurred on portions of the same study area at elevations ranging from 500–1,500 m. Reno et al. (2008) reported a mean annual rainfall of 150 cm for their study area.

Methods: Study area habitats were typed with California Wildlife Habitat Relations (CWHR) vegetation types (Mayer and Laudenslayer 1988) using 1991–1992 aerial photos and aerial photos from 1944. Vegetation types were ground-checked. Stand level vegetation typing for WHR included: tree height and diameter, species, basal area, trees/acre, snags and logs. Live-trapped animals were fitted with radio-collars and located 1–4 times/week using triangulation or walk-in techniques to determine rest site locations when animals were inactive. Fisher locations and rest site vegetation were quantified using 115-ft radius circular plots centered on the rest structure based on Bingham (1989) and Pious (1990), and typed using CWHR classification. Distances were measured to water, roads, landings, recent and historic logging. Used vs. expected distance to water (streams with water >6 months of the year) by CWHR type was quantified by distance class (<500 ft, 501–1100 ft, >1101 ft). Other measured variables included tree species, dbh, canopy closure (average of 48 spherical densiometer measurements), basal area/acre (100% sample of plot area), quadratic mean diameter of all trees greater than 5 inches dbh, distance to human disturbance, age of rest site tree, age of rest site stand (average cored age of 3–5 dominant and co-dominant trees). Use-availability analyses were performed for both individual animals and all animals combined. Minimum convex polygon (MCP) home ranges were estimated using the computer program "TELEM". Stand use was quantified at animal point locations. Available habitat was calculated at the MCP home range level and watershed level.

Self and Callas (2006) reported captures of 3 female and 1 male fishers in the Sacramento Canyon study area. Reno et al. (2008) report on home ranges of 3 female fishers radio-tagged in this study area. Home ranges were estimated using 95% and 100% MCP and 95% and 50% fixed kernel home range estimators. Home range estimates were based on helicopter relocations (n = 293), ground relocations (n = 120), den and rest tree locations (n = 86), and trap/re-trap locations (n =19). Only fishers with a minimum of 20 relocations annually were used for home range analyses.

Publications and reports: 4 unpublished reports (Self and Kerns 1992, 2001; Self and Callas 2006, Reno et al. 2008) and 1 conference abstract (Reno et al. 2007).

Results:

Landscape Scale

All information is from Self and Kerns (1992), and Self and Kerns (2001).

Key Findings

- In 1944, CWHR size classes 1–3 (<2–28 cm dbh) made up >80% of study area.
- In 1992, CWHR size classes 4–6 (>28 cm dbh) made up 79% of study area.
- In 1944, 46% of the area was in CWHR density class "S" (for sparse 10–24%). In 1992, CWHR stand density classes were relatively evenly distributed with 50% in CWHR density classes M and D (moderate and dense canopy closure >40%) while stands in the S closure class occurred on <25% of the study area.
- Klamath mixed conifer (KMC) and montane hardwood conifer (MHC) types were selected by 3 adult male fishers (63% of watershed and 95% of fisher use. Fishers also selectively used habitats based on CWHR size and density classes. Fishers selected CWHR size and density classes 3D, 4D, 5P, 5M.
- Montane chaparral and white fir types were not selected by fishers (29% of watershed and 4% use).
- Based on the first year of telemetry data, 2 male fishers had home range overlap. One home range had 28% overlap, 1 had 42% overlap. Fishers used the overlapping portions of home ranges as expected based on the proportion of home range area.
- Fishers selected more dense stands in winter, generally using CWHR D (60% of locations). Fishers used CWHR P more in summer (39% summer locations, 13% winter locations).

Author's Interpretation

- Over the last 50 yrs, the watershed has generally changed from early-seral open-forest conditions to mid-seral size classes with a relatively even distribution of CWHR canopy closure classes.
- They report significant non-random use of the habitat types within the study area. They found fishers to prefer forested habitats, habitats containing a significant hardwood component, and lower elevation forest types.
- Fishers selected areas with significant hardwood components, which may be related to prey density and prey dependency on hardwoods.
- Fisher habitat selection was highly variable by season and year. Fishers selected open-forest stands (CWHR P) during summer, but heavy brush in these stands would provide adequate cover while traveling.

Home Range Scale

All information is from Self and Kerns (1992), Self and Kerns (2001), and Reno et al. (2008).

Key Findings

- Over a 3-yr period, 3 radio-collared males were located 714 (550 summer, 154 winter) times. MCP home ranges averaged 2,850 ha (range = 2,359–3,486 ha).
- Telemetry error was estimated using error polygons and actual difference between triangulations and walk-in locations. Error distance was 22–721 m, error polygon size averaged 9.1 ha, with 80% of polygons <14.6 ha.
- Reno et al. (2008) reported annual home ranges for female fishers ranging from 2.57–14.23 km^2 (n = 3 fishers, n = 2 yrs).

Author(s) Interpretation

No interpretation provided.

Stand Scale

All information is from Self and Kerns (1992), and Self and Kerns (2001).

Key Findings

- Thirty four resting sites used by 3 adult male fishers were found. Of the 34 rest sites, 77% were located in CWHR size class 4 stands, with 39% in KMC/MHC 4D stand types.
- The HSI model worked well to predict winter habitat selection, but under-predicted the use of open habitat over the full year.

- The CWHR model did not predict fisher habitat use well.

Author(s) Interpretation
- The HSI model under predicted the use of open habitats (CWHR closure class P) when considering all the habitat use data combined across all seasons. It performed well when used to predict winter habitat use.
- When fishers used open stands for resting their rest sites were usually located in small patches of denser canopy within these open stand.

Site Scale
All information is from Self and Kerns (1992), and Self and Kerns (2001).

Key Findings
- Fishers selected rest sites in the <500 feet distance to water class. (Rest sites that were used more than once or by more than 1 individual were counted only once).
- Rest site characteristics were:
  - $\bar{x}$ canopy closure was 71% (SD = 20%)
  - $\bar{x}$ basal area/acre 1 was 60 ft^2 (SD = 104) (measurement of all plot trees >5 inches)
  - $\bar{x}$ dbh of rest trees was 30 in (SD = 12) (green trees)
  - $\bar{x}$ distance to water was 442 ft (SD = 809)
  - $\bar{x}$ distance to human disturbance was 224 ft (SD = 332)

Author(s) Interpretation
- Proximity to water appeared to be selected by fishers, but results could not be separated from vegetation type selection.
- Based on other literature, the author suggested that female rest sites and den sites might be comparable to male rest sites.

Structure Scale
All information is from Self and Kerns (1992), Self and Kerns (2001), Self and Callas (2006), and Reno et al. (2008).

Key Findings
- Twenty-seven of 34 rest sites (79%) used by 3 adult male fishers were green trees, 74% of these trees were Douglas-fir. Five rest sites (15%) were in snags and 2 (6%) were in logs.
- Mistletoe provided 81% of all of the micro-structures used by 3 male fishers while resting in green trees.
- Mean dbh of 27 rest trees was 30 in (SD = 12), mean age of 19 conifer rest trees was 100 yrs (SD = 47).
- Self and Callas (2006) reported 2 natal and 7 maternal dens from the Sacramento Canyon and Hayfork Summit study areas, however they did not distinguish in which study area each den was located.
- All dens were in tree cavities, 6 dens were in black oak (live), 2 were in live oak (live), and 1 was in a dead Douglas-fir.
- Natal dens were in black oak (18.7 in dbh) and live oak (51.8 in dbh).
- Maternal dens were in trees with $\bar{x}$ dbh = 32.7 in (n = 7; range = 18.7–65.5).
- Reno et al. (2008) reported characteristics of 15 natal and maternal dens (Table Sacramento Canyon 1). These data are not exclusive of those reported in Self and Callas (2006).
- Mean dbh of den trees was 76.4 cm.

Author(s) Interpretation
- Rest site trees tended to be larger relative to what was available on the plot.
- Authors emphasised the importance of maintaining some larger or older trees in managed forests.
- Reno et al. (2008) suggested that decay processes were important to cavity formation for den sites and hypothesize that in hardwoods fishers may use trees as small as 25 cm dbh if heartwood rot was present.

Table Sacramento Canyon 1. Characteristics of fisher reproductive den trees (modified from Reno et al. 2008.

Tree Species	Natal dens (*n*)	Maternal dens (*n*)	$\bar{x}$ dbh (cm)	$\bar{x}$ height (m)
Douglas-fir (snag)	0	4	90	14.4
Black oak (snag)	0	3	45	13.5
Black oak (live)	0	2	45	15.2
Incense cedar (live)	0	1	96	31.1
Incense cedar (snag)	0	1	91	9.1
White fir (live)	1	0	66	33.2
Port-Orford cedar[a] (snag)	0	1	113	17.1
Ponderosa pine (snag)	0	1	74	10.4
Unspecified conifer (snag)	1	0	68	10.4

[a] *Chamaecyparis lawsoniana*

2.7.5. Hoopa Valley Indian Reservation, Study Area 13

Study Objectives: The two main objectives of the 1996–1998 study were to: 1) investigate characteristics of fisher rest sites at the structure, site and home range scale; and 2) document home range size. During the 2004–present study the main objectives were to determine: 1) natal and pre-weaning den characteristics at the structure, site and home range scale, 2) habitat selection at the home range and stand scale for denning, resting and active behaviors, and 3) home range size and habitat composition. Additional objectives included 4) monitoring sex ratio and age structure of the population, 5) comparing relative density estimates between 1998-99 and 2004–05, 6) fisher survival rates, 7) denning chronology, rates, and success, 8) female reproductive rates, 9) monitoring rates of pathogen exposure and 10) development and testing of non-invasive population monitoring techniques.

Principal Investigator(s): J. M. Higley (Hoopa Tribal Forestry), S. M. Matthews (Wildlife Conservation Society), and J. S. Yaeger (Humboldt State University)

Duration: 1996–1998; 2004–ongoing

Study Area: The Hoopa Valley Indian Reservation is a 362 km^2 area immediately south of the junction of the Klamath and Trinity Rivers within the Klamath Bioregion. The Trinity River divides the Hoopa Valley Indian Reservation effectively into west and east halves. The elevation ranged from 76–1,170 m. The study area consisted of primarily montane hardwood-conifer communities (Mayer and Laudenslayer 1988) made up of mostly Douglas-fir, tanoak and madrone. Precipitation averaged 156 cm with <2% falling during summer. Snowfall was usually moderate ranging from none at lower elevations to 40 cm at higher elevations. The 1996–98 study occurred on the southeast portion of the reservation while the 2004–present study included all of the 1996–98 study area and expanded to include a substantial portion of the Reservation west of the Trinity River.

Methods: Fishers were live-trapped, ear-tagged (and PIT tagged 2004–present) and radio-collared. Traps were placed opportunistically throughout the study area. Ground-based telemetry was used to determine each animal's location based on triangulations. When animals were determined to be inactive telemetry was often employed to track fishers to rest and den sites by following the signal to its source. Home range size was calculated (95% minimum convex polygon [MCP]) and habitat composition was calculated for 95% fixed kernels. Multivariate analysis of variance (MANOVA) was used to test hypotheses that habitat use did not differ from random. Third-order habitat selection was investigated for active, resting, and denning locations, conducting a Euclidean distance analysis for each location type using 2 strata type scenarios, one with 7 strata and one with 8 strata (Tables Hoopa Valley 1 and 2 respectively). Distances from random points generated throughout each individual's 100% MCP home range estimate were compared to distances from fisher locations obtained with radio telemetry. Habitat selection was investigated using Euclidean distance analysis and statistical tests were completed using SAS 9.2 (SAS Institute, Cary, NC). Statistical tests were considered significant when $P \leq 0.05$ and marginally significant when $0.10 > P > 0.05$.

The primary objective at the site and structure scale was to characterize selection for habitat variables measured at fixed-radius circular 0.04 ha plots (1996–98) or 0.08 ha plots (2004–present) centered on the rest or den structure. Habitat data collection at fisher den and rest sites located during 2004–2007 is ongoing, therefore, only general information about structures has been reported to date. During 1996–1998 ocular estimates of foliar cover were made to the nearest 10% and then grouped into 4 categories: <26%; 26–50%; 51–75%; >75%. During 1996–1998 the same habitat variables were also measured at an equal number of random plots (same number of rest site points within each animal's home range) however, those plots were not tree centered.

Yaeger (2005) compared characteristics of trees used for resting to those available using random plots within each animal's home range. Trees ≥ 40 cm were considered to be available for fisher use. Chi-square goodness of fit and subdividing Chi-square analyses were used to determine significance of use verses availability. Using the same radio telemetry methods, adult female fishers were radio-collared and tracked to rest and den sites during 2005–2007, with an emphasis on locating den structures. For all tree-based structures used for resting or denning, tree species, dbh, decay class, and the presence of platforms and cavities were noted. A den was defined as a structure used 2 or more times in succession over 3 or more days during the birthing period (March–April). Dens were classified as: natal (location where parturition took place); maternal pre-weaning (any den used after the natal-parturition den and before the kits were weaned); maternal post-weaning (any den used after weaning and before the kits were actively following the mother).

Publications and reports: 1 thesis (Yaeger 2005) and 5 unpublished reports (Higley et al. 1998; Higley and Matthews 2006; Matthews 2007, 2008; Matthews et al. 2008).

Results:

Landscape Scale

All information is from Matthews et al. (2008).

Key Findings

- The results of the Euclidean distance analysis indicated that fishers selected for closed-canopy forest, sapling-brushy pole, and seedling stands and did not avoid any habitat types when establishing home ranges.

Author(s) Interpretation

- Although fishers exhibited selection for several strata types (closed-canopy forest, sapling-brushy pole, and seedling stands) for inclusion in home ranges, it was noted that analyses which included 8 strata types with a separation of the closed-canopy forest into mature and older forest, young growth and pole stands resulted in no selection being exhibited (Tables Hoopa Valley 1 and 2).

Home Range Scale

All information is from Yaeger (2005).

Table Hoopa Valley 1. Eight habitat types and definitions used to classify habitat (based on tree composition and timber management history) on the Hoopa Valley Reservation, CA (modified from Matthews et al. 2008).

Habitat type	Definition	Area (km^2)	Area (%)
Seedling (SDL)	<10 yrs old cutover stands	15.5	3.8
Sapling-brushy pole	10–29 yr-old cutover stands with a dense brush layer and small-diameter conifers and hardwoods	40.9	10.2
Young pole	10–29 yr-old cutover stands that have been pre-commercially thinned to remove the brush layer	6.6	1.6
Pole stand	30–45 yr-old cutover stands forming a complete forest canopy and begun stem exclusion	132.3	32.8
Young growth	46–80 yr-old stands regenerating following a natural disturbance (i.e. stand-replacing fire)	13.0	3.2
Mature and older forest	$\geq$80 yr-old stands with large-diameter conifers and hardwoods	151.8	37.7
Hardwood	Oak (black and white oak) and tanoak dominated habitat	25.6	6.4
Non-forested	Including valley urban zone, prairies, rocky outcrops, and landslides	17.1	4.2

Table Hoopa Valley 2. Seven habitat types and definitions used to classify habitat (based on tree composition and timber management history) on the Hoopa Valley Reservation, CA (modified from Matthews et al. 2008).

Habitat type	Definition	Area (km^2)	Area (%)
Seedling	<10 yrs old cutover stands	15.5	3.8
Sapling-brushy pole	10–29 yr-old cutover stands with a dense brush layer and small-diameter conifers and hardwoods	40.9	10.2
Young pole	10–29 yr-old cutover stands that have been pre-commercially thinned to remove the brush layer	6.6	1.6
Older closed-canopy forest	$\geq$30 yr-old stands with a closed forest canopy of conifers and hardwoods	310.9	77.2
Hardwood	Oak woodland habitat dominated by deciduous hardwoods (black and white oak)	11.8	2.9
Non-forested	Includes prairies, rocky outcrops, and landslides	6.6	1.6
Urban	Valley urban zone	10.5	2.6

Key Findings

- MCP (100%) home ranges based on rest, den and trap sites were calculated for 7 female ($\bar{x}$ = 168 ha, SE = 17, n = 7) and 2 male fishers (873 ha and 615 ha) (minimum number of points per animal = 10).

Author(s) Interpretation

- No interpretation provided.

Stand Scale

All is information from Matthews et al. (2008).

Key Findings

- When active fishers did not exhibit selection of stands within their home ranges using either the 7 or 8 strata type scenarios (Tables Hoopa Valley 1 and 2).
- During periods of resting fishers exhibited selection for both mature and older forests and pole stands using the 8 habitat strata approach and rested closer to pole stands than to seedling stands but did not statistically "avoid" any strata types.
- During periods of denning fishers did not exhibit selection for one habitat type over another while denning using the 8 habitat types.
- Using the 7 habitat type approach, during periods of denning fishers exhibited habitat selection within their home ranges. Fishers

selected older closed canopy forest and young pole types, did not avoid any strata types, and were located significantly closer to older closed-canopy forest than to all other habitat types.

Author(s) Interpretation

- The authors suggested, "Finding significance for selection of older closed-canopy forest for resting and denning confirmed our suspicion that fishers are not differentiating between pole stands, young growth, and mature and older forest in Hoopa. This is most likely an artefact of the amount of residual structure left in stands following harvests in the 1950s, 1960s, and early 1970s".
- Authors expressed concern with their ability to apply their results to ownerships outside of Hoopa. "Areas with more intensive historical management where fewer residual structures were left on the landscape may result in reduced habitat suitability for fishers in stands >30 yrs of age. While these more intensively managed stands may provide the closed canopy fishers have been found to select, these stands may not provide the structures needed for suitable resting and denning habitat. We caution other managers not to assume stands >30 yrs of age are suitable resting and denning habitat on their ownership unless the conservation of residual structure on their ownership was similar to that in Hoopa".

Site Scale

All information is from Yaeger (2005).

Key Findings

- During 1996–1998, 19 fishers (11 females, 8 males) were radio-collared and 218 rest/den structures were identified.
- Random plot data were used to characterize available habitat. Mean dbh of the 4 largest trees, canopy cover, and topographic position differed between rest and random locations when analyzed with the Friedman test.
- Mean dbh of the 4 largest trees was larger at rest sites than at random sites, canopy cover categories 26–50% and 51–75% were used more often than their availability, and fishers used rest sites near drainage-bottoms more often than on mid-slope or ridge-top locations.
- Five variables were selected by the stepwise procedure and correctly classified rest and random locations 70% and 76% of the time respectively; rest sites tended to be located in patches of larger-diameter trees composed of conifer and hardwood, in drainage-bottoms with >50% canopy cover, and were closer to landscape alterations (e.g., roads and managed stand edges) than the random sites.

Author(s) Interpretation

- Fisher rest sites were strongly associated with larger trees and the mean dbh of the 4 largest trees on rest plots was greater than on random plots.
- Dense canopy cover was also associated with fisher rest sites. Larger trees and dense canopy cover may provide more suitable resting structures and may also influence fisher prey abundance or availability while providing fishers the opportunity to escape potential predators.

Structure Scale

All information is from Yaeger (2005), Higley and Matthews (2006), and Matthews et al. (2008).

Key Findings

- During 1996–1998, 19 fishers (11 females, 8 males) were radio collared and 218 rest/den structures were identified. Fishers primarily used live trees (84%) for resting (Table Hoopa Valley 3).
- Of the live trees used, hardwoods (65%) were used more frequently than conifers (35%) but were essentially used in proportion to their availability (70% and 30% respectively). Douglas-fir was the most frequently used tree species (34%) followed by tanoak (27%) and black oak (26%).

Table Hoopa Valley 3. Fisher rest site type used at the Hoopa Valley Indian Reservation (January 1996 to June 1998; modified from Yaeger 2005).

Rest site type	*n*	%
Live Tree	183	84
Snag	22	10
Log	8	4
Other	5	2
Total	218	

Table Hoopa Valley 4. Mean, median and range of tree dbh of trees used as rest sites by fishers at the Hoopa Valley Indian Reservation (January 1996–June 1998; modified from Yaeger 2005).

		dbh (cm)				
Tree type	*n*	$\bar{x}$	SE	min	max	median
All rest trees	138	88.1	3.1	22.4	215.1	84.7
Conifer only	52	109.6	5.6	37.9	215.1	101.2
Hardwood only	86	75.1	2.8	22.4	144.0	77.2

- Fisher rest site trees had $\bar{x}$ dbh = 88 cm (range = 22.4–215.1). Conifer rest site trees had $\bar{x}$ dbh = 109.6 cm and hardwood rest site trees had $\bar{x}$ dbh = 75.1 cm (Table Hoopa Valley 4).
- Fishers used rest site trees with significantly larger dbh than mean dbh of the 4 largest trees on rest site plots. The rest tree was 1 of the 4 largest trees on 91% of the rest site plots and was the single largest tree on 46% of these plots.
- When resting in live trees the actual resting microsite or substrate was identified 149 times with 52% on platforms and 48% in cavities. In live trees, cavity rest sites were generally found in hardwoods while platform rest sites were generally found in conifers (Table Hoopa Valley 3). Tanoak and canyon live oak, however, provided both cavity and platform rest sites (Table Hoopa Valley 5).
- During 1996–98 12 reproductive den trees were found, including 6 live black oaks, 2 live tanoaks, 2 live white oaks, 1 Douglas-fir snag, and 1 chinquapin snag. Seven of 8 (88%) and 9/11 (81%) adult females monitored denned during 2005 and 2006, respectively.
- Twenty-five natal dens, 44 maternal-pre-weaning dens, and 2 maternal post-weaning dens were identified and tree species and dbh were recorded (Table Hoopa Valley 6).

