



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

2010

VOLUME I: Conservation Assessment

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PREFACE

This interagency conservation effort began in late 2005 in response to a 12-month status review and subsequent finding by the USDI Fish and Wildlife Service (2004) for the West Coast (Washington, Oregon, and California) Distinct Population Segment (DPS) of the fisher (*Martes pennanti*) stating that a listing was “...warranted but precluded by higher priority actions to amend the Lists of Endangered and Threatened Wildlife and Plants.” Following this finding, federal and state agency leadership recognized the need for and potential benefits of developing a conservation assessment and strategy for the West Coast DPS. Agency leaders subsequently formed a steering committee to oversee the development of a Conservation Assessment (Assessment) and Conservation Strategy (Strategy) by the Interagency Fisher Biology Team. Because the range of the West Coast DPS is contiguous with historical range in British Columbia, fishers will benefit from a coordinated conservation approach that includes both countries. The geographic scope of this conservation effort thus includes south-central British Columbia. The vision for the Assessment and Strategy is to provide an effective, integrated regional approach to achieve self-sustaining, interacting populations of fishers within their historical west coast range.

The steering committee was chaired by the Natural Resources Director of the USDA Forest Service (Dave Gibbons, Pacific Southwest Region [2005]; Cal Joyner, Pacific Northwest Region [2006–2007]; Jose Linares, Pacific Northwest Region [2008–present]). The steering committee included representatives from USDA Forest Service, Northern (Cindy Swanson) and Pacific Southwest (Art Gaffery, Chris Knopp, and Deborah Whitman) Regions; USDI Fish and Wildlife Service, Pacific (Theresa Rabot) and Pacific Southwest (Darrin Thome) Regions; USDI National Park Service, Pacific West Region (Kathy Jope and Steve Gibbons); USDI Bureau of Indian Affairs, Pacific Region (David Wooten); USDI Bureau of Land Management in Oregon (Mike Haske and Lee Folliard) and California (Paul Roush, Tom Pogacnik, and Amy Fesnock); Washington Department of Fish and Wildlife (Dave Brittell); Oregon Department of Fish and Wildlife (Don Whittaker); California Department of Fish and Game (Dale Steele); and British Columbia Ministry of Environment (John Metcalfe).

A Fisher Science Team was also formed: Keith Aubry (Lead, USDA Forest Service, Pacific Northwest Research Station), Steve Buskirk (University of Wyoming), Michael Schwartz (USDA Forest Service, Rocky Mountain Research Station), and Bill Zielinski (USDA Forest Service, Pacific Southwest Research Station). The Fisher Science Team was available for scientific consultation and orchestrated an independent peer-review of the Assessment.



The Interagency Fisher Biology Team (members identified here in front matter) produced 4 documents (Volumes I through IV) during this process. Volume I is a comprehensive review of best available information on fisher biology and habitat ecology based primarily on research conducted in south-central British Columbia, western Washington, western Oregon, and California (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. It references source material produced and available prior to 1 July 2008. Volume II (Key Findings from Fisher Habitat Studies in British Columbia, Montana, Idaho, Oregon, and California) provides a detailed summary of results from 27 study areas west of the Rocky Mountains 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, 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 area rather than rely exclusively on Volume II. Volume III (Threats Assessment) is an assessment of threats pertinent to fishers and fisher habitat within the Assessment Area. 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.”



ACKNOWLEDGEMENTS

We thank the many agencies and individuals that supported this multiyear effort to develop a fisher conservation assessment for south-central British Columbia, western Washington, western Oregon, and California. We thank the Fisher Science Team for insightful discussions on fisher ecology and population genetics. We are grateful to Tom DeMeo, Louisa Evers, and Bruce Hostetler for their respective insights and discussions on forest ecology, fire ecology, and forest insect and disease agents. Jo Ellen Richards documented discussions and Cindy Donegan facilitated many Fisher Biology Team meetings. Naomi Nichol edited an earlier version of this document. This Assessment 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 on the draft assessment from more than 20 biologists and resource managers associated with various federal, state, and provincial agencies, private industry, nongovernment organizations, and independent consultants. We are grateful to the many fisher researchers and other scientists who generously provided their photographs for use 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 these costs. The map-based figures were capably produced by Dave LaPlante (Natural Resources Geospatial). Lynn Sullivan (USDA Forest Service, Pacific Northwest Research Station) copy-edited this volume. Janine Koselak (USDI Bureau of Land Management, National Operations Center) capably managed the layout and publication process.