Table Hoopa Valley 5. Number and percent of fisher cavity and platform rest sites used in live trees by tree species at the Hoopa Valley Indian Reservation (January 1996–June 1998; modified from Yaeger 2005).

Tree species	Cavity	% Total cavities	Platform	% Total platforms
Douglas-fir	1	1	45	58
Sugar pine	0	0	1	1
Total conifer	1	1	46	59
Tanoak	17	24	21	27
Black oak	39	55	5	6
Canyon live oak	4	6	4	5
Pacific madrone	5	7	2	3
White oak	3	4	0	0
Chinquapin	1	1	0	0
Big-leaf maple	1	1	0	0
Total hardwood	70	99	32	41

Table Hoopa Valley 6. Number, mean dbh, and dbh range of natal-parturition, natal-pre weaning, and maternal den trees by tree species used by fishers on the Hoopa Valley Reservation, CA during 2005 and 2006 (modified from Matthews et al. 2008).

Den Type	Live trees n	Snags n	$\bar{x}$ dbh (cm)	dbh range (cm)
Natal-parturition				
Douglas-fir	2	3	135	104–192
Black oak	4	0	83	47.5–149
Tanoak	15	0	89	43–106.7
Chinquapin	2	0	46	36.6–55.6
Natal-pre-weaning				
Douglas-fir	5	5	130	76.2–205
Port-Orford cedar	1	0	137	
Sugar Pine	0	2	80	57.4–101.6
Black oak	7	2	68	35–85
White oak	1	0	62	
Madrone	0	1	88	
Tanoak	18	0	78	52.6–115.8
Chinquapin	0	1	95	
Maternal				
Douglas-fir	0	1	147	
Tanoak	1	0	72	
Totals				
Douglas-fir	7	9		76.2–205
Port-Orford cedar	1	0		
Sugar Pine	0	2		57.4–101.6
Black oak	11	2		35–149
White oak	1	0		
Madrone	0	1		
Tanoak	34	0		43–115.8
Chinquapin	2	1		36.6–95
Totals	56	15		35–205

- Fisher dens were found in 8 tree species and in both live and dead standing trees (Table Hoopa Valley 6).
- Female fishers that exhibited denning behavior until weaning used $\bar{x}$ = 3.2 dens/season (range = 2–6).
- Successive dens were located $\bar{x}$ = 433 m apart (SE = 65, n = 45). The cumulative distance moved between dens within a season was $\bar{x}$ = 934 m (range = 85–2422, SE = 227, n = 17).

Author(s) Interpretation

- Fishers predominately rested in live trees (>75%) with snags and logs comprising a majority of the remainder.
- Trees selected for resting were generally among the largest available within the stand or patch surrounding the rest site.
- Large live hardwoods appeared to be an important element of fisher resting habitat especially when considering the importance of cavities for rest and den sites.

2.7.6. Shasta-Trinity National Forest, Study Area 14

Study Objectives: The primary goals of this study were to describe various aspects of habitat ecology, home range characteristics, and diet of fishers in the eastern Klamath region. At one scale objectives were to describe habitat characteristics by comparing composition of buffers surrounding fisher rest sites (determined from radio-collared animals) to track plate locations with and without fisher detections. At finer scales the objective was to characterize biotic and abiotic variables associated with resting vs. random locations. Truex et al. (1998) conducted a meta-analysis of home range, site and structure scale data from this study area and the Pilot Creek and Tule River study areas to compare attributes of fisher home ranges and habitat associations. Yaeger (2005) also compared fine scale attributes of resting locations between this study area and Hoopa Valley Indian Reservation.

Principal Investigator(s): R. T. Golightly, S. J. Dark, A. E. Seglund, and J. S. Yaeger (Humboldt State University)

Duration: 1992–1997

Study Area: The study area was on the Shasta-Trinity National Forest and private land in Trinity County, California. It was located primarily in the Trinity River basin immediately surrounding Claire Engle Reservoir. The study area encompassed approx. 400 km^2 of primarily forested habitat ranging in elevation from 325–1,500 m. Main vegetation types included Douglas-fir, Klamath mixed conifer and montane hardwood communities. Mean annual precipitation was 108 cm with <8% falling during summer. Snowfall was usually moderate (3–241 cm).

Methods: Fishers were live-trapped and fitted with radio collars. Attempts were made to relocate animals weekly using walk-in surveys to locate rest sites and female den sites. Track plates were deployed across the study area to describe habitat at locations with and without fisher detections and relationships with other forest carnivores. Track-plate stations were placed approx. 50 m from roads; with 3 track plate stations (1-km spacing) per segment (3 km between segments). Concentric buffers (3.14 km^2) centered on the middle station of each segment were created in a raster based geographic information system (GIS) (25 x 25 m pixel) to collect landscape characteristics derived from Landsat Thematic Mapper (TM) images. Habitat sampling at rest sites, den sites, and track plate stations included fixed plot sampling to describe forest composition and structure, and measurement of overhead canopy closure using spherical densiometers. Habitat sampling occurred at random points within individual home ranges to assess habitat availability. At the landscape scale stepwise logistic regression analyses were used to develop predictive models of segments with fisher detections vs. segments without fisher detections. Univariate statistics were used to investigate the role of specific variables in habitat selection.

At the home range scale, Seglund (1995) used rest site locations to calculate minimum convex polygon (MCP) home range estimates to delineate areas for random point placement. Dark (1997) compared "landscape level habitat characteristics" within annual fisher home ranges (95% adaptive kernel [ADK]) using a 300-m radius buffer surrounding track plate locations with and without fisher detections and at fisher rest sites determined from radio-collared animals. Home range calculations included original data, plus data from Seglund (1995). Truex et al. (1998) compared home range sizes between Shasta-Trinity and 2 other study areas (Pilot Creek and Tule River). They compared home ranges only for animals monitored at least 9 months and located a minimum of 10 times. Meta-analysis included data from Seglund (1995) and Dark (1997). Yaeger (2005) reported home range sizes for Shasta-Trinity (calculations included original data, plus data from Seglund [1995] and Dark [1997)]) to compare with those from fishers on the Hoopa Valley Indian Reservation. Annual home ranges were reported using 100% MCP method for all locations available (i.e., rest sites and locations where researchers were "close" but did not identify rest structure).

At the site scale Seglund (1995) measured vegetation at 9.3-m (0.027 ha) fixed-radius plots. Truex et al. (1998) compared habitat characteristics at rest sites including measures of California Wildlife Habitat Relationship (CWHR) type (Mayer and Laudenslayer 1988) and class, trees and coarse woody debris. Yaeger (2005) measured vegetation at 0.04-ha fixed-radius plots. Rest-site plots were tree-centered, random plots were not tree-centered. The variable "dbh of 4 largest trees on plot" was reported as the mean of the 4 largest trees and was meant to compensate for random plots not being tree-centered. Canopy was reported as the mean of 4 spherical densiometer measurements at 5 m from plot center in 4 cardinal directions. Univariate statistics and logistic regression were used to describe differences between rest and random locations. Where appropriate, Seglund (1995) and Yaeger (2005) pooled data by sex and season (summer, 1 April–31 October; winter, 1 November–31 March).

At the structure scale authors compared use of tree species relative to their availability using Chi-square goodness of fit and subdividing Chi-square analyses. On random plots, trees >40 cm dbh were considered available to fishers. This minimum value was considered a conservative cut-off more than 1 standard deviation below the mean dbh of conifers or hardwoods used by fishers.

Publications and reports: 2 unpublished reports (Seglund and Golightly 1995, Truex et al. 1998), and 3 theses (Seglund 1995, Dark 1997, Yaeger 2005).

Results:

Landscape Scale

All information is from (Dark 1997).

Key Findings

- Pooled data from all surveys indicated that fishers were detected in habitats that had a greater amount of Douglas-fir, a greater amount of 51–75% canopy cover, less barren area, a greater density of low use roads (closed to public or seasonal use only), and fewer disjunct core areas (core was defined as an area of habitat >100 m from edge) in landscape buffers where fishers were detected (n = 26) vs. not detected (n = 16). While not significant at the 0.05 level, inclusion of low use road density and number of disjunct core areas (both at $P = 0.06$) in the logistic regression model improved classification accuracy.
- Douglas-fir had a negative correlation ($r^2 = -0.72$) with shrub cover and a positive correlation ($r^2 = 0.84$) with the 76–100% canopy cover class category.

Author(s) Interpretation

- Fishers were detected at track plate stations, and rested in areas dominated by late successional Douglas-fir forests that were less fragmented and less mixed conifer stands than other regions within their home range and the study area.
- The presence of fishers in landscape buffers with Douglas-fir habitat and high (>51%) canopy cover values was indicative of riparian vegetation. Riparian buffers resulted from previous timber harvests; consequently riparian habitat was characterized by residual Douglas-fir with high crown cover and dense understory.
- Fishers were detected in areas with fewer disjunct core areas indicating that there were more contiguous patches within these buffers implying that fishers on the Shasta-Trinity used large contiguous tracts of land.
- Where fishers were detected, there was a greater than average density of low use roads. But because low use roads were characterized by minimal human activity, it was also possible that the inclusion of this variable was a response to human activity.

Home Range Scale

All information is from Seglund (1995), Dark (1997), Truex et al. (1998), and Yaeger (2005). Data sets in these publications may not be mutually exclusive.

Key Findings

Seglund (1995)

- Home ranges were calculated for 3 males (1 juvenile), and 5 females (2 juveniles <22 months).
- There were 5–35 locations per fisher; monitored 4–13 months.
- Mean (SE) of female home ranges was 26.1 km^2 (5.5); range = 13.0–43.7.
- Mean (SE) of male home ranges was 34.3 km^2 (14.1); range = 9.5–58.3.

Dark (1997)

- Four male and 7 female fishers (age not reported) were monitored for 2–24 months resulting in 7–60 locations per fisher.

- MCP (100%) home ranges for male ranged from 6.7–76.6 km^2; females ranged from 2.1–43.7 km^2.
- ADK (95%) home ranges for males ranged from 11.4–138.6 km^2; female ranged from 3.1–87.7 km^2.
- Landscape habitat characteristics at rest sites were compared to station locations with 74 rest site locations and 79 track-plate station locations.
- Rest-site buffers differed on the east and west sides of the study area indicating that they could not be pooled. When grouped by individual or sex, non-significant results were obtained for the east side and west sides indicating that landscape characteristics at rest site buffers could be pooled across individuals and sex for each side.
- On the east side of the study area, rest sites (n = 48) had more area of 50–75% canopy cover and fewer core areas than stations where fishers were not detected (n = 28).
- On the west side of the study area, rest sites (n = 25) had more area of Douglas-fir, fewer disjunct core areas, less barren area, and less mixed conifer habitat than stations where fishers were not detected (n = 24).
- There was no difference in landscape characteristics between rest site buffers and station buffers that had positive fisher detections, however, power may have been too low to detect differences because only 25 track plate stations on the east side and 9 on the west side had positive fisher detections.

Truex et al. (1998)

- Female home ranges were significantly larger on the Shasta-Trinity (n = 5) than on the Pilot Creek (n = 5) and Tule River (n = 7) study areas. Male home ranges on the Shasta-Trinity (n = 6)were also considerably larger than on the Pilot Creek (n = 2) and Tule River (n = 4) study areas.

Yaeger (2005)

- Number of locations per individual not reported, but home range estimates were calculated for animals with a minimum of 10 locations; monitoring period not reported; age not reported.
- Mean (SE) of female home range (n = 7) was 2347 (471) ha; no range reported.
- Mean (SE) of male home range (n = 9) was 3,827 (895) ha; no range reported.

Author(s) Interpretation

Seglund (1995)

- Sample sizes for home range estimates were relatively low for each individual, thus it is likely that actual home range size was underestimated.

Dark (1997)

- Interpretations were similar to landscape scale reported by this author.
- There were no differences in habitat between resting and track plate locations with positive detections. This may have been a result of: 1) low power; 2) track plate locations were not necessarily representative of locations that fishers used for travel; 3) fishers may in general use the same type of habitat for all activities [travel, foraging, and resting].

Truex et al. (1998)

- Larger home ranges at Shasta-Trinity compared to Pilot Creek and Tule River suggested relatively lower quality habitat at Shasta-Trinity. The authors also suggested the larger home range sizes may be due to larger body mass of fishers in Klamath area.

Yaeger (2005)

- Relatively larger home ranges in Shasta-Trinity compared to Hoopa Valley Indian Reservation may be indicative of better habitat conditions at Hoopa Valley Indian Reservation.

Stand Scale

At this time no information is available at this scale.

Site Scale

All information is from Seglund (1995), Truex et al. (1998), and Yaeger (2005). Data sets in these publications may not be mutually exclusive.

Key Findings

Seglund (1995)

- Fisher rest sites (n = 114) were located and variables measured.
- There were no differences between males (n = 66 rest sites) and females (n = 48 rest sites) in their use of rest sites during any season; subsequently all animals were pooled for the analyses.
- Fifteen of 22 variables measured were found to be significantly different and were included in the stepwise procedure (Table Shasta-Trinity 1), 8 variables were included in the predictive model with an 83% correct classification.

Truex et al. (1998)

- Characteristics of fisher rest sites were different among the 3 study areas (Table Shasta-Trinity 2).
- Canopy was less dense at rest sites in the Shasta-Trinity study than at Pilot Creek or Tule River study areas, however tended to be dense in all study areas.
- Mean basal area was similar between Shasta-Trinity and Tule River and less than that at Pilot Creek.

Table Shasta-Trinity 1. Habitat variables measured at fisher rest and random sites using 0.027-ha plots. X = variable used in stepwise procedure to discriminate fisher rest sites and random sites (modified from Seglund 1995).

	Rest sites (n = 114)		Random sites (n = 100)		
Variable	$\bar{x}$	SE	$\bar{x}$	SE	In model
Basal area (m^2)	26.2	1.0	16.7	1.3	X
Aspect (°)	155.3	10.9	198.8	10.3	
Canopy cover (%)	85.4	0.7	70.3	2.4	
Drainage (% of plots within 100 m)	0.8	0.0	0.3	0.0	
Human disturbance (% of plots within 100 m)	0.5	0.0	0.8	0.0	X
Shrub cover (%)	2.1	0.2	1.3	0.1	X
Dead and down cover (%)	3.4	0.1	3.0	0.1	X
Topographic position	1.7	0.1	2.0	0.1	
Distance to water (% of plots within 100 m)	0.3	0.0	0.1	0.0	X
Conifer species (no.)	2.4	0.1	2.8	0.1	
Hardwood species (no.)	1.7	0.1	1.4	0.1	X
dbh 4 biggest trees (cm)	62.4	2.2	42.9	1.9	X
Snags (no. in plot)	0.8	0.1	0.4	0.1	
Logs (no. in plot)	4.3	0.4	7.0	0.7	
Vegetation layers (no.)	[a]	[a]	[a]	[a]	X

[a] values not reported.

Table Shasta-Trinity 2. Habitat characteristics of fisher rest sites at 3 study areas in California (modified from Truex et al. 1998).

Variable	Shasta-Trinity $\bar{x}$ (SD)	Pilot Creek $\bar{x}$ (SD)	Tule River $\bar{x}$ (SD)
Basal area (m^2/ha)	59.8 (30.9)	75.6 (27.6)	62.6 (26.1)
Tree dbh (cm)	46.2 (28.2)	118.3 (35.6)	89.6 (29.5)
Canopy closure (%)	88.2 (12.8)	93.9 (7.5)	92.5 (9.1)

- Mean dbh of the 4 largest trees at fisher rest sites was much smaller in the Shasta-Trinity than Pilot Creek and Tule River.
- Rest sites were primarily located within montane hardwood-conifer (52.4%) and Douglas-fir (37.8%) habitat types at Shasta-Trinity compared to Douglas-fir and mixed conifer (76.2% total) in the Pilot Creek study and mixed conifer and montane hardwood (83.5% total) in the Tule River study.

Yaeger (2005)

- 19 fishers (10 females, 9 males) were radio-tracked, each animal located a mean of 15 times (range = 1–50).
- 296 individual confirmed rest structures were identified.
- Variables predicting fisher rest sites at Shasta-Trinity differed slightly over 3 yrs of research due to slight shifts in areas of concentrated sampling effort and consequently were not pooled. Ten habitat variables examined at Shasta-Trinity significantly predicted fisher rest sites in logistic regression models in at least 1 of the 3 yrs of the study (Tables Shasta-Trinity 3 and 4).

Table Shasta-Trinity 3. Habitat variables that significantly predicted fisher rest sites in logistic regression models in at least 1 of the 3 yrs of the Shasta-Trinity study (modified from Yaeger 2005).

Model variable	Year 1	Year 2	Year 3
$\bar{x}$ dbh of 4 largest trees	X		
Canopy cover		X	X
No. of hardwood species		X	X
Presence of conifer			X
Aspect	X		
Topographic position		X	
Presence of human disturbance	X		
Presence of landscape alteration	X		X
Presence of water within 100 m	X	X	X
Basal area			X

Author(s) Interpretation

Seglund (1995)

- Fishers may not use rest sites randomly but may select habitats with a specific configuration. The habitat characteristics and rest structures at rest sites structurally resemble mature forest conditions.
- Fishers may have used rest sites with larger trees because they may provide an abundance of rest site structures, adequate canopy cover, thermoregulatory benefits, concealment from predators, or intercept greater amount of snow than younger stands.
- The specifics of why fishers rested closer to riparian and streamside habitats were unresolved. However, explanations include: riparian buffer areas from historical timber harvest that may have left substantially more mature forests than in upland areas, thermal protection from high summer temperatures, thermal cover and snow interception in winter, travel corridors, and possible increases in prey density and diversity.
- Rest sites were structurally more diverse than random sites. Rest sites contained greater vertical structural diversity, higher percentage of woody debris, and higher percent shrub cover, and more hardwood species. These conditions may create a more favourable microclimate, greater number of habitat niches to support a more diverse prey population, and may provide a greater number of shelter and refuge sites.
- Resting locations may be more susceptible to disturbance than other activities (traveling or foraging) because rest sites were further from human disturbance (i.e., recent timber harvest, houses, campground, and roads).

Table Shasta-Trinity 4. Mean (SE) values for habitat variables at fisher rest and random locations in the Shasta-Trinity study area. Rest site values were not pooled over 3 yrs of the research. Random site variables were not pooled due to differences between east and west sides of the study area (modified from Yaeger 2005).

	Rest sites			Random sites	
Variable	Year 1	Year 2	Year 3	West	East
Number of sites	107	66	119	37	66
$\bar{x}$ dbh of 4 largest trees (cm)	65.4 (2.9)	57.8 (2.4)	61.5 (1.7)	52.5 (2.9)	44.2 (2.3)
Canopy cover (%)					
<26% coverage	1.9	0	0	5.4	9.1
26–50% coverage	4.7	0	0	2.7	15.2
51–75% coverage	10.4	19.7	4.2	18.9	31.8
>75% coverage	83	80.3	95.8	73	43.9
Number of hardwood species on plot	1.4 (0.1)	1.7 (0.1)	2.5 (0.1)	1.3 (0.1)	1.2 (0.1)
Presence of conifer (%)	99.1	100	97.5	100	95.5
Aspect (%)					
North	37.4	22.7	28.8	27	21.2
South	18.7	30.3	22.9	24.3	24.2
East	25.2	21.2	16.9	40.5	19.7
West	18.7	25.8	31.4	8.1	34.8
Topographic position (%)					
Ridge-top	24.3	9.1	18.5	35.1	34.8
Mid-slope	23.4	53	30.3	24.3	37.9
Drainage-bottom	52.3	37.9	51.3	40.5	27.3
Human disturbance within 100 m (%)	40.2	83.3	58	81.1	84.8
Water within 100 m (%)	60.7	50	56.3	16.2	13.6

Yaeger (2005)

- Fisher rest sites were strongly associated with larger trees. The mean dbh of 4 largest trees on rest plots was greater than on random plots in all 3 yrs of the Shasta-Trinity study. Larger trees may provide more suitable resting structures, in the form of larger platforms or cavities, or provide greater levels of overhead cover which may provide increased protection from predators, more favourable microclimates, and increased abundance and (or) vulnerability of prey species.

- It was difficult to separate the influence of distance to water and use of lower slope positions. Rest sites were located on lower slopes more often than random plots during year 2 of the study, while proximity to water was a significant predictor of fisher rest sites in all 3 years. Association with water at Shasta-Trinity may have been a result of drier site conditions (compared to Hoopa Valley Indian Reservation), but this hypothesis may be confounded by historical timber practices. Riparian buffers from timber harvests may have resulted in larger trees or denser canopies in these areas that may be the primary attractant and thus correlated with water. Other potential reasons included thermal protection from high summer temperatures, thermal cover and snow interception in winter, travel corridors, and possible increases in prey density and diversity.

Structure Scale

All information is from Seglund (1995), Truex et al. (1998), and Yaeger (2005). Data sets in these publications may not be mutually exclusive.

Key Findings

Seglund (1995)

- Three males (2 juveniles) and 7 females (2 juveniles) were captured, immobilized, and fitted with radio collars. Fishers were located 125 times; 114 rest sites identified.
- Fisher use of rest structures differed between summer and winter (Table Shasta-Trinity 5)
- Females increased their use of snags in winter but males did not. Males predominantly used the canopy of live trees in both seasons.
- Rest site re-use was observed on 5 occasions (3%).
- Mean (SE) dbh of live trees was 105 cm (4.05); range = 36.4–187.3, median = 116.2.
- Species used (>5% frequency) included: live trees: 56 (74%) Douglas-fir, 8 (11%) black oak, 6 (8%) ponderosa pine; snags: 12 (57%) Douglas-fir, 4 (19%) ponderosa pine, 3 (14%) sugar pine.
- Fifty-nine percent of rest trees had crowns that were normal, 38% had broken or dead tops, and 3% had forked tops. Mean dbh of trees with broken or dead tops was 123 cm; mean dbh of trees with normal tops was 114 cm.
- Rest trees were predominantly in dominant height (50%) and canopy (51%) and co-dominant height (40%) and canopy (33%) classes. Rest trees were rarely in suppressed or emergent height (10%) and canopy (16%) classes.
- In live trees fishers were observed (n = 28) using nests (54%), large lateral limbs and limb clusters (35%), witches brooms (7%), and cavities (4%).
- Mean (SE) dbh of snags was 119.2 cm (7.3); range = 49.5–196, median = 121. Most snags used as rest sites were moderately decayed (class 2) (76%), with 14% decayed (class 3) and 10% sound (class 1). All snags contained cavities.
- Fifteen rest sites were on the ground. Six ground sites occurred in hollow logs or underneath a single log in coarse woody debris. Seven occurred in yarded log piles left by logging operations. One ground site was under the snow in tanoak brush and another was under a root cluster of a bigleaf maple tree. Mean (SE) diameter at large end of logs used as rest sites was 86.5 cm

Table Shasta-Trinity 5. Rest structure use by 10 radio-collared fishers by sex and season (Summer, 1 Apr–31 Oct; Winter, 1 Nov–31 Mar) at Shasta-Trinity (modified from Seglund 1995).

			Summer		Winter	
Variable	*n*	%[a]	*n*	%[b]	*n*	%[b]
Live trees						
Females	26		15	58	11	42
Males	50		38	76	12	24
Total	76	67	53	70	23	30
Snags						
Females	19		4	21	15	79
Males	4		4	100	0	0
Total	23	20	8	35	15	65
Log and subnivean sites						
Females	3		1	33	2	67
Males	12		9	75	3	25
Total	15	13	10	64	5	36

[a] Percent total of rest structures in live tree, snag, or log/subnivean categories.
[b] Percent used per season.

(11.7); range = 30–155, median = 77.5. All but 1 log contained hollow cavities. All logs were moderately decayed (class 2) except 1 that was sound (class 1).

Truex et al. (1998)

- Fishers were found resting more frequently in platforms at Shasta-Trinity than the Pilot Creek and Tule River study areas.
- Considerably more small diameter trees were used at Shasta-Trinity compared to the Pilot Creek and Tule River study areas.

Yaeger (2005)

- 19 fishers (10 females, 9 males) were tracked over 3 yrs, each animal was located a mean of 15 times (range = 1–50).
- Individual confirmed rest structures were located 296 times.
- Sexes and seasons were pooled.
- Fishers primarily used live trees for resting (Table Shasta-Trinity 6). Other structures used included snags and logs, and rarely included on the ground under shrubs, slash piles, rootwads, or in wood rat nests. Fishers used live conifers most frequently (64%), followed by live hardwoods (12%).

Table Shasta-Trinity 6. Fisher use of live trees, snags, and logs for rest structures (modified from Yaeger 2005).

Structure type	*n*	%
Live tree	225	76
Snag	40	14
Log	27	9
Other	4	1
Total	296	

- Of live trees used (*n* = 225), hardwoods (16%) and conifers (84%) were not used in proportion to their availability (7% and 93% respectively).
- Douglas-fir was the most frequently used tree species for resting (Table Shasta-Trinity 7).
- When resting in live trees, the actual resting substrate was identified 154 times. Nineteen percent were in cavities while 81% were on platforms. In live trees, cavity rest sites were generally found in hardwoods while platform rest sites were generally found in conifers. With a few exceptions, this pattern of cavity and platform use was similar when hardwood and conifer groups were separated by individual trees species.
- Mean dbh of trees used for rest sites was greater than mean dbh of the 4 largest trees on the plot during all 3 yrs of the study (Table Shasta-Trinity 8).

Table Shasta-Trinity 7. Tree species used by resting fishers (modified from Yaeger 2005).

	Rest trees		Random plots		Test values	
Species	(*n*)	% rest trees	trees (*n*)	% random	X^2	*P*
Douglas-fir	146	65	160	65	2.82	0.093
Ponderosa pine	23	10	29	12	1.21	0.271
Sugar pine	11	5	20	8	4.18	0.041
Jeffrey pine	3	1	0	0	[a]	
White fir	4	2	9	4	[a]	
Pacific yew	1	0	0	0	[a]	
Incense cedar	1	0	11	4	[a]	
Black oak	23	10	13	5	8.71	0.003
Canyon live oak	11	5	4	2	[a]	
Chinquapin	2	1	0	0	[a]	
Total	225	100	246	100		

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

- Mean dbh of trees used for reproductive den sites was 73.7 cm (Table Shasta-Trinity 9).

Author(s) Interpretation

Seglund (1995)

- Live trees were the predominant resting structure with the majority (72%) occurring in large late-seral Douglas-fir >90 cm dbh. These trees often had lower branches that were large horizontally flattened fan shape arrays. In smaller Douglas-fir trees, nests created by birds, mammals or natural accumulations were used.
- When resting in snags, fishers predominantly used Douglas-firs that were moderately decayed (class 2).
- Explanations of observed increased use of snags by females in winter included: thermoregulatory benefit, females smaller size (compared to males) increasing cavity availability, or general availability of snags within each individuals home range rather than actual selection.
- Fishers showed little rest site fidelity with the exception of reproductive females. Compared to American martens, which have been reported to have high re-use of resting structures, Seglund suggested fishers may not experience the same energetic extremes as marten due to fishers relatively larger size and occupancy of warmer regions.

Truex et al. (1998)

- Fishers appear to exist in poorer quality habitat at Shasta-Trinity than in the others studies compared. However, it is clear that Shasta-Trinity has been subjected to more timber harvest, and more by clear-cutting, than the Pilot Creek and Tule River study areas.
- The prevalent use of platforms in small diameter trees on the Shasta-Trinity study in conjunction with the relatively limited use of large diameter live trees and snags warrants further discussion.

Table Shasta-Trinity 8. Mean dbh of trees used for rest sites and the 4 largest trees on sample plots at Shasta-Trinity (modified from Yaeger 2005).

			dbh		
	Comparison	*n*	$\bar{x}$	SE	*P*
Year 1	Rest site	15	124.8	8.2	≤0.001
	Mean of four largest trees	15	73.3	4.8	
Year 2	Rest site	43	94.5	6.9	≤0.001
	Mean of four largest trees	43	67.8	2.8	
Year 3	Rest site	89	91.9	4.1	≤0.001
	Mean of four largest trees	89	63.4	1.9	

Table Shasta-Trinity 9. Characteristics of trees used by fishers for reproductive den sites identified in Shasta-Trinity (modified from Yaeger 2005 with additional data from Truex et al. 1998).

Structure	Tree species	dbh (cm)	Presence of cavities
Snag	Ponderosa pine	78	Yes
Live tree	Black oak	88	No
Live tree	Canyon live oak	52.2	Yes
Live tree	Canyon live oak	40.5	Yes
Live tree	Black oak	51.3	Yes
Live tree	Black oak	125.6	Yes
Live tree	Douglas-fir	n/a	n/a
$\bar{x}$ (SE)		73.7 (10.9)	

Extensive historic timber harvest within the Shasta-Trinity study area has likely resulted not only in the conversion of mature forests to early seral stages (through clear-cutting), but also in a decrease in the occurrence of large diameter living trees and, consequently, in the recruitment of large diameter snags and logs.

Yaeger (2005)

- Live tree use is important. Fishers predominantly rested in live trees (>75%). Live trees presumably provide a greater abundance of sturdy substrates (cavities or platforms) than may be available from either snags or logs. Furthermore, living trees with dead portions typically stand longer than snags and can take hundreds of years to fully undergo the decay process.

- Live hardwoods appeared to be an important element of fisher resting habitat. When live trees were grouped into conifer and hardwood categories, fisher use of each group for resting was not in proportion to its availability.
- When individual tree species were investigated, each conifer species was used in proportion to its availability. Black oaks were used more than they were available. The greater than expected use of black oaks was likely best explained by differences in fisher use of cavities or platforms as resting substrates. Rest sites in conifers were generally on platforms while cavity use was most frequent in hardwoods.
- Cavity availability and use appeared to be associated with the availability of hardwoods. The proportional use of cavities was similar to proportional use of live hardwood trees. The availability of hardwoods, and possibly cavities, may be limited at Shasta-Trinity when compared to Hoopa Valley Indian Reservation. If cavities were limited at Shasta-Trinity, the reduced number of suitable den sites could potentially affect reproduction.
- In addition to providing cavities, mast-producing hardwoods, such as black oak, may play an important habitat role because they provide substantial food for potential prey species and may increase mast-eating rodent abundance.
- Fishers used trees that were much larger in diameter than available. Resting structures (trees, snags, and logs) need to be sufficiently large in diameter to supply resting locations (cavities or platforms) that can accommodate the large-bodied fisher. The likelihood of larger lateral limbs, horizontally fan shaped branch arrays, or pockets of decay suitably-sized for resting fishers increases with tree diameter (and presumably tree age). For cavity formation, trees must be old enough for ecological processes (e.g., decay, woodpecker activity) to form cavities of sufficient size for fisher access.

2.7.7. Shasta Lake, Study Area 15

Study Objectives: To support biological resource inventory and related reservoir management planning. Surveys were conducted to determine the presence, distribution, and habitat associations of fishers in the Shasta Lake area.

Principal Investigator(s): L. Lindstrand III (North State Resources)

Duration: 2003–2006

Study Area: The study area was immediately adjacent to Shasta Reservoir on Shasta-Trinity National Forest, Shasta County, California. Habitats within the study area were Sierran mixed conifer, ponderosa pine, closed-cone pine cypress, montane hardwood-conifer, montane hardwood, blue oak woodland, blue oak-foothill pine, montane riparian, mixed chaparral, annual grassland, fresh emergent wetland, lacustrine, riverine, barren, and urban. Much of the western portions of Shasta Lake were in an area heavily affected by copper smelting and related mining between the late 1800s and early 1900s. These activities denuded most vegetation over a 725 km^2 area. Re-vegetation and erosion control work occurred from the 1930s to the 1960s. The average annual precipitation was 156 cm, and average annual temperatures ranged from 10° C in winter to 32° C in summer. Elevations within the study area ranged from 326–366 m and the terrain was moderate to steep.

Methods: Surveys were conducted to determine the presence and distribution of fishers following the methods of Zielinski and Kucera (1995). Two photographic bait stations were located within each sample unit (n = 32), although 1 photographic station was used in smaller sample units (n = 21). Fifty-three sample units, consisting of 85 stations, were used during the 2004 and 2005 survey effort. All stations were operated for a 28-day period. Each station was checked every 7 days during the 28-day period. No formal habitat analyses were presented. Descriptions of habitat associations at stations with positive detections were provided.

Publications and reports: 1 published conference transaction (Lindstrand 2006).

Results:

Landscape Scale

All information is from Lindstrand (2006).

Key Findings

- Fishers were detected in 11 sample units at 13 stations within the main body of Shasta Lake and the arms of Big Backbone Creek, Sacramento River, Squaw Creek, and Pit River. No detections occurred within the McCloud River arm, and no detections occurred in the Squaw Creek arm after 2003. The 13 detections were located throughout the entire region surrounding Shasta Lake except for a large portion of the north–central part of the lake.

- Three detections occurred near (<0.8–2.4 km) human population centers (residential and marina developments). Ten detections occurred in remote locations on both sides of Interstate 5 and Union Pacific Railroad corridors.

- Tree habitats were described as generally open to moderate canopied hardwood-conifer stands dominated by California black oak, canyon live oak, ponderosa pine, and occasional Douglas-fir. Hardwood and chaparral habitats were dominated by evergreen and deciduous tree and shrub species such as California black oak, canyon live oak, whiteleaf manzanita (*Arctostaphylos manzanita*), buck brush (*Ceanothus* spp.), and brewer oak (*Quercus garryana* var. *breweri*). Blue oak-foothill pine habitats occurred as small inclusions of blue oak, (*Quercus douglasii*) interior live oak (*Quercus wislizeni*), and foothill pine (*Pinus sabiniana*). Although uncommon, there were scattered patches of dense-canopy conifer and mixed conifer stands in addition to large trees, downed woody debris, and conifer and hardwood snags in the study area.

Author(s) Interpretation

- Habitats where fishers were detected at Shasta Lake are generally not characterized as the traditional conifer-dominated habitats they are known to use in California.

- Fishers can occupy or reoccupy newly suitable habitats in ≤50 yrs.

Home Range Scale

At this time no information is available at this scale.

Stand Scale

At this time no information is available at this scale.

Site Scale

At this time no information is available at this scale.

Structure Scale

At this time no information is available at this scale.

2.7.8. Big Bar, Study Area 16

Study Objectives: The primary objective was to compare fisher habitat use between heavily managed and lightly managed areas. At the home range scale the authors set out to determine home range size and habitat selection within home ranges and to compare the results between these 2 sub-areas within the study area. At the stand scale the objective was to compare stand level habitat use between the lightly harvested and heavily harvested sub-areas of the study area.

Principal Investigator(s): S. Buck, A. Mossman, and C. Mullis (Humboldt State University)

Duration: 1977–1979

Study Area: The Big Bar study area was in Shasta-Trinity National Forest, 9 km south of the Trinity River at Big Bar, Trinity County, CA. It was located between the main stem and south forks of the Trinity River and encompassed approx. 150 km^2 of primarily forested habitat ranging in elevation from 730–1,912 m. The study area was USDA Forest Service (89%) and private lands (11%). Primary vegetation types were coniferous and mixed coniferous-hardwood forests. Most precipitation occurred during cool winter months with minor amounts of snow. Snow events were short and usually followed by warming temperatures, rain and rapid snow melt. Both sub-areas had been affected by logging but 1 was lightly harvested (LH – 17% harvested) and the other more heavily harvested (HH – 32% harvested). Both sub-areas were similar in elevation range and primary vegetative cover. Both areas had sustained some clear-cutting (LH – 5%; HH – 7%). The heavily harvested area had 25% of the area logged using overstory removal of 30–70% while the lightly harvest area had 12% of the area logged with this method.

Methods: Adult, sub-adult and juvenile fishers were live-trapped and fitted with radio transmitters. Fisher relocations were accomplished by 3 methods: 1) walking to the source of the signal of inactive animals, 2) triangulation from a distance on active or inactive animals and 3) using fixed wing aircraft. USDA Forest Service timber-type maps were used to determine habitat use within the study area. One hundred and nine timber types were grouped into 4 timber-type groups. The percentage of each fisher's telemetry locations within each timber-type group was used to describe each fisher's habitat use and was compared to the availability of the timber-type groups within the fisher's home range. Snow tracking was attempted each winter.

Publications and reports: 2 unpublished reports (Buck et al. 1979, Buck et al. 1983), 2 theses (Buck 1982, Mullis 1985), and 1 peer reviewed publication (Buck et al. 1994).

Results:

Landscape Scale

At this time no information is available at this scale.

Home Range Scale

Information is primarily from Buck et al. (1994) and Buck et al. (1983), however some information from Buck (1982) and Mullis (1985) is also included.

Key Findings

- Buck et al. (1994) captured 21 fishers, 14 males and 7 females in the 2 sub-areas combined. All but 1 male were radio-collared.
- Buck et al. (1983) reported mean home ranges of 18.9 km^2 and 7.5 km^2 for male and female fishers respectively. Home range estimates were based on from 4 to 84 locations and as short as 1.5 months of monitoring up to 14 months.
- The authors also reported home ranges for adult and juvenile animals and for each sub area separately.
- They suggested that fisher survival was lower in the HH sub-area than the LH sub-area. Seven mortalities occurred during their study including 3 adults (2M, 1F) and 4 juveniles.
- All 7 mortalities occurred in "sub-optimal" habitat (clearcuts with no overhead canopy, hardwood dominated stands).
- Four of the12 fishers collared within the HH site died there. Three of the 8 fishers collared in the LH site died, 2 within the HH site.
- Four mortalities were caused by predation by other carnivores while 1 juvenile from the HH site was "almost certainly killed by another fisher". The remaining 2 causes of mortality were unknown.

Author(s) Interpretation

- The authors concluded that fisher survival was likely lower in the HH portion of their study site than in the LH portion.

Stand Scale

Information is primarily from Buck et al. (1994) and Buck et al. (1983), however some information from Buck (1982) and Mullis (1985) is also included.

Key Findings

- Buck et al. (1983) reported that fishers selected mixed species old growth stands with conifer and hardwood over other stand ages and types.
- Fishers avoided open areas.
- Re-analysis of their data indicated that female fishers exhibited strong selection of mature habitat and avoided younger stands within the portion of their study area which had been heavily managed (Buck et al. 1994). Their analysis was based on 169 telemetry locations within the LH sub area and 260 locations in the HH sub area. Point locations included estimated locations based primarily on ground based triangulations from roads or on foot, but also included some from fixed wing aircraft telemetry locations.

Author(s) Interpretation

- Habitat selection determined by telemetry differed from that determined by snow tracking. The authors suggested convincingly that the snow tracking was biased towards open areas because of the nature of the snow conditions in the area and the fact that they used road based transects to locate the tracks in the first place.
- They also considered that the telemetry based habitat selection could have been biased towards closed canopy areas because fishers using open areas would most likely be in foraging mode and moving too quickly for the observers to achieve triangulations.
- Ultimately they determined that fishers avoided open areas and even tended to avoid more open timber type groups.
- In general fishers avoided pure hardwood stands. The hardwood timber type group was composed of stands of live oak, Oregon white oak, Pacific madrone, mixed commercial hardwoods and stands which included less than 40% crown closure of small conifers mixed with hardwoods.

Site Scale

At this time no information is available at this scale.

Structure Scale

At this time no information is available at this scale.

2.7.9. Pilot Creek, Six Rivers National Forest, Study Area 17

Study Objectives: Zielinski et al. (2004*b*) compared home range size and habitat composition of home ranges between the Pilot Creek and Tule River study areas. Zielinski et al. (2004*a*) characterized and compared fisher resting site selection in the same study areas. Truex et al. (1998) conducted a meta-analysis of home range, site and structure scale data from this study area and the Shasta-Trinity and Tule River study areas to compare attributes of fisher home ranges and habitat associations.

Principal Investigator(s): W. J. Zielinski, and R. L. Truex (USDA Forest Service, Pacific Southwest Research Station)

Duration: 1993–1997

Study Area: The Pilot Creek study area was 400 km^2 in the Six Rivers and Shasta-Trinity National Forests, Humboldt and Trinity Counties, CA. Elevations ranged from 600–1,800 m. The northern part of the study area (Pilot Creek) was primarily composed of stands of Douglas-fir, white fir, Oregon white oak, tanoak, red fir

(*Abies magnifica*), and dry grasslands, with minor components of California black oak, canyon live oak, incense cedar, and ponderosa pine. Most of this part of the study area was mid- and late seral forests. The southern part of the study area (Cedar Gap) ranged in elevation from 850–1,800 m. Forest communities were primarily white fir and Douglas-fir. Summers were warm and dry, winters cool and moist with most precipitation falling as snow at higher elevations.

Methods: Zielinski et al. (2004*b*) live captured 31 fishers (13M, 18F), radio-collared 22 fishers (8M, 14F), and used fixed wing, ground triangulation telemetry and walk-in techniques to locate them. Fisher home ranges (100% minimum convex polygon [MCP]) were calculated using CALHOME for 9 focal fishers (2M, 7F) which had ≥20 locations (minimum 10 rest site locations) and had been monitored continuously for ≥10 months. Because of the number of non-point source locations (fixed wing and triangulation), non-point locations were re-sampled with associated error measures and mean and error estimates for home ranges were calculated. Vegetation composition of home ranges was calculated using existing USDA Forest Service vegetation coverage aggregated into 5 classes (Douglas-fir, true fir, oak-pine, white oak, and grassland) and 3 seral stages (early, mid, and late). Fisher rest sites were located using walk-in telemetry only (Zielinski et al. 2004*a*). Rest structures were categorized into 1 of 14 types. Metrics of the individual resting structure were recorded for all rest sites located. Topographic, vegetation cover type, tree abundance, tree size, ground cover, snow depth (winter), and canopy closure data were sampled at each rest site and at 20 randomly located "available" points within each fisher home range. Tree composition and densities were assessed using variable radius prism plots. Two 25-m perpendicular line intercept transects were used to evaluate ground cover attributes. Canopy closure was measured at plot center and the ends of each transect using a spherical densiometer. Logistic regression techniques were used to develop resource selection functions using data from focal fishers that described fisher selection of resting sites. Information theoretic approaches were used to select best models (Akaike weight >0.90). Top models were tested with data reserved from model development.

Truex et al. (1998) compared home range sizes between Pilot Creek and 2 other study areas (Shasta-Trinity and Tule River). They compared home ranges only for animals monitored at least 9 months and located a minimum of 10 times. At the site scale Truex et al. (1998) compared habitat characteristics at rest sites including measures of California Wildlife Habitat Relationships (CWHR) type (Mayer and Laudenslayer 1988) and class, trees and coarse woody debris.

Publications and reports: 2 unpublished progress reports (Zielinski et al. 1994*b*, 1995*c*), 1 unpublished report (Truex et al. 1998), and 2 peer-reviewed manuscripts (Zielinski et al. 2004*a*, *b*).

Results:

Landscape Scale

At this time no information is available at this scale.

Home Range Scale

All information is from Truex et al. (1998) and Zielinski et al. (2004*b*).

Key Findings

- Truex et al. (1998) reported that female home ranges were significantly larger on the Shasta-Trinity (n = 5) than on the Pilot Creek (n = 5) and Tule River (n = 7) study areas. Male home ranges on the Shasta-Trinity (n = 6) were also considerably larger than on the Pilot Creek (n = 2) and Tule River (n = 4) study areas.

- Zielinski et al. (2004*b*) reported that male fisher home ranges were larger than those of female fishers at both Pilot Creek and Tule River and home ranges of fishers at Pilot Creek were larger than those at Tule River (Table Pilot Creek 1).

- Home ranges in the Pilot Creek study area were primarily composed of mid- and late seral Douglas-fir and true fir types (Table Pilot Creek 2).
- There were no differences in home range composition between males and females.

Author(s) Interpretation

- Truex et al. (1998) implied that larger home ranges at Shasta-Trinity compared to Pilot Creek and Tule River suggested relatively lower quality habitat at Shasta-Trinity. They also suggest the larger home range sizes may be due to larger body masses of fishers in Klamath area.
- Zielinski et al. (2004*b*) further suggested that the differential in home range sizes between Pilot Creek and Tule River indicated a differential in habitat quality, with Tule River likely having better fisher habitat quality.
- Zielinski et al. (2004*b*) suggested that the range of values associated with the 4 dominant habitat types in fisher home ranges at Pilot Creek represent conditions that they could occupy, not necessarily threshold levels.
- The prevalence of habitats containing black oak (a species commonly used by fishers as rest sites) at Tule River (19% of female fisher home ranges) compared to Pilot Creek (9% of female fisher home ranges) may be partly responsible for the observed differences in home range size and suggested differences in habitat quality between the 2 study areas.

Stand Scale

At this time no information is available at this scale.

Site Scale

All information is from Truex et al. (1998) and Zielinski et al. (2004*a*).

Table Pilot Creek 1. Fisher home ranges sizes (km^2) at Pilot Creek and Tule River study areas (modified from Zielinski et al. 2004*b*).

	Pilot Creek			Tule River		
	n	$\bar{x}$	SE	*n*	$\bar{x}$	SE
Female	7	15.0	2.2	8	5.3	0.7
Male	2	58.1	29.6	4	30.0	7.8

Table Pilot Creek 2. Average habitat type composition (%) of fisher home ranges at Pilot Creek study area (modified from Zielinski et al. 2004*b*).

	Females	Males
Douglas-fir early-seral	7.5	6.3
Douglas-fir mid-seral	25.0	22.4
Douglas-fir late-seral	15.0	10.5
True fir early-seral	8.8	12.5
True fir mid-seral	18.9	16.3
True fir late-seral	13.8	14.6
Oak-Pine early-seral	2.5	0.4
Oak-Pine mid-seral	5.3	0.3
Oak-Pine late-seral	0	0
White oak early-seral	4.3	7.1
White oak mid-seral	1.6	5.8
White oak late-seral	0	0
Grassland	0.8	3.8

Key Findings

- Truex et al. (1998) found that characteristics of fisher rest sites were different among the 3 study areas (Table Pilot Creek 3).
- Canopy was less dense at rest sites in the Shasta-Trinity study than at Pilot Creek or Tule River study areas, however tended to be dense in all study areas.
- Mean basal area was similar between Shasta-Trinity and Tule River and less than that at Pilot Creek.
- Mean dbh of the 4 largest trees at fisher rest sites was much smaller in the Shasta-Trinity than Pilot Creek and Tule River.
- Rest sites were primarily located within montane hardwood-conifer (52.4%) and Douglas-

Table Pilot Creek 3. Habitat characteristics of fisher rest sites at 3 study areas in California (modified from Truex et al. 1998).

Variable	Shasta-Trinity $\bar{x}$ (SD)	Pilot Creek $\bar{x}$ (SD)	Tule River $\bar{x}$ (SD)
Basal area (m^2/ha)	59.8 (30.9)	75.6 (27.6)	62.6 (26.1)
Tree dbh (cm)	46.2 (28.2)	118.3 (35.6)	89.6 (29.5)
Canopy closure (%)	88.2 (12.8)	93.9 (7.5)	92.5 (9.1)

fir (37.8%) habitat types at Shasta-Trinity compared to Douglas-fir and mixed conifer (76.2% total) in the Pilot Creek study and mixed conifer and montane hardwood (83.5% total) in the Tule River study.

- Zielinski et al. (2004*a*) reported fisher rest sites had larger maximum dbh, mean canopy and shrub canopy closures, more large snags, and were on steeper slope than random sites (Table Pilot Creek 4).
- Rest site characteristics differed between study areas, however most rest sites had >60% canopy closure in both areas and trees were most frequently large (Pilot Creek >61 cm dbh) or moderately large (Tule River 28–61 cm dbh).
- Basal area and frequency of large snags were greater at rest sites of female fishers than male fishers.
- Twenty one fishers (6M, 15F) from both study areas were used for development of resource selection models for resting sites.
- A single model with 3 variables (mean canopy closure, maximum dbh and slope) accounted for >0.90 Akaike weight for fisher rest sites overall; this model suggested that fishers selected rest sites with denser canopies, larger maximum tree sizes and steeper slopes.
- A single model with 4 variables (mean canopy closure, maximum dbh, slope, and presence of large conifer snags) accounted for >0.90 Akaike

Table Pilot Creek 4. Mean habitat characteristics of fisher rest sites and random sites at Pilot Creek and Tule River study areas (modified from Zielinski et al. 2004*a*).

	Pilot Creek		Tule River	
Habitat Variable	Rest sites	Random sites	Rest sites	Random sites
Basal area (m^2/ha)	71.9	57.8	61.3	61.5
Conifer basal area (m^2/ha)	55.5	42.1	48.0	48.2
Hardwood basal area (m^2/ha)	16.0	15.2	13.3	13.2
Basal area small trees (m^2/ha)	30.4	27.6	35.6	36.7
Basal area large trees (m^2/ha	23.6	19.9	16.5	17.4
Basal area snags (m^2/ha)	9.3	6.9	10.5	10.0
Average dbh (cm)	70.7	61.2	57.2	52.7
Maximum dbh (cm)	147.7	119.1[a]	118.8	104.9[a]
Average canopy closure (%)	95.0	86.7	92.1	90.3
Shrub canopy closure (%)	15.8	na	14.3	na
Slope (%)	47.4	42.8	51.5	42.4
Presence of large (>102 cm dbh) conifer snags (% of sites)	47.2	22.8[a]	36.9	24.7[a]
Presence of water within 100 m (% of sites)	44.3	42.2	51.9	27.8[a]

[a] mean value of random sites significantly different than that of corresponding rest sites

weight for female fisher rest sites overall; this model suggested that female fishers selected rest sites with denser canopies, larger maximum tree sizes, steeper slopes, and presence of large conifer snags.

- A single model with 3 variables (mean canopy closure, maximum dbh and presence of large conifer snags) accounted for >0.90 Akaike weight for fisher rest sites in Pilot Creek; this model suggested that fishers at the Pilot Creek study area selected rest sites with denser canopies, larger maximum tree sizes and presence of large conifer snags.
- Two averaged models accounted for >0.90 Akaike weight for the Tule River study area; the resulting model had 4 variables (maximum dbh, standard deviation of dbh, slope and presence of water; this model suggested that fishers at the Tule River study area selected rest sites with larger trees, wider variation in tree size, steeper slopes and closer to water.

Author(s) Interpretation

- Zielinski et al. (2004*a*) state that both vegetative and topographic features are important in selection of rest sites by fishers.
- Fishers consistently select rest sites with dense canopy cover and presence of large structures although there may be considerable variability of size of structures on the site.
- The predictive power of rest site models were limited which suggested that other factors not evaluated may play a role in rest site selection.
- Selection for sites closer to water in the Tule River study area may reflect differences in climate conditions between this area and Pilot Creek study area; the Tule River in the southern Sierra Nevada is hotter and drier.

Structure Scale

All information is from Truex et al. (1998), Zielinski et al. (1995*c*), and Zielinski et al. (2004*a*).

Key Findings

- Zielinski et al. (1995*c*) identified 7 reproductive dens including 2 presumed natal dens.
- Six dens were in standing trees (4 live trees, 2 snags) and 1 was in a log. Most dens (6/7) were found in large diameter conifers (range = 73–138 cm dbh) and 1 was in a 56 cm dbh black oak.
- Truex et al. (1998) reported that fishers were found resting more frequently in platforms at Shasta-Trinity than the Pilot Creek and Tule River study areas.
- Considerably more small diameter trees were used at Shasta-Trinity compared to the Pilot Creek and Tule River study areas.
- Zielinski et al. (2004*a*) located resting fishers 202 times at 195 different resting structures in the Pilot Creek study area (3.5% re-use).
- Live trees comprised 46.4% of all resting structures in the Pilot Creek and Tule River study areas.
- Most rest structures in the Pilot Creek study area were Douglas-fir (65.6%).
- Hardwoods comprised 45% of all resting structures in both study areas (85% of these were black oak), however use of black oak was less prevalent in Pilot Creek (10.9% of rest structures) than at Tule River (37.5% of rest structures).
- The size of resting structures by type (hardwood, conifer-live, conifer-snag, platform, log) was similar among study areas and sexes, and rest structures were typically larger than trees in the vicinity of the structure and within home ranges.
- Logs ($\bar{x}$ = 123 cm maximum diameter), live conifers ($\bar{x}$ = 117.2 cm dbh) and snags ($\bar{x}$ = 119.8 cm dbh) were the largest structures used for resting, followed by platforms ($\bar{x}$ = 71 cm dbh) and hardwoods ($\bar{x}$ = 69 cm dbh).
- Males used platform rest structures more than females, females used snags more than males

and there was more use of platforms in the Pilot Creek study area than the Tule River study area.

Author(s) Interpretation

- Truex et al. (1998) suggested that fishers appear to exist in poorer quality habitat at Shasta-Trinity than in the others studies compared. However, it was clear that Shasta-Trinity had been subjected to more timber harvest, and more by clear-cutting, than the Pilot Creek and Tule River study areas.
- The prevalent use of platforms in small diameter trees on the Shasta-Trinity study in conjunction with the relatively limited use of large diameter live trees and snags warrants further discussion. Extensive historic timber harvest within the Shasta-Trinity study area has likely resulted not only in the conversion of mature forests to early seral stages (through clear-cutting), but also in a decrease in the occurrence of large diameter living trees and, consequently, in the recruitment of large diameter snags and logs.
- Zielinski et al. (2004*a*) inferred that the prevalence of the use of large rest structures suggests that fishers prefer to rest in the largest trees or snags available.
- Structural characteristics of trees used for resting appeared to be much more important than tree species, in particular size, and internal decay – all characteristics of older trees.
- Re-use of rest structures was limited, suggesting that fishers require abundant rest structures within their home ranges.
- Female fishers' more prevalent use of cavities in standing trees suggest that security from predators and protection from weather extremes may be more constraining for them.
- Although live trees were the most common resting structure a substantive portion of rest structures were snags and logs suggesting that these structures are important resting habitat for fishers.

2.7.10. Hayfork Summit, Study Area 18

Study Objectives: The primary purpose of this project was to investigate the occurrence of fishers and describe fisher reproductive habitat in eastern portions of the Klamath Province, particularly on industrial timberlands managed by Sierra Pacific Industries. Objectives were to document the presence of adult males, adult females, and juvenile fishers, describe the home ranges of adult female fishers, characterize the reproductive status of adult female fishers, identify natal and maternal fisher dens, characterize the habitat surrounding these sites, and to document disease status of fishers in their study area.

Principal Investigator(s): S. Self (Sierra Pacific Industries) and R. Callas (California Department of Fish and Game)

Duration: 2005–2006; 2008

Study Area: The study area was on Sierra Pacific Industries and Roseburg Resource Company lands in northern Shasta and southern Trinity counties, California. Elevation ranged from 500–1,600 m. A study area description was not provided, but Figure 1 of Self and Callas (2006) shows 2 study areas (this study area and the Sacramento Canyon study area) located just south of Claire Engle reservoir and bisected by California Highway 299 in the vicinity of Sacramento Canyon.

Methods: Fishers were captured, fitted with radio collars, and relocated 2–4 times weekly to establish movement patterns and detect the onset of parturition. Information regarding den characteristics, stand and landscape conditions at den sites had not been collected at the time of this progress report. Self and Callas (2006) report captures of 20 fishers (6F, 14M) in the Hayfork Summit study area. Reno et al. (2008) reported 33 captures of fishers (9F, 24M). These data sets are not exclusive. Reno et al. (2008) reported home ranges for 3 female fishers radio-tagged in this study area. Home ranges were estimated using 95% and 100% minimum convex polygon (MCP) and 95% and 50% fixed kernel home range estimators. Home range estimates were based on helicopter relocations (*n* = 293), ground relocations (*n* = 120), den and rest tree locations (*n* = 86), and trap/re-trap locations (*n* = 19). Only fishers with a minimum of 20 relocations annually were used for home range analyses.

Publications and reports: 2 unpublished reports (Self and Callas 2006, Reno et al. 2008) and 1 conference abstract (Reno et al. 2007).

Results:

Landscape Scale

At this time no information is available at this scale.

Home Range Scale

Key Findings

- Reno et al. (2008) reported annual home ranges for female fishers ranging from 4.49–21.44 km^2 (*n* = 6 fishers, *n* = 2 yrs).

Author(s) Interpretation

Home range sizes for adult females with kits were approximately half that of females without kits.

Stand Scale

At this time no information is available at this scale.

Site Scale

At this time no information is available at this scale.

Structure Scale

All information is from Self and Callas (2006).

Key Findings

- Twenty-four individual fishers were captured a total of 43 times (24 initial captures and 19 re-captures).
- Three female fishers and 1 male fisher were captured in the Sacramento Canyon study area.
- Six female fishers and 14 male fishers were captured in the South Weaverville area.
- Of 9 females collared, 8 were considered to be adults and 1 was a sub-adult.
- Self and Callas (2006) report 2 natal and 7 maternal dens from the Sacramento Canyon and Hayfork Summit study areas, however they do not distinguish which study area each den was located in (Table Hayfork Summit 1).
- All located dens were in cavities in standing live or dead trees, in black oak (*n* = 6), live oak (*n* = 2), or Douglas-fir (*n* = 1). All but the Douglas-fir were live trees. Of the 2 natal dens, 1 was in a black oak and 1 in a live oak. Dens used by fishers during this study were primarily in cavities formed by decay, where limbs were broken at the trunk of trees, or in cavities apparently excavated by pileated woodpeckers.
- Reno et al. (2008) reported characteristics of 46 natal and maternal dens (Table Hayfork Summit 2). These data are not exclusive of those reported in Self and Callas (2006).
- Mean dbh of den trees was 73.8 cm.

Author(s) Interpretation

- Reno et al. (2008) suggested that decay processes were important to cavity formation for den sites and hypothesized that in hardwoods fishers may use trees as small as 25 cm dbh if heartwood decay was present.

Table Hayfork Summit 1. Descriptive information for den locations identified on the Sacramento Canyon and Hayfork Summit study areas (modified from Self and Callas 2006).

Den type	Tree species	Den tree condition	dbh (inches)	Date 1st used	Comments
Natal	Black oak	Live	18.7	4/4/2006	Cavity entrance located above forest canopy, approximately 40 ft up the bole, with use beginning prior to deciduous leaf-out, so no canopy cover existed over the den entrance during early use. Overstory removed from stand 10–15 yrs ago.
Maternal	Black oak	Live	25.2	4/21/2006	Den entrance located approximately 9 ft above ground. Two kits heard in cavity and a picture revealed at least 2 kits in cavity. Overstory removed from stand 10–15 yrs ago.
Maternal	Black oak	Live	20.3	5/18/2006	Several separate fisher scats found on ground within 10 ft of base of den tree. Area selectively logged 10–15 yrs ago. Overstory removed from stand 10–15 yrs ago.
Maternal	Douglas-fir	Dead	65.5	6/2/2006	Large, tall snag with dead reformed top in streamside zone. Zone selectively logged 10–15 yrs ago.
Natal	Live oak	Live	51.8	3/22/2006	At 7 ft, bole branched into 4 separate stems, ranging in diameter at base from 16–32 in. Stem believed to be used as den was 24 inches diameter at base. Den tree located in steep, rocky live oak stand.
Maternal	Black oak	Live	21.6	4/26/2006	Den tree located in timber stand logged in 2003 using shelterwood removal. Oaks 12 in and larger and spaced approximately 75 ft. apart were left along with sapling/pole conifer stand. Several separate fisher scats located near base of tree.
Maternal	Black oak	Live	21.1	5/18/2006	Den tree located in same timber stand as 423M1, logged in 2003 using shelterwood removal. Oaks 12 in and larger and spaced approximately 75 ft apart were left along with sapling/pole conifer stand.
Maternal	Black oak	Live	28.9	5/31/2006	Den tree located on main ridgeline between 2 watersheds. Overstory removed from stand 10–15 yrs ago.
Maternal	Live oak	Live	45.8	6/2/2006	Den tree located in steep, rocky, live oak stand.

Table Hayfork Summit 2. Characteristics of fisher reproductive den trees (modified from Reno et al. (2008).

Tree species	Natal dens *n*	Maternal dens *n*	$\bar{x}$ dbh (cm)	$\bar{x}$ Height (m)
Black oak–live	5	20	53	15.1
Live oak–live	1	7	102	15.3
Douglas-fir–snag	0	6	119	20.8
Douglas-fir–live	1	2	130	36.8
Black oak–snag	0	1	37	9.4
Live oak–snag	0	1	44	4.9
Live oak–dead limb fall	0	1	n/a	n/a
Bigleaf maple	0	1	31	13.7

2.7.11 Coastal Northwestern California, Study Area 19

Study Objectives: The objectives were to 1) systematically survey for the occurrence of fishers and other forest carnivores within a 50 km band along the northwest coast of California; 2) if detections of fishers were obtained, to quantify the habitat associated with the detections and to describe the distribution of detections within the study area.

Principal Investigator(s): R. Golightly (Humboldt State University)

Duration: 1994

Study Area: The study area was on private and public lands in Humboldt and Del Norte Counties on the northwest coast of California. The study area extended from the Oregon border to the southern end of Humboldt Redwoods State Park in southern Humboldt County and from the Pacific coast east approximately 50 km inland. The study was in the redwood zone (Mayer and Laudenslayer 1988) with Douglas-fir becoming increasingly more dominant in the transition from the mesic coast to more xeric interior. The authors did not report study area elevation.

Methods: Ten west–east systematic track plate survey routes were established along accessible roads. Six track plate stations were placed at 1-km intervals to create a segment; segments were separated by 5-km minimum intervals. Segments were also pooled into 0–10 km and >10 km from the coast. Station placement was 10–100 m from road, targeting watercourses when possible. Track plate stations (n = 234) in 39 segments were surveyed. Each segment of 6 stations was assigned 1 of 4 habitat types (Coastal, Redwood, Transition, or Douglas-fir) based on dominant tree species. Fixed radius plots (0.04 ha) were used at each station to describe vegetation characteristics. At the stand scale fixed radius plots (0.04 ha) were used to describe vegetation characteristics at 11 stations with detections and 109 stations without detections. Chi-square tests were used to test for differences in habitat types with fisher detections. Logistic regression was used to build probability models from stations with and without detections.

Publications and reports: 1 unpublished report (Beyer and Golightly 1996).

Results:

Landscape Scale

All information is from Beyer and Golightly (1996).

Key Findings

- Fishers were detected at 30 stations in 17 segments across the survey area in all 4 habitat types.
- North to south comparisons found the greatest detection ratios were obtained from the central part of the study area.
- There was a significant difference in detection ratios among the 4 habitats:
  - coastal habitat (n = 2 segments surveyed) detections were greater than expected (although sample size was small),
  - redwood habitat (n = 11 segments surveyed) detections were less than expected,
  - transition habitat (n = 15 segments surveyed) detections were greater than expected, and
  - Douglas-fir habitat (n = 11 segments surveyed) detections were similar to expected.
- There was a significant difference in detections relative to the distance from the ocean.
- There were higher detection ratios at mid distances from the ocean and lower ratios at western and eastern extremes.

Author(s) Interpretation

- There were fewer fisher detections in the northern and southern ends of the study area

This could have been due to a change in habitat characteristics, although without geographic information system (GIS) analysis it was unclear how habitat patterns correlated with observed detection patterns.

- Relatively higher detection ratios were found in the transition and Douglas-fir habitats. The authors suggested availability of prey could be positively associated with these habitats and affect detection patterns.
- They did not discuss how fishers used the redwood zone and stated it remains unclear whether fisher detections were lower near the ocean because the habitat is less preferred or because anecdotal information suggested human disturbance was greater.

Home Range Scale

At this time no information is available at this scale.

Stand Scale

At this time no information is available at this scale.

Site Scale

All information is from Beyer and Golightly (1996).

Key Findings

- In final models of forward and backward stepwise regressions, variables correctly classifying (70% both forward and backward) stations with detections (n = 11) vs. stations without detections (n = 109) included: ground cover, distance to ocean, elevation, edge, and road canopy gap (Table Coastal Northwestern California 1).

Author(s) Interpretation

No interpretation provided.

Structure Scale

At this time no information is available at this scale.

Table Coastal Northwestern California 1. Values associated with stations with fisher detections vs. stations without detections (modified from Beyer and Golightly 1996).

	Detected (n = 11)		Not detected (n = 109)		
	$\bar{x}$	SE	$\bar{x}$	SE	*P*
Distance to ocean (km)	6.7	2.2	11.2	0.7	0.02
dbh of 3 largest trees on plot (cm)	53.3	7.7	65.1	6.2	0.46
Distance to water (m)	152	34	143	11	0.88
Canopy cover (%)	86.8	2.6	86.8	1.1	0.75
No. of logs	3.1	1	2.7	0.2	0.89
Edge (m)	336	73	184	22	0.01
Elevation (km)	466	6.8	454	30	0.73
Distance to road (m)	41.8	6.8	45.1	3.5	0.82
Road canopy gap (m)	6.3	1.5	7.8	0.6	0.54
Harvest history (yr)[a]	25.3	3.2	25.6	1.5	0.13

[a] Ten plots with detections and 61 without detections had documentable history from which last harvest could be obtained.

2.7.12. Northern California Inventory, Study Area 20

Study Objectives: To predict the distribution of the fishers across the Klamath region of northwestern California and southwestern Oregon by identifying habitat attributes associated with detection survey data. At the site scale, objectives were to predict fisher distribution across the Klamath region of northwestern California and southwestern Oregon by identifying habitat attributes associated with detection survey data using plot level data, and to determine if plot level attributes alone were useful to predict fisher presence. Using the best resultant fisher habitat model, objectives included: generating hypotheses as to mechanisms controlling habitat selection and the scales at which these operate, analyzing the regional distribution to identify potential reasons for concern for population viability (e.g. barriers to dispersal), and investigating why fishers seem to have persisted in northern California but not in other regions of the west. In a re-analysis (Carroll 2005) objectives included: testing the applicability of the Carroll et al. (1999) model using a newly available data set consisting of 1,160 survey points from the more coastal California redwood zone, describing areas of poor and good fit between the 1999 model and redwood zone data, reviewing similarities and contrasts in the univariate relationships between fisher detection habitat variables in the redwood zone versus the interior Douglas-fir zone, creating new models based on the overall survey set combining the new redwood data and interior zone surveys used in the 1999 model, and if appropriate, using these new models to predict habitat suitability in the northern Sierra Nevada. The objectives of Zielinski et al. (2006*a*) were to compare the needs of fishers and spotted owls (*Strix occidentalis*) to determine the degree to which existing conservation plans would accommodate both species. Davis et al. (2007) analyzed these fisher detection data against a suite of mapped environmental (biotic and abiotic) variables to investigate potential reasons for the disjunct nature of fisher distribution in California.

Principal Investigator(s): C. Carroll (Klamath Center for Conservation Research) and W. J. Zielinski (USDA Forest Service, Pacific Southwest Research Station)

Duration: 1991–1995; 1996–1997

Study Area: The study area was in the Klamath region of northwestern California and Southwestern Oregon and adjacent portions of the northern California coast. The study area encompassed 67,000 km^2 of the Klamath region. Elevation ranged from 0–2,700 m. Douglas-fir / mixed evergreen-hardwood was the most extensive forest type in the Klamath region. White fir and red fir forests were found at higher elevations. To the east, more xeric forest types were dominated by ponderosa pine, gray pine (*Pinus sabineana*), and California black and Oregon white oaks. To the west, redwood/western hemlock forests formed a landscape mosaic with patches of oak woodlands. Bordering the region to the north were the western hemlock/Sitka spruce forests of the Oregon Coast Range. Mean annual precipitation across the area ranged from 500–3,000 mm. Precipitation occurred primarily in winter months. Zielinski et al. (2005) investigated historical and contemporary distributions of carnivores from the southern Cascades to the southern Sierra Nevada. Davis et al. (2007), used data from the Siskiyou Mountains of northern California through the southern Cascades down to the Piute Mountains of the southern Sierra Nevada.

Methods: "Retrospective data" (n = 682) from surveys conducted between 1991 and 1995 were of 3 types: 35mm remote-camera stations, 110 remote-camera stations, and sooted track-plate stations. The sampling design for the surveys varied from stations dispersed on roadside transects to stations dispersed throughout a 10-km^2 survey unit. Surveys conducted for ≥ 12 days were included in the analyses. The validation data set (n = 468 stations in 78 sample units) was composed of a pentagonal array of 6 track plate stations, with each station separated by 500 m. Geographic information systems (GIS) data available for analysis included information on roads, hydrology, elevation, land-management category, precipitation, and vegetation (1993 California Timberland Task Force [TTF]). The TTF vegetation layer was based on classification (accuracy estimated at 60–80%) of Landsat Thematic Mapper (TM) imagery. All data were re-sampled to 1-ha resolution for analyses. Zielinski et al. (2006*a*) used the reserve selection program MARXAN and existing fisher (Carroll et al. 1999) and spotted owl (Zabel et al. 2003) models to examine reserve selection that might benefit both species. No original fisher habitat association data were analyzed or presented. Zielinski et al. (2005)

compared current fisher detection data to historic descriptions of fisher distribution and compared these to changes in measures of human density and forest cover. Human densities were evaluated using 1930 and 1990 census data. Vegetation data were derived from historic vegetation type map surveys (conducted 1929–1934) and 1996 vegetation maps derived for the Sierra Nevada Ecosystem Project. Davis et al. (2007), used fisher detection survey data collected from 1996–2002 by USDA Forest Service (Zielinski et al. 2005) and evaluated the predictive power of a suite of environmental variables using a resource selection function approach with step-wise general additive models. They first used univariate tests to examine differences between predictor variables at detection and non-detection sites. They evaluated fisher habitat predictors for the state wide data set and evaluated separate regional predictive models for 3 distinct data sets: Klamath/Shasta Trinity; the unoccupied portion of the northern and central Sierra Nevada; and the southern Sierra Nevada. They considered 5 categories of landscape-scale habitat variables: topography; precipitation; field observations of forest structure and composition; vegetation structure and composition derived from Landsat Thematic Mapper imagery and digital elevation data; and road influence. Model robustness was evaluated using 5-fold cross-wise evaluation. Davis et al. (2007) also used an alternate modelling approach (maximum entropy) to search for corroboration of their initial modelling analyses.

Publications and reports: 1 thesis (Carroll 1997), 3 unpublished reports (Zielinski et al. 1997*b*, 2000, Carroll 2005), and 5 peer reviewed publications (Carroll et al. 1999, Davis et al. 2007, Zielinski et al. 1997*c*, 2005, 2006*a*).

Results:

Landscape Scale

All information is from Carroll (1997), Carroll et al. (1999), and Carroll (2005).

Key Findings

Univariate Comparisons for 1999 model

- When corrected for spatial autocorrelation, tree canopy closure, hardwood diameter, and conifer variance remained significant at the level of P <0.10 (Table Northern California Inventory 1). Based on GIS derived data, the 10 km^2 scale had the greatest explanatory power. Comparison of models at multiple scales showed canopy cover density to be significant at all scales.

Performance of 1999 model in redwood zone

- Comparisons of univariate relationships between fisher detections and habitat variables in redwood and non-redwood zone data noted the following patterns:
  - *Canopy cover density:* The pattern of linear increase in fisher detections with increased density was consistent between the interior zone and redwood zone data. However, in the redwood zone data, there was a potential decrease in detections in landscapes with >80% average density, a relationship which was not observed in the interior zone data because few sites there had density >75%. This pattern may have been due to the relatively low detection rate in coastal old-growth redwood stands.
  - *Tree size class:* A similar quadratic univariate relationship between fisher detections and size class was noted in both interior zone and redwood zone data sets. However, size class had an inconsistent relationship with fisher detections in the multivariate models, being expressed as a linear negative relationship in the 1999 model, versus a strong linear univariate positive relationship in the redwood zone data. This was likely due to correlations with other vegetation variables.
  - Hardwood quadratic mean dbh had a linear positive correlation with fisher detections in both data sets. This relationship was much stronger in the interior zone, perhaps because

Table Northern California Inventory 1. GIS derived station attributes of sites with and without detections of fishers in retrospective data set (from Carroll et al. 1999).

Variable	Detection No x (SD) $n = 508$	Detection Yes x (SD) $n = 174$	P conventional	P CRH[d] corrected
Tree canopy closure	58.2 (25.5)	65.6 (27.7)	<0.001	0.097
Tree canopy closure MA[a] (km^2)				
1	60.7 (13.3)	67.3 (12.9)	<0.001	0.128
5	60.5 (11.8)	66.9 (11.9)	<0.001	0.113
10	60.5 (11.2)	66.7 (11.5)	<0.001	0.125
20	60.5 (10.6)	66.5 (11.2)	<0.001	0.133
30	60.5 (10.2)	66.3 (11.0)	<0.001	0.142
50	60.3 (10.0)	66.0 (11.1)	<0.001	0.155
100	60.1 (9.7)	65.6 (11.3)	<0.001	0.192
Percent conifer	69.0 (26.0)	63.9 (24.9)	0.008	0.125
Percent conifer MA (10 km^2)	67.4 (9.6)	65.7 (9.6)	0.01	0.44
Tree size class	2.30 (1.09)	2.32 (1.13)	0.636	0.805
Tree size class MA (10 km^2)	2.28 (0.36)	2.29 (0.34)	0.494	0.84
Conifer QMDBH[b]	21.4 (7.5)	22.1 (8.3)	0.269	0.604
Hardwood QMDBH	10.6 (3.4)	11.5 (3.5)	<0.001	0.08
Hardwood QMDBH MA (10 km^2)	6.18 (2.14)	7.04 (2.22)	<0.001	0.107
CWHR[c] fisher habitat index	2.55 (0.90)	2.71 (0.70)	0.049	0.19
CWHR index MA (10 km^2)	2.51 (0.34)	2.61 (0.25)	0.002	0.236
Tree canopy closure variance MA (10 km^2)	2.26 (3.11)	2.19 (3.06)	0.017	0.273
Tree size variance MA (10 km^2)	1.01 (0.11)	0.98 (0.10)	0.002	0.356
Conifer variance MA (10 km^2)	2.42 (3.11)	2.27 (2.63)	<0.001	0.007
Road density (km/km^2)	1.54 (0.86)	1.63 (0.85)	0.222	0.632
UTM easting (10^5 m)	4.68 (0.25)	4.66 (0.27)	0.037	0.689
UTM northing (10^6 m)	4.57 (0.06)	4.55 (0.05)	<0.001	0.217
Annual precipitation (10^3 mm)	1.55 (0.52)	1.44 (0.42)	0.004	0.518
Elevation (10^2 m)	11.24 (3.75)	9.98 (4.09)	<0.001	0.337
Total survey duration (days)	26.8 (13.0)	24.4 (8.3)	0.006	0.377

[a] MA = Moving Average – composite measurements derived by means of a moving-average spatial model implemented in GIS by the moving-window method.
[b] QMDBH = Quadratic mean diameter – measurement of tree diameter in cm that emphasizes the larger dbh.
[c] CWHR = California Wildlife Habitat Relationships system – (Mayer and Laudenslayer 1988).
[d] CRH = Cliford-Richardson-Hemon test—test of significance of associations between spatially auto-correlated variables.

interior hardwoods (e.g., *Quercus* spp.) were more likely to be mast-producing, and to form cavities, than were coastal hardwoods such as alder.

- *Percent conifer:* The univariate relationship between percent conifer and fisher detections was similar in both interior zone and redwood zone data in showing a quadratic relationship with a peak near 55% conifer. This relationship was less evident in the interior zone data as few sites had <55% conifer. Similar to tree size class, however, percent conifer had an inconsistent relationship with fisher detections in the multivariate models, being expressed as a univariate negative relationship in the 1999 model, versus a univariate positive relationship in the redwood zone data.

- *Elevation:* Elevation showed a negative relationship with fisher detections in the interior zone data, vs. a positive association in the redwood zone data. These simply expressed 2 segments of a quadratic relationship in which fisher distribution was centered at mid-elevations (approx. 800 m) in the Douglas-fir/mixed evergreen-hardwood zone.
- *Precipitation:* The relationship of fisher detections to precipitation showed a similar pattern to that of elevation, peaking at approx. 1,900 mm. This would imply that the positive coefficient for precipitation in the 1999 model may have had low generality.
- *Terrain ruggedness index (TRI):* TRI showed a relatively consistent positive relationship with fisher detections in both data sets, although there was a possible decline at very high TRI values.

- Zielinski et al. (2005) reported that current fisher distribution was markedly decreased from historical distribution. The north/south gap in fisher distribution aligned well with increased levels of anthropogenic environmental change.
- Davis et al. (2007) reported that based on univariate comparisons fisher detections were significantly associated with latitude-adjusted elevation, relief, paved roads and all vegetation and structure variables although these results were very different for the southern Sierra Nevada dataset (Table Northern California Inventory 2).
- GIS derived measures of habitat performed as good as or better than field derived values.
- Fisher detections were closely associated with late seral and late seral hardwood forests, and areas with high tree cover and larger trees.

Table Northern California Inventory 2. Results of univariate tests of association between environmental variables and fisher detections (modified from Davis et al. 2007). Significant relationships (Wilcoxon *U* test) are indicated by symbols (+ positively associated with fisher detections, – negatively associated with fisher detections).

Variable	State wide	Klamath-Shasta and Southern Sierra Nevada	Klamath-Shasta	Southern Sierra Nevada
Adjusted elevation	–			
Relief	+	+	+	
Annual precipitation				
Paved roads	+	+	+	
Improved roads				
Field CWHR	+	+	+	
Field CWHR2	+	+	+	
Field hardwood	+	+	+	
Field structure	+	+	+	
GIS CWHR	+	+	+	
GIS CWHR2	+	+	+	
GIS structure	+	+	+	
GIS dense hardwood	+	+	+	
GIS dense forest	+	+	+	+

- The best state wide model predicting fisher detections included annual precipitation, relief and dense forest. When Davis et al. (2007) accounted for spatial autocorrelation, the model accounted for 81–90% of fisher detections.
- The state wide model performed well in the Klamath/Shasta and northern Sierra Nevada but not in the southern Sierra Nevada. Annual precipitation was a consistent variable in all models; relief was a consistent variable within all models but the southern Sierra Nevada (Table Northern California Inventory 3). Davis et al. (2007) noted that no models performed well for the southern Sierra Nevada study area.

Tables Northern California Inventory 3. Variables (GIS-derived) associated with non-spatial general additive models for predicting fisher detections (modified from Davis et al. 2007).

Model	Variables
State wide	annual precipitation, dense forest, relief
Klamath-Shasta and Southern Sierra Nevada	annual precipitation, CWHR2, relief
Klamath-Shasta	relief, structure, annual precipitation
Southern Sierra Nevada	annual precipitation, dense forest, adjusted elevation

- Davis et al. (2007) reported that fisher detections were positively associated with late seral stages of mid-montane forest types, late seral hardwood forest, and the fraction of the landscape occupied by dense mid-montane forest.
- Alternate modelling techniques provided predictive model results which were highly correlated with those produced by general additive models.

Author(s) Interpretation

- The best predictors of fisher distribution proved to be landscape- and regional scale variables, rather than the fine-scale variables often used in wildlife-habitat models. If, as the Carroll et al. (1999) study suggests, habitat selection by fishers is dominated by factors operating at the home-range scale and above, regional-scale conservation planning for the fisher may be possible without fine-scale data on vegetation or prey abundance. Fishers appear strongly associated with forest cover, and this attribute is relatively easy to measure with satellite imagery.
- The relatively good fit between the 1999 model and the 2005 redwood zone survey data was encouraging, given that no redwood zone data was used in constructing the 1999 model. It implies that predictor variables such as canopy closure are biologically-relevant limiting factors whose correlation with fisher distribution has some generality across forest types and ecoregions.
- Among the vegetation variables, the tree canopy closure moving average had the highest significance and the clearest biological interpretation. Landscapes with higher levels of overhead cover may provide increased protection from predation, lower the energy costs of traveling between foraging sites, and provide more favourable microclimate and increased abundance or vulnerability of preferred prey species.
- The percent conifer moving average is only marginally significant in its main effect but retains significance through its interaction term. The negative interaction between the percent-conifer moving average and the tree canopy closure moving average suggests that increasing tree canopy closure has a more positive effect in mixed conifer/evergreen-hardwood landscapes than in purely conifer landscapes.
- Hardwood diameter was highly significant in all comparisons. Possible explanations included cavity use as rest and den sites and mast production stimulating prey densities.
- Tree size class moving average had the most complex and difficult to interpret of the 3 correlations. The tree size moving average had low univariate significance, and its effect in the multivariate model was generally negative. This contradicted results from fine-scale studies of fishers in this region that showed an association of fisher rest sites with large trees. The generally negative net contribution of size class moving average in the multivariate model was misleading if interpreted as if it were a univariate effect. An increase in other covariates such as canopy cover density in older stands may actually have resulted in a different univariate correlation. Removing this variable from the model may have more interpretability, but the higher Bayesian statistic used to score the model argues for the retention of size class moving average in the model. It appeared that landscape level tree size class had a positive correlation with fisher detection in more mesic forests of the Douglas-fir/mixed

evergreen zone, at least up to a certain threshold. The relationship between tree size and fisher distribution in the more xeric pine and oak forests of the eastern Klamath is uncertain.

- Variables not significant in the multivariate model included elevation and road density. Elevation is correlated with vegetation variables, particularly percent conifer ($r^2 = 0.70$). The fact that vegetation had more explanatory power than elevation suggests that the often noted correlation of fisher distribution with elevation may be due to the effects of vegetation, either directly or as a mediator of snow condition. A lack of road effect was attributed to the evidence that public lands in the Klamath have not experienced the magnitude of logging that has occurred in other parts of the Pacific Northwest. Because of this, "natural" gradients in habitat quality due to regional gradients in forest structure and productivity may be as significant as the effects of human impact.

- The UTM easting variable was correlated with the climatic gradients in precipitation, temperature, and elevation, which are the most influential abiotic factors controlling the distribution of the region's diverse flora. These floristic changes can be expected to change the relationship of the forest structure to fisher distribution. They are also expected to influence prey species composition.

- The late seral Douglas-fir/mixed evergreen-hardwood forests of the region may produce landscapes with an optimal combination of habitat resources for fishers: high levels of canopy closure, large wood provided by the conifers and mast provided by the hardwoods. Due to its steep topography, the Klamath region has lost less of its late-successional forest than have forest lands in the Oregon Coast and Cascades. Furthermore, the sprouting ability of both evergreen hardwoods and redwoods helps these forests recover canopy closure more rapidly after disturbance, making their habitat more resilient to logging. This would make these landscapes more similar to eastern forests that to other western forests and might help explain the persistence of fishers in both the eastern U.S. and in the Klamath region.

- This study demonstrated that conclusions drawn from habitat selection studies may be highly dependent on the scales at which selection is measured. Whereas plot-level analysis of the validation data might indicate that there is no significant association between fishers and tree size class, a landscape level analysis reached the opposite conclusion. Analyses at multiple scales may be especially critical for understanding the distribution of wide-ranging carnivores such as the fisher.

- Davis et al. (2007) suggested that fisher association (at a univariate level) with paved roads may have been an artefact of correlation between these and vegetation associated with waterways where roads are most commonly located.

- Davis et al. (2007) suggested that fisher habitat in the southern Sierra Nevada may be more fine-grained and heterogeneous than other study areas and that this may be responsible for poor performance of predictive models here.

- Davis et al. (2007) suggested that habitat in concert with other factors (dispersal and demography) may be responsible for the lack of fisher detections in the northern Sierra Nevada.

Home Range Scale

At this time no information is available at this scale.

Stand Scale

At this time no information is available at this scale.

Site Scale

All information is from Carroll (1997), Carroll et al. (1999), and Carroll (2005).

Key Findings

- After accounting for spatial autocorrelation, comparisons of plot-level (approx. 0.05 ha) attributes at fisher detection sites from the validation survey stations resulted in hardwood quadratic mean dbh, conifer and total basal area, and transformed micro- and macro-aspect remaining significantly higher ($P < 0.01$) (Table Northern California Inventory 4).

Table Northern California Inventory 4. Station attributes of sites with and without detections of fishers in validation surveys derived from GIS and plot-level measurements (modified from Carroll et al. 1999).

	Detection			
Station attributes	No $\bar{x}$ (SD) (n = 384)	Yes $\bar{x}$ (SD) (n = 84)	p	p CRH[c] corrected
GIS attributes				
Tree canopy closure MA[a] (10 km^2)	68.5 (10.9)	71.3 (8.5)	0.05	0.506
Percent conifer MA (10 km^2)	69.9 (11.2)	63.5 (10.8)	<0.001	0.379
Tree size class MA (10 km^2)	2.55 (0.58)	2.45 (0.29)	0.123	0.759
Annual precipitation (10^3 mm)	2.06 (0.70)	1.44 (0.40)	<0.001	0.422
UTM easting (10^5 m)	4.37 (0.28)	4.56 (0.19)	<0.001	0.471
UTM northing (10^6 m)	4.62 (0.47)	4.55 (0.29)	<0.001	0.176
Predicted probability	0.12 (0.14)	0.33 (0.23)	<0.001	0.087
Field measurements				
Elevation (m)	769 (357)	852 (406)	0.164	0.684
Slope	42.8 (20.7)	44.0 (18.3)	0.614	0.755
Transformed macro-aspect	0.986 (0.696)	1.218 (0.762)	0.004	0.028
Transformed micro-aspect	0.958 (0.702)	1.168 (0.763)	0.02	0.028
Total basal area (m^2/ha)	37.4 (20.2)	47.3 (20.0)	<0.001	0.058
Conifer basal area	21.1 (17.8)	26.5 (15.9)	0.001	0.039
Hardwood basal area	12.2 (15.6)	16.1 (15.8)	0.017	0.128
Snag basal area	4.1 (6.4)	4.7 (7.1)	0.749	0.792
Mean QMDBH[b] (cm)	53.7 (31.6)	61.8 (28.4)	0.014	0.228
Conifer QMDBH	59.6 (42.4)	64.9 (38.3)	0.211	0.476
Hardwood QMDBH	16.6 (19.7)	27.4 (26.2)	<0.001	0.046
Snag QMBDH	25.9 (39.0)	35.4 (47.5)	0.356	0.294
Canopy closure (%)	78.1 (27.1)	87.1 (13.6)	0.317	0.485
Log count (15–30 cm class)	2.03 (2.93)	1.94 (2.54)	0.697	0.898
Log count (30–60 cm class)	0.96 (1.59)	0.96 (1.48)	0.891	0.956
Log count (60–90 cm class)	0.42 (0.86)	0.44 (0.78)	0.539	0.731
Log count (>90 cm class)	0.28 (0.64)	0.27 (0.81)	0.572	0.776
Bear damage (% of visits)	17.2 (22.3)	14.5 (20.4)	0.344	0.685
Ocular estimates				
Overstory canopy closure	42 (24)	43 (22)	0.55	0.585
Understory canopy closure	34 (24)	41 (24)	0.013	0.129
Overstory + understory canopy closure	76 (24)	85 (15)	<0.001	0.102
Shrub canopy closure	55 (29)	38 (25)	<0.001	0.312
Percent conifer	64 (30)	64 (26)	0.761	0.827

[a] MA = Moving Average – composite measurements derived by means of a moving-average spatial model implemented in GIS by the moving-window method.

[b] QMDBH = Quadratic mean diameter – measurement of tree diameter in cm that emphasizes the larger dbh.

[c] CRH = Cliford-Richardson-Hemon test—test of significance of associations between spatially auto-correlated variables.

- Addition of plot-level variables to the landscape-level model, however, did not significantly improve model performance. Hardwood diameter was highly significant ($P < 0.01$) in both the plot-level and combined models.

Author(s) Interpretation

- The best predictors of fisher distribution proved to be landscape- and regional scale variables, rather than the fine-scale variables often used in wildlife-habitat models.
- Although the plot-level vegetation variables examined had little explanatory power, they were measured at a scale of approximately 0.05 ha and may not have fully represented the characteristics of a vegetation patch.
- Other fine-scale attributes such as spatial and temporal variation in prey abundance may also have been important.
- Some proportion of the variation in the distribution and abundance of a species will be determined by factors unrelated to the current habitat pattern, such as historical effects and stochastic variability in habitat occupancy.
- The relationships between fisher detections and fisher population density and between density and individual survival and reproduction were also untested.

Structure Scale

At this time no information is available at this scale.

2.7.13. Mendocino National Forest, Study Area 21

Study Objectives: This study compared habitat characteristics at detection and non-detection sites surveyed for fishers within higher elevation portions of the Mendocino National Forest. They assessed the distribution, relative abundance and habitat associations of fishers on the Mendocino National Forest at higher elevation conifer-dominated forests of primarily true fir. The authors compared landscape, stand and site-level attributes between stations with detections and those without detections. Vegetation plots were completed at all detection and non-detection stations to compare site characteristics between detection and non-detection sites.

Principal Investigator(s): K. M. Slauson and W. J. Zielinski (USDA Forest Service, Pacific Southwest Research Station)

Duration: 2006

Study Area: The Mendocino study area was approximately 2,800 km^2 and included parts of Colusa, Glenn, Lake, Mendocino, Tehama, and Trinity Counties, California. Elevations ranged from 230–2,500 m.

Methods: Track plate surveys were conducted primarily above 2,000 m in older true fir forest types but ranged in elevation from 653–2,234 m ($\bar{x}$ = 1,615 m). Additional sample units were included in mesic, late-successional, conifer dominated forests. Sample units consisted of 6 track stations that were spaced by a minimum of 0.8 km within each 4 mi^2 area selected for survey. Stations were placed in the latest successional stages and moistest microsites possible while maintaining the required spacing. Stations were baited with a drumstick-sized piece of chicken and a commercial lure (GUSTO) was used as an attractant. Stations were checked and re-baited every 3–4 days.

Habitat variables were sampled at each station using a combination of fixed and variable-radius plots and transects. Topographic variables were also collected including elevation and distance to surface water. Basal area of conifers, hardwoods and snags were estimated using a 20-factor prism sweep to identify the sample of trees. Canopy closure, tree species composition, and shrub cover were estimated within a 0.49-ha plot centered on each track plate station. Downed wood, stumps and snags were sampled using 4 25-m long, 5-m wide belt transects radiating out from each track plate station. Each site was classified according to California Wildlife Habitat Relationships (CWHR) system (Mayer and Laudenslayer 1988) to assign a habitat type, size class, and canopy cover class. The sex of each detected animal was determined based on the measurements of tracks.

Publications and reports: 1 unpublished report (Slauson and Zielinski 2007).

Results:

Landscape Scale

All information is from Slauson and Zielinski (2007).

Key Findings

- Fishers were detected at lower elevation ($\bar{x}$ = 1,499 m [SE = 66.8]) sites than sites with no detections ($\bar{x}$ = 1,631 m [SE = 29.5]).
- Fishers detections were no more likely to be within 250 m of water than non-detection sites.

Author's Interpretation

- This study focused primarily on mid to high elevation sites with late-successional patches of mesic forest. Therefore, the results only apply to distinguish sites where fishers were and were not detected in that context.
- Given that context, it was not surprising that fishers were detected at sites at lower elevations and not in the immediate vicinity of water.

Home Range Scale

At this time no information is available at this scale.

Stand Scale

All information is from Slauson and Zielinski (2007).

Key Findings

- Fishers exhibited higher use of Douglas-fir and Klamath mixed conifer CWHR stand types and lower use of montane-hardwood conifer and true fir habitats.

Author(s) Interpretation

- The lower use of true fir habitats further reflected fisher use of lower elevations.

Site Scale

All information is from Slauson and Zielinski (2007).

Key Findings

- Tree species composition was similar between detection and non-detection sites. However, white fir and red fir ranked lower at detection sites while incense cedar and black oak ranked higher.
- Estimated tree canopy cover was significantly higher at sites with fisher detections than at non-detection sites ($\bar{x}$ = 78.1%, SE = 2.87 vs. $\bar{x}$ = 67.6%, SE = 1.18; P = 0.0024).
- Although basal area of conifers was similar between detection and non-detection sites the higher use of the largest CHWR tree size classes (5 and 6) and lower used of mid size classes (3 and 4) was apparent.
- Hardwood basal area was significantly higher at detection sites than at non-detection sites.
- Total basal area of snags was lower at detection sites, although not significantly, while the density of medium and large snags did not differ between detection and non-detection sites.
- The density of medium (30–60 cm) and large (>90 cm) logs was significantly higher at sites where fishers were detected.

Author(s) Interpretation

- Fishers were detected at sites with larger hardwood components, dominated by black oak, and had significantly higher tree canopy closure, both of which are recurrent findings in most studies of fisher habitat associations in California.
- The significantly higher densities of medium to large logs at sites with fisher detections were also noteworthy.

Structure Scale

At this time no information is available at this scale.

2.8. Southern Sierra Nevada, California Fisher Population

2.8.1. Sierra Nevada Fire and Fire Surrogate, Study Area 22

Study Objectives: To compare changes in habitat conditions important to fishers resulting from fuel management treatments. Specifically, to assess changes in select variables considered important to fishers and other species associated with old-forest conditions and changes in predicted probability of resource use (surrogate for habitat quality) by fishers.

Principal Investigator(s): R. L. Truex (USDA Forest Service, Sequoia National Forest) and W. J. Zielinski (USDA Forest Service, Pacific Southwest Research Station)

Duration: 1994–1997

Study Area: The study area consisted of 2 sites located in Blodgett Forest Research Station (BFRS) and Sequoia-Kings Canyon. Blodgett Forest Research Station was a 1,780 ha experimental forest owned and managed by the University of California, Berkeley located along the Georgetown Divide in the central Sierra Nevada, El Dorado County, CA. Common tree species at BRFS were Douglas-fir, white fir, ponderosa pine, sugar pine, incense cedar, California black oak, and tanoak. Habitats were primarily mixed conifer, however some ponderosa pine montane hardwood-conifer habitats were also present. Topography was rolling, slope averaged <30%, and elevation ranged from approx. 1,200–1,500 m. The Sequoia-Kings Canyon site occurred in Tulare County within Sequoia National Park in the southern Sierra Nevada, CA. The study site was located on a northwest aspect bench above the Marble Fork of the Kaweah River. Topography was somewhat steeper than Blodgett Forest (20–50% slope). Elevation ranged from 1,900–2,150 m. Habitat was predominantly old-growth mixed conifer. White fir was the dominant tree species. Other trees present included red fir, ponderosa pine, sugar pine, incense cedar, Pacific dogwood (*Cornus nuttallii*) and California black oak.

Methods: At the BFRS site 12 treatment units (15–30 ha) were randomly assigned to 1 of 4 treatments (control, mechanical harvest, mechanical harvest followed by area burn, area burn only). At the Sequoia Kings Canyon site treatment units (15–20 ha) (control, early burn, late burn) were assigned based on recent fire history. Permanent monitoring plots were established within each treatment unit and habitat variables were assessed pre- and post-treatment. Within each treatment unit habitat data were collected during late spring or summer at 10 randomly selected plots before and after treatment implementation. Post-treatment sampling was conducted approximately 1 yr after treatment implementation. Habitat sampling protocols described by Zielinski et al. (2004*a*) using plot-based and plotless techniques were used to assess habitat. Data were collected on the following variables: percent slope, presence of water within 100 m, basal area of hardwoods, average dbh of all trees in sample, average hardwood dbh, standard deviation of dbh of all trees in sample, maximum dbh of all trees in sample, presence of ≥ 1 conifer snag >102 cm dbh, and average canopy closure. The authors used logistic regression techniques to develop predictive retrospective (resting habitat) and prospective (foraging habitat) models using previously published and unpublished data from fisher rest sites (Zielinski et al. 2004*b*) and fisher detections at track plates (Zielinski et al. unpub. data). Resting site models were based on >500 used and available sites from 19 radio-collared fishers. Foraging habitat models were based on data collected at 101 track plate stations. Model selection was informed by information-theoretic approaches. Predictive models were selected if they accounted for >0.90 of Akaike weights. Models were applied to habitat data collected pre- and post-treatment to evaluate the effects of treatment on fisher resting and foraging habitat suitability. Nested ANOVA were used to test for treatment effects.

Publications and reports: 1 unpublished report (Truex and Zielinski 2005).

Results:

Landscape Scale

At this time no information is available at this scale.

Home Range Scale

At this time no information is available at this scale.

Stand Scale

At this time no information is available at this scale.

Site Scale

All information is from Truex and Zielinski (2005).

Key Findings

- The fisher rest site model consisted of 3 variables: average canopy, average hardwood dbh and maximum tree size.
- Fishers selected to rest in habitats with denser canopy, larger mean hardwood diameter and larger mean diameter of trees overall.
- Model averaging procedures were necessary to develop the foraging model as no individual model had an Akaike weight of >0.90.
- The resulting foraging site model consisted of 8 variables: average canopy, average hardwood dbh, maximum tree dbh, average tree dbh, basal area of hardwoods, presence of water within 100 m, presence of conifer snags >102 cm, and slope.
- Resting habitat suitability at the Sequoia site was better than at the BFRS site, and both were poorer overall relative to the study sites from which the data for model development originated.
- Foraging habitat suitability was similar at both study sites, and poorer than fisher detection sites used to develop the foraging model but similar to habitat suitability at non-detection sites.
- Treatment significantly reduced resting habitat suitability on the BFRS site; mechanical only and mechanical plus fire treatments differed significantly from the control, fire only did not.
- Treatment effects on foraging habitat suitability were non-evident at the Blodgett site and marginal at the Sequoia site.

Author(s) Interpretation

- Fuel management treatments can substantially affect resting habitat suitability for fishers, primarily through reduction of canopy cover.
- The lack of significant treatment effects on foraging habitat may have been a result of the complexity of the foraging habitat model and the fact that it contained many variables not affected by treatments.
- Although some methods had significant effects on fisher habitat suitability, the ability to direct them so as to mitigate some of this effect was deemed to be important to moderating the duration of the effect relative to the objectives of the treatment.

Structure Scale

At this time no information is available at this scale.

2.8.2. Kings River, Sierra National Forest, Study Area 23

Study Objectives: Boroski et al.'s (2002) objectives were to document fisher presence, evaluate changes in fisher habitat and to understand fisher habitat characteristics. Mazzoni's (2002) objectives were to carry out part of this work, specifically to describe rest structures of male and female fishers and the habitats they were found within, to evaluate whether fisher home ranges had high proportions of high quality habitat and to determine whether fisher habitat had changed within the study area over the past 39 yrs. Zielinski et al. (2006*b*) evaluated the utility of using standardized USDA Forest Service FIA data as a predictor of fisher resting habitat.

Principal Investigator(s): B. Boroski (H. T. Harvey and Associates), R. Golightly (Humboldt State University), W. J. Zielinski (USDA Forest Service, Pacific Southwest Research Station), M. J. Jordan (University of California Berkeley), and A. K. Mazzoni (Fresno State University)

Duration: 1995–1996; 1999–2001; 2003–2004

Study Area: The study area was 263 km^2 (Mazzoni 2002) and 317 km^2 (Jordan 2007) within the Kings River Administrative Study Area in Sierra National Forest. Elevation ranged from 294–2,592 m. The study area was comprised of coniferous forest habitats including Sierran mixed conifer, montane hardwood-conifer, white fir and ponderosa pine.

Methods: Boroski et al. (2002) conducted surveys using sooted aluminum track-plates at 160 stations over 8 elevational transects during the winters of 1995 and 1996. Two 22-day surveys were conducted in each year. Road-based track surveys and remote camera surveys were subsequently used in 1999 to re-evaluate track plate results. Mazzoni (2002) live-captured and radio-tagged 9 fishers (3F, 6M). Fishers were relocated using triangulation and walk-in procedures during Oct 1999–May 2000 and Oct 2000–Apr 2001. At each identified rest structure Mazzoni (2002) recorded tree species, dbh, tree height, mistletoe occurrence and decay class. Characteristics of rest sites were compared using descriptive univariate statistics. Rest site characteristics were evaluated using concentric 0.07 and 1.0-ha plots around the rest structure. Measured characteristics included canopy cover (multiple moose horn readings), ground cover, log cover, and shrub cover. Tree characteristics were measured for trees >76 cm dbh in the larger plot, and >10 cm dbh and >2 m height in the smaller plot. Berger-Parker index was used to characterize canopy layering. Rest site characteristics were compared to those of 160 random plots. Adaptive kernel (ADK; 70%) and minimum convex polygon (MCP; 100%, 70%) home ranges were calculated for fishers with >20 locations. Vegetation was classified using the California Wildlife Habitat Relationships (CWHR) classification scheme (Mayer and Laudenslayer 1988). Landscape scale habitat selection was evaluated by comparing composition of 70% ADK home ranges with random home ranges using MANOVA techniques. Mazzoni (2002) compared fisher habitat values between 1957 and her study by evaluating relative proportions of the landscape with ≥ 20% canopy (high) and <20% canopy cover (low). Jordon et al. (2005) used live-trapping, remote genetic capture, and photo capture-recapture techniques to estimate fisher densities. Zielinski et al. (2006*b*) randomly selected 35 fisher rest sites from Mazzoni's (2002) study and 40 randomly selected fisher rest sites from another study (see Tule River key findings; Zielinski et al. 2004*b*). They collected habitat data per USDA Forest Service FIA protocols and conducted univariate comparisons of characteristics of fisher rest sites to existing randomly selected FIA plots within these 2 study areas. They used logistic regression modelling and information theoretic approaches to develop and evaluate the effectiveness of using FIA data as a predictor of fisher resting habitat.

Publications and reports: 1 draft final report (Jordan et al. 2005), 1 thesis (Mazzoni 2002), 1 dissertation (Jordan 2007), and 3 peer-reviewed publications (Boroski et al. 2002, Zielinski et al. 2006*b*, Jordan et al. 2007).

Results:

Landscape Scale

All information is from Boroski et al. (2002), Mazzoni (2002), and Jordan et al. (2005).

Key Findings

- Boroski et al. (2002) reported fishers were detected at track-plate stations at elevations ranging from 1,114–2,040 m and detected by remote cameras and snow track surveys at elevations as high as 2,438 m in snow depths ranging from 5–124 cm.
- Mazzoni (2002) reported that female fishers included significantly more CWHR class 1 (high quality reproduction; medium quality foraging) and less class 4 (no reproductive habitat; low–medium quality foraging) habitat within home ranges than was available within the landscape.
- Jordan et al. (2005) reported that fishers were captured over the entire elevation range (1,200–2,400 m) of their study however most fishers were recorded below 1,800 m.

Author(s) Interpretation

No interpretation provided.

Home Range Scale

All information is from Mazzoni (2002).

Key Findings

- Mean home ranges sizes (100% MCP) were 11.9 km^2 (F) and 21.9 km^2 (M).

Author(s) Interpretation

No interpretation provided.

Stand Scale

At this time no information is available at this scale.

Site Scale

All information is from Mazzoni (2002) and Zielinski et al. (2006*b*).

Key Findings

- Rest sites occurred in Sierran mixed conifer (49.1%), white fir-Sierran mixed conifer (9.4%), montane hardwood-conifer (15.1%), ponderosa pine, and (18.9%), and white fir (7.5%) types.
- No site scale differences were observed between male and female rest sites.
- Rest sites had greater canopy cover, log cover, basal area, crown volume, canopy layering, and were closer to ephemeral and permanent streams than random sites (Table Kings River 1).
- Zielinski et al. (2006*b*) found that mean values of most variables examined were significantly different between fisher rest sites and FIA plots (findings include data from Tule River study area).
- Substantial differences were noted for total basal area, conifer basal area, small tree basal area, large tree basal area, black oak basal area, number of conifers, number of large snags, number of downed logs, maximum dbh, percentage of high shrubs and maximum tree age (Table Kings River 2).

Table Kings River 1. Site characteristics of fisher rest sites (modified from Mazzoni 2002).

Variable	$\bar{x}$	SD	*n*
Canopy cover (%)	72.8	12.9	53
Log cover (dm/l5 m)	5.9	4.9	51
Basal area/ha	68.5	26.2	53
Crown volume (m^3/ha)	65,247	33,832	53
Distance from ephemeral stream (m)	41.6	29.4	76
Distance from permanent stream (m)	114.1	108.2	76
Ground cover <1m (dm/l5 m)	37.4	36.0	51
Ground cover >1 (dm/15 m)	21.2	21.0	51
Crown evenness >60% cover	2.4	0.5	44
Large snag presence (No./ha)	5.7	3.8	53
Large hardwoods (No./ha)	1.4	2.3	53

Table Kings River 2. Attributes of habitat variables ($\bar{x}$, SE) measured at fisher rest sites and FIA plots in Kings River and Tule River study areas (modified from Zielinski et al. 2006*b*).

Parameter	Resting sites	FIA plots
Elevation (m)	1,621.9 (22.7)	1,767.0 (20.2)
Vegetation cover (%)		
Hardwood	14.1 (1.9)	17.6 (1.8)
Shrub	13.3 (1.4)	24.8 (1.6)
Low shrub	11.6 (1.7)	7.8 (0.8)
Basal area (m^2/ha)		
Total	58.7 (2.5)	40.1 (1.6)
Small tree (<51 cm dbh)	25.0 (1.4)	15.5 (0.7)
Large tree (>52 cm dbh)	11.6 (1.8)	7.0 (0.7)
Quercus kelloggii	5.6 (0.7)	3.1 (0.4)
Conifer	51.6 (2.6)	35.2 (1.7)
Hardwood	7.1 (0.8)	4.9 (0.5)
No. conifer stems	1120.6 (90.9)	531.4 (33.8)
Tree dbh (cm)		
Mean tree	19.4 (0.9)	23.7 (0.9)
Mean hardwood	20.3 (2.1)	14.2 (1.1)
Maximum tree	145.6 (7.3)	111.3 (3.2)
Tree age (yr)		
Mean	118.4 (3.9)	113.9 (4.1)
Minimum	38.3 (1.9)	42.2 (2.3)
Maximum	317.4 (23.1)	230.8 (10.5)
Largest conifer snag (cm dbh)	110.6 (5.5)	79.8 (3.1)
Number of large snags (>38.1 cm dbh)	15.4 (1.1)	10.7 (0.8)
Volume of logs (m^3/ha)	169.4 (33.4)	118.0 (9.7)
Number of downed logs/ha	64.6 (4.1)	48.4 (2.5)

- The best predictive model included maximum tree dbh, basal area of small trees, percent slope, mean canopy cover, largest conifer snag dbh, and hardwood dbh. The variables are listed in decreasing order of influence on decrease in deviance, however this model only explained 31.5% of deviance.
- Few FIA plots had habitat suitability values that classified them as fisher resting habitat, whereas >80% of fisher rest sites were correctly classified as fisher habitat by the model.

Author(s) Interpretation

- Zielinski et al. (2006*b*) note that while their rest site model included variables common to previous analyses of rest site data, the amount of unexplained deviance suggests that other factors/variables not included in the model must be influencing fishers choice of rest sites.
- Despite this, they posited that the model had high success in assigning known fisher rest sites to "rest site habitat" and the commonality between it and other analyses of fisher rest sites make it a useful tool for a variety of fisher rest site habitat assessment and monitoring applications.

Structure Scale

All information is from Mazzoni (2002).

Key Findings

- During 2 field seasons 78 fisher rest sites (57F, 21M) were identified in trees (n = 59), snags (n = 12), logs (n = 3), stumps (n = 2) and rock crevices (n = 2).
- Mean dbh of rest trees was 95.2 cm (Table Kings River 3).
- Most fisher rest sites were located in conifers (Table Kings River 4).
- White fir, ponderosa pine, and black oak were used more than expected by female fishers; incense cedar and sugar pine were used less than expected. There were no significant differences in use of tree species between males and females.

Table Kings River 3. Characteristics of fisher rest trees and snags in the Kings Rivers study area (modified from Mazzoni 2002).

		dbh (cm)		Height (m)	
Structure	Gender	n	$\bar{x}$ (SD)	n	$\bar{x}$ (SD)
Live tree	F	43	98.1 (29)	34	37.8 (12)
Live tree	M	10	82.9 (20.6)	8	33.2 (13.7)
Snag	F	6	98.8 (31.9)	6	15.0 (12.1)
Snag	M	6	134.7 (55.9)	5	19.3 (18.0)

Table Kings River 4. Fisher rest tree characteristics in the Kings Rivers study area (modified from Mazzoni 2002).

Species	Female use (*n*)	Male use (*n*)	Mistletoe brooms present (*n*)
White fir	18	1	13
Ponderosa pine	16	6	16
Sugar pine	6	1	4
Incense cedar	2	1	0
Black oak	7	1	1

- 3 fishers re-used rest sites 2–5 times.

Author(s) Interpretation

- Presence of mistletoe bundles may have been an important factor in rest structure and rest tree species selection.

2.8.3. Sequoia-Kings Canyon, Study Area 24

Study Objectives: To determine the distribution and habitat associations of American martens and fishers in Sequoia-Kings Canyon National Parks, to document occurrence of other mesocarnivores, and to evaluate the California Wildlife Habitat Relationships model for American marten.

Principal Investigator(s): R. Green (Humboldt State University)

Duration: 2002–2004

Study Area: This study was conducted in Sequoia-Kings Canyon National Park in the southern Sierra Nevada of California. The study area was approximately 3,500 km^2 and elevation ranged from 500–4,400 m. Habitats included chaparral and oak-dominated communities, mixed conifer forest and giant sequoia groves (*Sequoiadendron giganteum*) at mid-elevation, red fir and lodgepole pine in the subalpine and alpine lakes and high granite peaks at upper elevations. Designated wilderness comprised >84% of the Parks.

Methods: Detection devices were distributed at sites on a 5-km sampling grid. Each site had 5 detection devices: 3 enclosed track plates, 1 open plate, and 1 remote camera. Devices were placed on the site in a cross-shaped pattern with an enclosed track plate in the center and the 4 remaining devices placed 150 m away in each cardinal direction (the distance could extend up to 250 m as needed). Each site was baited with cat food mixed with lard and monitored/re-baited every 3 days for 15 days. Habitat type, tree size class, and canopy cover were visually estimated by one individual, and recorded in classes described in the California Wildlife Habitat Relationships (CWHR) system vegetation manual (Mayer and Laudenslayer 1988) at a 25-m radius plot around each detection device. Jaccard's similarity coefficient was used to compare habitat types surveyed relative to the species detected in each type. Chi-squared tests of independence or two-tailed Fisher's exact tests were calculated for tree size class and canopy cover categories where appropriate for species detected at >10% of all sites.

Publications and reports: 1 thesis (Green 2007).

Results:

Landscape Scale

Key findings

- Fishers were detected across the study area in mid-elevation conifer forest habitats with moderate to dense canopy cover.

Author(s) Interpretation

- The black oak component of coniferous forests may be an important influence on fisher use of conifer habitats.

Home Range Scale

At this time no information is available at this scale.

Stand Scale

At this time no information is available at this scale.

Site Scale

Information is from Green 2007.

Key findings

- Fishers were detected at 9/79 sites (11.4%) between 1,000 and 2,870 m elevation.
- Fifty-six percent of the fisher detections were in Sierran mixed conifer, 22% in montane hardwood, 11% in subalpine conifer, and 11% in white fir habitat types.
- Fishers were detected in sites with ≥40 percent canopy cover more than expected compared to sites with <40 percent canopy cover.
- Fishers were not detected at sites with tree size classes 5 and 6 more than expected compared to sites with tree size classes 3 and 4.

Author(s) Interpretation

- Fishers were detected at 67% of the sites in middle elevation coniferous and 67% of the sites in the largest tree size classes (although this was not different than expected based on availability of sites surveyed).
- Sierran mixed conifer with extensive canopy cover and large trees may be important to fishers in the southern Sierra Nevada.
- Seventy-eight percent of sites with fisher detections had a hardwood component and bordered a stream.
- Subalpine forest may be used infrequently (based on 1 detection over the 3-yr study and 15% of the sites located in that type).
- Fishers have a more restricted distribution (than marten) in the Parks and they were primarily associated with continuous mid-elevation forests on the western slope.
- Fisher detections fell within the historic range described by Grinnell et al. (1937) and overlapped some historic records (Schempf and White 1974).

Structure Scale

At this time no information is available at this scale.

2.8.4. Tule River, Study Area 25

Study Objectives: Zielinski et al. (2004*b*) compared home range size and habitat composition of home ranges between the Pilot Creek and Tule River study areas. Zielinski et al. (2004*a*) characterized and compared fisher resting site habitat selection in the same study areas. Truex et al. (1998) conducted a meta-analysis of home range, site and structure scale data from this study area and the Pilot Creek and Shasta-Trinity study areas to compare attributes of fisher home ranges and habitat associations. Zielinski et al. (2006*b*) evaluated the utility of using standardized USDA Forest Service FIA data as a predictor of fisher resting habitat.

Principal Investigator(s): W. J. Zielinski and R. L. Truex (USDA Forest Service), and R. H. Barrett (University of California, Berkley)

Duration: 1994–1996

Study Area: The study area was 300 km^2 in Sequoia National Forest, Tulare County, California. Elevations ranged from approx. 800–>3,000 m. Primary vegetation types (Mayer and Laudenslayer 1988) were Sierran mixed conifer, ponderosa pine, red fir, montane hardwood, and various chaparral types. Stands with mean tree dbh >30 cm covered >56% of the study area and stands with mean tree dbh >61cm dbh covered >10% of the study area. Forest harvesting, where present, was most commonly individual tree selection. Weather consisted of hot, dry summers and cool moist winters with precipitation often falling as snow in the higher elevations.

Methods: Zielinski et al. (2004*b*) live captured 33 fishers (11M, 22F), radio-collared 23 fishers (8M, 15F), and used fixed wing, ground triangulation telemetry and walk-in techniques to locate them. Fisher home ranges (100% minimum convex polygon [MCP]) were calculated using CALHOME for 12 focal fishers (4M, 8F) which had ≥ 20 locations (minimum 10 rest site locations) and had been monitored continuously for ≥ 10 months. Because of the number of non-point source locations (fixed wing and triangulation), non-point locations were re-sampled with associated error measures and mean and error estimates for home ranges were calculated. Vegetation composition of home ranges was calculated using existing USDA Forest Service vegetation coverage for Sequoia National Forest (based on LANDSAT Thematic Mapper imagery, SPOT imagery and aerial photography) which resulted in 11 California Wildlife Habitat Relationships (CWHR) vegetation types (Mayer and Laudenslayer 1988), 5 CWHR size classes, and 4 CWHR canopy closure classes. Fisher rest sites were located using walk-in telemetry only (Zielinski et al. 2004*b*). Rest structures were categorized into 1 of 14 types. Metrics of the individual resting structure were recorded for all fisher rest sites. Topographic, vegetation cover type, tree abundance, tree size, ground cover, snow depth (winter), and canopy closure data were sampled at each rest site and at 20 randomly located "available" points within each fisher home range. Tree composition and densities were assessed using variable radius prism plots. Two 25-m perpendicular line intercept transects were used to evaluate ground cover attributes. Canopy closure was measured at plot center and the ends of each transect using a spherical densiometer. Logistic regression techniques were used to develop resource selection functions using data from focal fishers that described fisher selection of resting sites. Information theoretic approaches were used to select best models (Akaike weight >0.90). Top models were tested with data reserved from model development. Zielinski et al. (2006*b*) randomly selected 40 fisher rest sites from Zielinski et al.'s (2004*b*) study and 35 randomly selected fisher rest sites from another study (see Kings River key findings; Mazzoni 2002). They collected habitat data per US Forest Service FIA protocols and conducted univariate comparisons of characteristics of fisher rest sites to existing randomly selected FIA plots within these 2 study areas. They used logistic regression modelling and information theoretic approaches to develop and evaluate the effectiveness of using FIA data as a predictor of fisher resting habitat.

Truex et al. (1998) compared home range sizes between Tule River and 2 other study areas (Pilot Creek and Shasta-Trinity). They compared home ranges only for animals monitored at least 9 months and located a minimum of 10 times. At the site scale Truex et al. (1998) compared habitat characteristics at rest sites including measures of CWHR type and class, trees and coarse woody debris.

Publications and reports: 4 unpublished progress reports (Zielinski et al. 1994*a*; 1995*a, b*; 1997*a*), 1 unpublished report (Truex et al. 1998), and 3 peer-reviewed manuscripts (Zielinski et al. 2004*a, b*; 2006*b*).

Results:

Landscape Scale

At this time no information is available at this scale.

Home Range Scale

All information is from Truex et al. (1998) and Zielinski et al. (2004*b*).

Key Findings

- Truex et al. (1998) reported that female home ranges were significantly larger on the Shasta-Trinity (n = 5) than on the Pilot Creek (n = 5) and Tule River (n = 7) study areas. Male home ranges on the Shasta-Trinity (n = 6) were also considerably larger than on the Pilot Creek (n = 2) and Tule River (n = 4) study areas.
- Zielinski et al. (2004*b*) reported that male fisher home ranges were larger than those of female

fishers at both Pilot Creek and Tule River and home ranges of fishers at Pilot Creek were larger than those at Tule River (Table Tule River 1).

- Sierran mixed conifer, ponderosa pine and montane hardwood comprised most of female home ranges at Tule River (Table Tule River 2).
- Male fisher home ranges were comprised primarily of Sierran mixed conifer, ponderosa pine, red fir and montane hardwood.
- Stands with trees 29–61 cm dbh and stands with 60–100% canopy closure comprised most of the home ranges of both sexes of fishers (Table Tule River 2).
- More than 80% of fisher home ranges (both sexes) were in stands with >40% canopy closure.

Author(s) Interpretation

- Truex et al. (1998) suggested that larger home ranges at Shasta-Trinity compared to Pilot Creek and Tule River) implied relatively lower quality habitat at Shasta-Trinity. The authors also suggest the larger home range sizes may have been due to larger body masses of fishers in Klamath area.
- Zielinski et al. (2004*b*) further suggested that the differential in home range sizes between Pilot Creek and Tule River indicated a differential in habitat quality, with Tule River likely having better fisher habitat quality.
- Zielinski et al. (2004*b*) suggest that differences between sexes in the composition of red fir in home ranges reflected females' selection of lower elevation, higher quality habitats and males need to traverse higher elevation habitats in order to access multiple females.
- The prevalence of habitats containing black oak (a species commonly used by fishers as rest sites) at Tule River (19% of female fisher home ranges) compared to Pilot Creek (9% of female fisher home ranges) may be partly responsible for the observed differences in home range size and suggested differences in habitat quality between the 2 study areas.

Table Tule River 1. Fisher home ranges sizes (km^2) at Pilot Creek and Tule River study areas (modified from Zielinski et al. 2004*b*).

	Pilot Creek			Tule River		
Gender	*n*	$\bar{x}$	SE	*n*	$\bar{x}$	SE
Female	7	15.0	2.2	8	5.3	0.7
Male	2	58.1	29.6	4	30.0	7.8

Table Tule River 2. Average habitat type (CWHR), stand size, and canopy closure composition (%) of fisher home ranges in the Tule River study area (modified from Zielinski et al. 2004*b*).

Variable	Female	Male
Habitat type		
Sierran mixed conifer	38.5	44.0
Ponderosa pine	40.2	18.5
Montane hardwood	14.0	8.9
Red fir	0	21.9
Montane hardwood conifer	5.7	1.9
Montane chaparral	1.2	3.2
Barren	0.2	1.1
Lodgepole pine	0	0.6
Mixed chaparral	.2	0
Urban	0	0
Tree size class (cm dbh)		
Not determined	1.8	4.7
<2.5	0.3	0.2
2.6–15.2	1.6	1.7
15.3–28.9	22.2	21.2
29.0–61.0	61.2	59.6
>61.0	12.9	12.6
Canopy closure (%)		
Not determined	1.0	2.3
10–24	0.5	2.2
25–39	4.7	8.2
40–59	20.3	26.9
60–100	71.7	55.6

Stand Scale

At this time no information is available at this scale.

Site Scale

All information is from Truex et al. (1998), Zielinski et al. (2004*a*), and Zielinski et al. (2006*b*).

Key Findings

- Truex et al. (1998) found that characteristics of fisher rest sites were different among the 3 study areas (Table Tule River 3).
- Canopy was less dense at rest sites in the Shasta-Trinity study than at Pilot Creek or Tule River study areas, however tended to be dense in all study areas.
- Mean basal area was similar between Shasta-Trinity and Tule River and less than that at Pilot Creek.

Table Tule River 3. Habitat characteristics of fisher rest sites at 3 study areas in California (modified from Truex et al. 1998).

Variable	Shasta-Trinity $\bar{x}$ (SD)	Pilot Creek $\bar{x}$ (SD)	Tule River $\bar{x}$ (SD)
Basal area (m²/ha)	59.8 (30.9)	75.6 (27.6)	62.6 (26.1)
Tree dbh (cm)	46.2 (28.2)	118.3 (35.6)	89.6 (29.5)
Canopy closure (%)	88.2 (12.8)	93.9 (7.5)	92.5 (9.1)

- Mean dbh of the 4 largest trees at fisher rest sites was much smaller in the Shasta-Trinity than Pilot Creek and Tule River.
- Rest sites were primarily located within montane hardwood conifer (52.4%) and Douglas-fir (37.8%) habitat types at Shasta-Trinity compared to Douglas-fir and mixed conifer (76.2% total) in the Pilot Creek study and mixed conifer and montane hardwood (83.5% total) in the Tule River study.
- Zielinski et al. (2004*a*) reported fisher rest sites had larger maximum dbh, canopy and shrub canopy closure, more large snags, and were on steeper slope than random sites (Table Tule River 4).
- Rest site characteristics differed between study areas, however most rest sites had >60% canopy closure in both areas and trees were most frequently large (Pilot Creek >61 cm dbh) or moderately large (Tule River 28–61 cm dbh).
- Basal area and frequency of large snags were greater at rest sites of female fishers than male fishers.

Table Tule River 4. Average habitat characteristics of fisher rest sites and random sites at Pilot Creek and Tule River study areas (modified from Zielinski et al. 2004*a*).

Habitat variable	Pilot Creek Rest sites	Pilot Creek Random sites	Tule River Rest sites	Tule River Random sites
Basal area (m²/ha)	71.9	57.8	61.3	61.5
Conifer basal area (m²/ha)	55.5	42.1	48.0	48.2
Hardwood basal area (m²/ha)	16.0	15.2	13.3	13.2
Basal area small trees (m²/ha)	30.4	27.6	35.6	36.7
Basal area large trees (m²/ha	23.6	19.9	16.5	17.4
Basal area snags (m²/ha)	9.3	6.9	10.5	10.0
Average dbh (cm)	70.7	61.2	57.2	52.7
Maximum dbh (cm)	147.7	119.1[a]	118.8	104.9[a]
Average canopy closure (%)	95.0	86.7	92.1	90.3
Shrub canopy closure (%)				
Slope (%)	15.8	na	14.3	na
Presence of large (>102 cm dbh) conifer snags (% of sites)	47.2	22.8[a]	36.9	24.7[a]
Presence of water within 100 m (% of sites)	44.3	42.2	51.9	27.8[a]

[a] mean value of random sites significantly different than that of corresponding rest sites

- Twenty one fishers (6M, 15F) from both study areas were used for development of resource selection models for resting sites.
- A single model with 3 variables (canopy closure, maximum dbh and slope) accounted for >0.90 Akaike weight for fisher rest sites overall; this model suggested that fishers selected rest sites with denser canopies, larger maximum tree sizes and steeper slopes.
- A single model with 4 variables (canopy closure, maximum dbh, slope, and presence of large conifer snags) accounted for >0.90 Akaike weight for female fisher rest sites overall; this model suggested that female fishers selected rest sites with denser canopies, larger maximum tree sizes, steeper slopes, and presence of large conifer snags.
- Two averaged models accounted for >0.90 Akaike weight for the Tule River study area; the resulting model had 4 variables (maximum dbh, standard deviation dbh, slope and presence of water; this model suggested that fishers at the Tule River study area selected rest sites with larger trees, wider variation in tree size, steeper slopes and closer to water.
- Zielinski et al. (2006*b*) found that mean values of most variables examined were significantly different between fisher rest sites and FIA plots (findings include data from Tule River study area).
- Substantial differences were noted for total basal area, conifer basal area, small tree basal area, large tree basal area, black oak basal area, number of conifers, number of large snags, number of downed logs, maximum dbh, percentage of high shrubs and maximum tree age (Table Tule River 5).
- The best predictive model included maximum tree dbh, basal area of small trees, percentage of slope, mean canopy cover, largest conifer snag dbh, and hardwood dbh. The variables are listed in decreasing order of influence on decrease in deviance, however this model only explained 31.5% of deviance.

Table Tule River 5. Attributes of habitat variables ($\bar{x}$, SE) measured at fisher rest sites and FIA plots in Kings River and Tule River study area (modified from Zielinski et al. 2006*b*).

Parameter	Resting sites	FIA plots
Elevation (m)	1,621.9 (22.7)	1,767.0 (20.2)
Vegetation cover (%)		
Hardwood	14.1 (1.9)	17.6 (1.8)
Shrub	13.3 (1.4)	24.8 (1.6)
Low shrub	11.6 (1.7)	7.8 (0.8)
Basal area (m^2/ha)		
Total	58.7 (2.5)	40.1 (1.6)
Small tree (<51 cm dbh)	25.0 (1.4)	15.5 (0.7)
Large tree (>52 cm dbh)	11.6 (1.8)	7.0 (0.7)
Quercus kelloggii	5.6 (0.7)	3.1 (0.4)
Conifer	51.6 (2.6)	35.2 (1.7)
Hardwood	7.1 (0.8)	4.9 (0.5)
No. conifer stems	1120.6 (90.9)	531.4 (33.8)
Tree dbh (cm)		
Mean tree	19.4 (0.9)	23.7 (0.9)
Mean hardwood	20.3 (2.1)	14.2 (1.1)
Maximum tree	145.6 (7.3)	111.3 (3.2)
Tree age (yrs)		
Mean	118.4 (3.9)	113.9 (4.1)
Minimum	38.3 (1.9)	42.2 (2.3)
Maximum	317.4 (23.1)	230.8 (10.5)
Largest conifer snag (cm dbh)	110.6 (5.5)	79.8 (3.1)
No. large snags (>38.1 cm dbh)	15.4 (1.1)	10.7 (0.8)
Volume of logs (m^3/ha)	169.4 (33.4)	118.0 (9.7)
No. downed logs/ha	64.6 (4.1)	48.4 (2.5)

- Few FIA plots had habitat suitability values that classified them as fisher resting habitat, whereas >80% of fisher rest sites were correctly classified as fisher habitat by the model.

Author(s) Interpretation

- Zielinski et al. (2004*a*) state that both vegetative and topographic features are important in selection of rest sites by fishers.
- Fishers consistently select rest sites with dense canopy cover and presence of large structures although there may be considerable variability of size of structures on the site.

- The predictive power of rest site models were limited which suggested that other factors not evaluated play a role in rest site selection.
- Selection for sites closer to water in the Tule Creek study area may reflect differences in climate conditions between this area and Pilot Creek study area; the Tule Creek in the southern Sierra Nevada is hotter and drier.

Structure Scale

All information is from Truex et al. (1998) and Zielinski et al. (1995*b*, 1997*a*, 2004*a*).

Key Findings

- Zielinski et al. (1995*b*, 1997*a*) identified 8 reproductive dens, including 5 natal dens. All natal dens were in cavities of large (76–148 cm dbh) standing trees (2 snags, 2 live trees), including 2 black oaks.
- Truex et al. (1998) reported that fishers were found resting more frequently in platforms at Shasta-Trinity than the Pilot Creek and Tule River study areas.
- Considerably more small diameter trees were used at Shasta-Trinity compared to the Pilot Creek and Tule River study areas.
- Zielinski et al. (2004*a*) located resting fishers 397 time at 338 different resting structures in the Tule River study area (13.8% re-use).
- Live trees comprised 46.4% of all resting structures in the Pilot Creek and Tule River study areas.
- Hardwoods comprised 45% of all resting structures in both study areas (85% of these were black oak), however use of black oak was less prevalent in Pilot Creek (10.9% of rest structures) than at Tule River (37.5% of rest structures).
- The size of resting structures by type (hardwood, conifer-live, conifer-snag, platform, log) was similar among study areas and sexes, and rest structures were typically larger than trees in the vicinity of the structure and within home ranges.
- Logs ($\bar{x}$ = 123 cm maximum diameter), live conifers ($\bar{x}$ = 117.2 cm dbh) and snags ($\bar{x}$ = 119.8 cm dbh) were the largest structures used for resting, followed by platforms ($\bar{x}$ = 71 cm dbh) and hardwoods ($\bar{x}$ = 69 cm dbh).
- Males used platform rest structures more than females, females used snags more than males and there was more use of platforms in the Pilot Creek study area than the Tule River study area.

Author(s) Interpretation

- Truex et al. (1998) suggested that fishers appear to exist in poorer quality habitat at Shasta-Trinity than in the others studies compared. However, it was clear that Shasta-Trinity had been subjected to more timber harvest, and more by clear-cutting, than the Pilot Creek and Tule River study areas.
- The prevalent use of platforms in small diameter trees on the Shasta-Trinity study in conjunction with the relatively limited use of large diameter live trees and snags warranted further discussion. Extensive historic timber harvest within the Shasta-Trinity study area had likely resulted not only in the conversion of mature forests to early seral stages (through clear-cutting), but also in a decrease in the occurrence of large diameter living trees and, consequently, in the recruitment of large diameter snags and logs.
- Zielinski et al. (2004*a*) inferred that the prevalence of the use of large rest structures suggests that fishers prefer to rest in the largest trees or snags available.
- Structural characteristics of trees used for resting appeared to be much more important than tree species, in particular size, and internal decay–all characteristics of older trees.
- Re-use of rest structures was limited, suggesting that fishers require abundant rest structures within their home ranges.

- Female fishers' more prevalent use of cavities in standing trees suggest that security from predators and protection from weather extremes may be more constraining for them.
- Although live trees were the most common resting structure a substantive portion of rest structures were snags and logs suggesting that these structures are important resting habitat for fishers.

2.8.5. Sequoia National Forest Inventory, Study Area 26

Study Objectives: To gather information on the distribution of martens and fishers and relate that to habitat characteristics and human disturbance parameters in an area of proposed timber harvest.

Principal Investigator(s): S. A. Laymon, (Kern River Research Center)

Duration: 1991

Study Area: The study area was on the western slope of Greenhorn Mountains in Sequoia National Forest, Tulare County, CA. The study area was drained by Starvation, Tyler, Deer, and Capinero creeks and White River. Elevation ranged from 1,170–2,460 m. California Wildlife Habitat Relationships (CWHR) habitat types (Mayer and Laudenslayer 1988) within the study area included montane hardwood, montane hardwood-conifer, ponderosa pine, Sierran mixed conifer, white fir, red fir, and lodgepole pine.

Methods: Survey sites (n = 70) were established within 300 m of 1-km UTM grid intersections. Survey sites were preferably located within older dense forest and in riparian areas. If habitat was disturbed within the 300 m or the site was inaccessible within that radius then survey sites were located further away than 300 m. Remote cameras were established at all sites, track plates were located at all sites that were within 500 m of a road. Descriptive site data were recorded at each survey point including elevation, slope aspect, human activity, and land features (rock outcrops, openings, and streams). Dominant vegetation type, canopy closure, seral stage, and ground cover were recorded at each site per CWHR classification. Log, snag and live tree densities were recorded using point-quarter methods. Habitat parameters at detection and non-detection points were compared using univariate analyses.

Publications and reports: 1 unpublished report (Laymon et al. 1991).

Results:

Landscape Scale

All information is from Laymon et al. (1991).

Key Findings

- Fishers were detected at 8 survey stations (7 times with remote cameras and 4 times with track plates) ranging in elevation from 1,512–2,194 m.

Author(s) Interpretation

- No interpretation provided.

Home Range Scale

At this time no information is available at this scale.

Stand Scale

At this time no information is available at this scale.

Site Scale

All information is from Laymon et al. (1991).

Key Findings

- Fisher detections were at sites with significantly greater basal area (mean quadratic diameter).
- Eighty-six percent of sites with fisher detections were in seral stage 5 (old-growth) whereas only 24% of non-detection sites were seral stage 5.
- The authors report that fishers were detected at sites closer to streams, further from openings,

with larger trees, denser canopy and greater snag density, however these differences were not statistically significant.

Author(s) Interpretation

- Fishers were more likely to be detected in older forests.

Structure Scale

At this time no information is available at this scale.

2.8.6. Sierra Nevada Inventory and Monitoring, Study Area 27

Study Objectives: Objectives for studies conducted in this study area consistently involved collection of systematic survey data across large regional landscapes for fishers and other mesocarnivores and development of models of environmental conditions associated with fisher detections. Zielinski et al. (1997*b*, 2000, 2005) report data and analyses for this study area and the Northern California Inventory study area. Davis et al. (2007) analyzed these fisher detection data against a suite of mapped environmental (biotic and abiotic) variables to investigate potential reasons for the disjunct nature of fisher distribution in California. Spencer et al. (2008) modeled the effects of fires and fuels management on fishers in the southern Sierra Nevada. Multiple studies reported on detection data for fishers and other mesocarnivores, describe the geographic range of these species, and provide baseline data for monitoring changes in populations (Campbell 2004, Zielinski et al. 1997*b*, 2000, 2005). Campbell (2004) examined habitat associated with fisher and other mesocarnivore detections in the Sierra Nevada. Campbell et al. (2000) reviewed existing data to evaluate risk of various forest management alternatives to fishers and 3 other carnivores in the Sierra Nevada but present no original fisher habitat association data.

Principal Investigator(s): L. A. Campbell (U. C. Davis), F. W. Davis (U. C. Santa Barbara), W. D. Spencer (Conservation Biology Institute), and W. J. Zielinski (USDA Forest Service, Southwest Research Station)

Duration: 1996–1999; 1996–2002; 2001–2006

Study Area: The reports and publications pertinent to this study area cover a large geographic area. All publications and reports pertain to the Sierra Nevada; however some contain findings for the Northern California Inventory study area. Campbell (2004) investigated mesocarnivore distribution and habitat associations in the central and southern Sierra Nevada within an elevation range of 760–2,750 m. Zielinski et al. (2005) investigated historical and contemporary distributions of carnivores from the southern Cascades to the southern Sierra Nevada. Davis et al. (2007) used data from the Siskiyou Mountains of northern California through the southern Cascades down to the Piute Mountains of the southern Sierra Nevada. Zielinski et al. (1997*b*, *c*; 2000) reported progress on surveys conducted in the Klamath Mountains of northwestern California, the southern Cascades and the Sierra Nevada. Spencer et al. (2008) is relevant to fisher populations within the Sierra, Sequoia, and Stanislaus National Forests and Yosemite and Sequoia-Kings Canyon National Parks in the southern Sierra Nevada. Elevation within this study area ranged from 21–4,409 m. Data sets are not exclusive to individual publications and reports within this study area.

Methods: Campbell (2004) used mesocarnivore detection survey data collected using USDA Forest Service protocols (Zielinski and Kucera 1995) from 1996–1999. Campbell used transect and plotless methods to characterize habitat data collected at each survey location and derived map-based measures of precipitation, road density and habitat composition. Average values were used for continuous variables with multiple measures and analyses were conducted at 5 spatial scales. Campbell used bootstrapping techniques to develop predicted distributions of species detections by habitat type. Univariate tests of association (Wilcoxon *U*) were used to evaluate species detections relative to habitat variables. Campbell (2004) used classification trees to develop multivariate predictive models. Models were developed to compare habitats in areas where fishers do and do not occur. Zielinski et al. (2005) compared current fisher detection data to historic descriptions of fisher distribution and compared these to changes in measures of human density and forest cover. Human densities were evaluated using 1930 and 1990 census data. Vegetation data were derived from historic vegetation type map surveys (conducted 1929–1934) and 1996 vegetation maps derived for the Sierra Nevada Ecosystem Project. Davis et al. (2007) used fisher detection survey data collected from 1996–2002 by USDA Forest Service (Zielinski et al. 2005) and evaluated the predictive power of a suite of environmental variables using a resource selection function approach with step-wise general additive models. They first used univariate tests to examine differences between predictor variables at detection and non-detection sites. They evaluated fisher habitat predictors for the state wide data set and evaluated separate regional predictive models for 3 distinct data sets: Klamath/Shasta Trinity; the unoccupied portion of the northern and central Sierra Nevada; and the southern Sierra Nevada. They considered 5 categories of landscape-scale habitat variables: topography; precipitation; field observations of forest structure and composition; vegetation structure and composition derived from Landsat Thematic Mapper imagery and digital elevation data; and road influence. Model robustness was evaluated using 5-fold cross-wise evaluation. Davis et al. (2007) also used an alternate modelling approach (maximum entropy) to search for corroboration of their initial modelling analyses. Spencer et al. (2008) evaluated fisher habitat associations using resource selection function analyses based on general additive models with a 5-km^2 moving window analysis. They evaluated fisher detection/non-detection data collected by the USDA Forest Service from 2000–2005 against a suite of >250 potential models (previously published and ones based on expert hypotheses) at a fisher home range scale. They used an existing rest site model (Zielinski et al. 2006*b*) to evaluate the abundance and distribution of rest site microhabitat within their study area and relative to predicted fisher habitat at the larger scale. They tested their models against reserved data from surveys previous to those used for model development. Spencer et al. (2008) used top performing models as a basis for evaluating effects of fuels treatment on potential fisher population distribution.

Publications and reports: 3 unpublished reports (Campbell et al. 2000, Zielinski et al. 1997*b*, 2000), 1 peer reviewed report (Spencer et al. 2008), 1 dissertation (Campbell 2004), and 3 peer-reviewed manuscripts (Davis et al. 2007, Zielinski et al.1997*c*, 2005).

Results:

Landscape Scale

All information is from Campbell (2004), Zielinski et al. (2005), Davis et al. (2007), and Spencer et al. (2008).

Key Findings

- Campbell (2004) found that fishers were most commonly detected in Sierran mixed-conifer, montane hardwood-conifer and montane hardwood types. Detections were positively associated with drier areas, hardwoods, dense stands of medium-sized trees, shrub cover and steep slopes.

- Campbell (2004) reported that only 3 models significantly correctly classified fisher detections and the best model was at the plot scale and was comprised of a single variable (slope).
- Habitats within fisher distribution were best delineated from those outside of fisher distribution by more and larger trees, both conifers and hardwoods, steeper slopes, more shrub cover, fewer roads, lower precipitation, lower road density, and less habitat variability.
- Zielinski et al. (2005) reported that current fisher distribution was markedly decreased from historic distribution. The north/south gap in fisher distribution aligned well with increased levels of anthropogenic environmental change.
- Davis et al. (2007) reported that based on univariate comparisons fisher detections were significantly associated with latitude-adjusted elevation, relief, paved roads and all vegetation and structure variables although these results were very different for the southern Sierra Nevada dataset (Table Sierra Inventory 1).
- Geographic information system (GIS) derived measures of habitat performed as well as or better than field derived values.
- Fisher detections were closely associated with late seral habitats, late seral hardwood forests, and areas with high tree cover and larger trees.
- The best state wide model predicting fisher detections included annual precipitation, relief and dense forest. When Davis et al. (2007) accounted for spatial autocorrelation, their model accounted for 81–90% of fisher detections.
- The state wide model performed well in the Klamath/Shasta and northern Sierra Nevada but not in the southern Sierra Nevada. Annual precipitation was a consistent variable in all models; relief was a consistent variable within all models but the southern Sierra Nevada (Table Sierra Inventory 2). Davis et al. (2007) noted that no models performed well for the southern Sierra Nevada study area.
- Davis et al. (2007) reported that fisher detections were positively associated with late seral stages of mid-montane forest types, late seral hardwood forest, and the fraction of the landscape occupied by dense mid-montane forest.

Table Sierra Inventory 1. Results of univariate tests of association between environmental variables and fisher detections (modified from Davis et al. 2007). Significant relationships (Wilcoxon U test) are indicated by symbols (+ positively associated with fisher detections; – negatively associated with fisher detections).

Variable	State wide	Klamath-Shasta and Southern Sierra Nevada	Klamath-Shasta	Southern Sierra Nevada
Adjusted elevation	–			
Relief	+	+	+	
Annual precipitation				
Paved roads	+	+	+	
Improved roads				
Field CWHR[a]	+	+	+	
Field CWHR2	+	+	+	
Field hardwood	+	+	+	
Field structure	+	+	+	
GIS CWHR	+	+	+	
GIS CWHR2	+	+	+	
GIS structure	+	+	+	
GIS dense hardwood	+	+	+	
GIS dense forest	+	+	+	+

[a] CWHR = California Wildlife Habitat Relationships system – (Mayer and Laudenslayer 1988).

Tables Sierra Inventory 2. Variables (GIS-derived) associated with non-spatial general additive models for predicting fisher detections (modified from Davis et al. 2007).

Model	Variables
State wide	annual precipitation, dense forest, relief
Klamath-Shasta and Southern Sierra Nevada	annual precipitation, CWHR2, relief
Klamath-Shasta	relief, structure, annual precipitation
Southern Sierra Nevada	annual precipitation, dense forest, adjusted elevation

- Alternate modelling techniques provided predictive model results which were highly correlated with those produced by general additive models.

- Spencer et al. (2008) found that fisher distribution was best predicted by a single model comprised of 3 variables: latitude-adjusted elevation, mean annual precipitation, and total above ground biomass of trees. This model accounted for 83–91% fit to fisher detections/non-detections depending on the model of fisher presence evaluated and was far superior to the next best models.

- All top models contained 2 abiotic variables (elevation and isolation index or precipitation) and 1 biotic variable (a vegetation characteristic).

- Spencer et al. (2008) state that their results confirm that fishers in the southern Sierra Nevada are associated with dense, old, large forests in mid-elevation zones (1,300–2,400 m).

- Spencer et al. (2008) noted that predicted fisher habitat in this region is restricted to a mid-elevation band and is somewhat fragmented due to its association with major river canyons.

Author(s) Interpretation

- Campbell (2004) suggested that slope might account for a variety of other correlated habitat variables to which fishers were responding.

- Davis et al. (2007) suggested that fisher association (at a univariate level) with paved roads may have been an artefact of correlation between these and vegetation associated with waterways where roads are most commonly located.

- Davis et al. (2007) suggested that fisher habitat in the southern Sierra Nevada may be more fine-grained and heterogeneous than other study areas and that this may be responsible for poor performance of predictive models here.

- Davis et al. (2007) suggested that habitat in concert with other factors (dispersal and demography) may be responsible for the lack of fisher detections in the northern Sierra Nevada.

- Spencer et al. (2008) concluded that fishers in the southern Sierra Nevada appear to be associated with mid-slope habitats with low solar exposure, low annual precipitation and their habitat is concentrated in and near older stands of large mixed conifers and areas with black oaks (which provide resting structures and support prey.

Home Range Scale

At this time no information is available at this scale.

Stand Scale

At this time no information is available at this scale.

Site Scale

All information is from Spencer et al. (2008).

Key Findings

- Spencer et al. (2008) found that rest sites with high predicted value were relatively rare in the southern Sierra Nevada and correlation between predicted fisher rest site microhabitat and landscape scale habitat quality was low (0.29).

- Predicted fisher rest site microhabitat value was only considered suitable (habitat rating >0.5) at 5% of evaluated FIA plots.

Author(s) Interpretation

- Fisher rest site microhabitats appear to be limiting and as such should be the focus of management attention.

Structure Scale

At this time no information is available at this scale.

USDA Forest Service Pacific Northwest Research Station

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APPENDICES

Appendix 1.1. Scientific and common names used in Volume II

Plants

Grand fir	*Abies grandis*
Subalpine fir	*Abies lasiocarpa*
Red fir	*Abies magnifica*
Shasta red fir	*Abies magnifica v. shastensis*
Alder	*Alnus* spp.
Madrone	*Arbutus menziesii*
Whiteleaf manzanita	*Arctostaphylos manzanita*
Incense cedar	*Calocedrus decurrens*
Golden chinquapin	*Castanopsis chrysophylla*
Buck brush	*Ceanothus* spp.
Port-Orford cedar	*Chamaecyparis lawsoniana*
Pacific dogwood	*Cornus nuttallii*
Common juniper	*Juniperus communis*
Western larch	*Larix occidentalis*
Tanoak	*Lithocarpus densiflorus*
Engelmann spruce	*Picea engelmanii*
White spruce	*Picea glauca*
Hybrid spruce	*Picea glauca* x *engelmannii*
Sitka spruce	*Picea sitchensis*
Whitebark pine	*Pinus albicaulus*
Lodgepole pine	*Pinus contorta*
Sugar pine	*Pinus lambertiana*
Ponderosa pine	*Pinus ponderosa*
Gray or foothill pine	*Pinus sabiniana*
Poplar, Cottonwood, or aspen	*Populus* spp.
Trembling aspen	*Populus tremuloides*
Black cottonwood	*Populus trichocarpa trichocarpa*
Douglas-fir	*Pseudotsuga menziesii*
Oak	*Quercus* spp.
White oak	*Quercus alba*
Live oak	*Quercus chrysolepsis*
Blue Oak	*Quercus douglasii*
Oregon white oak	*Quercus garryana*
Brewer oak	*Quercus garryana* var. *breweri*
Black oak	*Quercus kelloggi*
Interior Live Oak	*Quercus wislizeni*
Willow	*Salix* spp.
Redwood	*Sequoia sempervirens*
Giant sequoia	*Sequoiadendron giganteum*
Soopolallie	*Shepherdia canadensis*
Pacific yew	*Taxus brevifolia*
Western redcedar	*Thuja plicata*
Western hemlock	*Tsuga heterophylla*
Mountain hemlock	*Tsuga mertensiana*

Animals

Grouse	*Bonasa* spp.
Pileated woodpecker	*Drycopus pileatus*
Snowshoe hare	*Lepus americanus*
American marten	*Martes americana*
Fisher	*Martes pennanti*
Woodrat	*Neotoma* spp.
Spotted owl	*Strix occidentalis*
Chipmunk	*Tamias* spp.
Red squirrels	*Tamiasciurus hudsonicus*

Fungi

Spruce broom rust	*Chrysomyxa arctostaphyli*
Fir broom rust	*Melampsorella caryophyllacearum*