CHAPTER 1. INTRODUCTION

1.1. Background

Fishers (*Martes pennanti*) were once widely distributed in montane forests of western North America (Hagmeier 1956, Gibilisco 1994; see Chapter 5). Following European settlement, fisher distribution and abundance declined primarily owing to anthropogenic stressors including direct and indirect mortality and habitat loss (USDI Fish and Wildlife Service 2004; see Chapters 4 and 5). Concern regarding population declines eventually resulted in restrictions or closures of fisher harvest seasons in portions of British Columbia (1982, 2003), Washington (1934), Oregon (1937), California (1946), Idaho (unknown date), and Montana (1930; see Chapter 5). Subsequently, continued concern regarding the status of the fisher in the Pacific states (Washington, Oregon, and California) led to petitions to list this species under

the U.S. Endangered Species Act. The most recent petition (Center for Biological Diversity 2000), delivered to the USDI Fish and Wildlife Service in November 2000, was to list the West Coast Distinct Population Segment (DPS) of the fisher. In 2004, the USDI Fish and Wildlife Service released their 12-month finding that listing of the West Coast DPS of the fisher was "...warranted but precluded by higher priority actions to amend the Lists of Endangered and Threatened Wildlife and Plants" (USDI Fish and Wildlife Service 2004).

Currently in western North America, there are extant fisher populations in British Columbia, Oregon, California, Idaho, and Montana, and their status, determined by various provincial and state governments, ranges from special concern to endangered (Table 1.1; see also Chapter 5). Fishers

Table 1.1. Conservation and management status of fisher populations in British Columbia, Montana, Idaho, Washington, Oregon, and California. Subnational (state or provincial level) conservation status ranks^a are: SH = possibly extirpated, S1 = critically imperiled, S2 = imperiled, S3 = vulnerable, and S2S3 = status ranges from imperiled to vulnerable.

Jurisdiction	Status ^a	Designation	Management
Central and northern British Columbia	S2S3	Furbearer ^b Special concern ^c	Legal harvest
Southern British Columbia	S2S3	Furbearer ^b Special concern ^c	No legal harvest
Montana	S3	Furbearer	Legal harvest ^d
Idaho	S1	Furbearer ^e Critically imperilled ^f	No legal harvest
Washington	SH	Endangered ^g	No legal harvest
Oregon	S2	Furbearer Sensitive critical	No legal harvest
California	S2S3	Furbearer Special concern	No legal harvest

^a NatureServe Conservation Status Ranks <http://www.natureserve.org/explorer/ranking.htm>.

^b British Columbia Wildlife Act designation.

^c British Columbia Conservation Data Center designation.

^d Annual limit of 7 fishers.

^e Idaho Fish and Game designation.

^f Idaho Conservation Data Center designation.

^g It is thought that fishers in Washington have been extirpated (Hayes and Lewis 2006).



occur throughout central, north-central, and northeastern British Columbia. Breeding populations of fishers are currently believed to be absent in the Cascade, Hozomeen, and Okanagan Ranges, and the Thompson Plateau of south-central British Columbia (Lofroth 2004), but this has not been verified with detailed inventory. Fishers are thought to be extirpated in Washington and northern Oregon and are currently the subject of a reintroduction program in Olympic National Park, Washington (Hayes and Lewis 2006, USDI National Park Service 2007). Fisher distribution has been greatly reduced to 3 isolated populations elsewhere in Oregon and California (Chapter 5): 1) the Cascade Range in southern Oregon (Aubry and Lewis 2003, Aubry and Raley 2006); 2) the Klamath-Siskiyou Mountains of southwestern Oregon and northern California and the North Coast Ranges of California (Zielinski et al.

1995c, Aubry and Lewis 2003); and 3) the southern Sierra Nevada in California (Zielinski et al. 1995c). California Department of Fish and Game was petitioned to list Pacific fisher under the California Endangered Species Act in 2008 (California Fish and Game Commission 2009a). The outcome of the 90-day finding was to complete a 12-month status review making fishers a candidate species for listing in California (California Fish and Game Commission 2009b). In the Rocky Mountains, fishers currently are known to occur in north-central Idaho (Jones 1991, Cushman et al. 2008), west-central Montana (Vinkey et al. 2006), and northwestern Montana (Vinkey et al. 2006).

Although numerous other conservation assessments exist for fishers in various regions of western North America (Table 1.2), considerable research

Table 1.2. Conservation assessments and strategies for fisher populations in western North America.

Region	Title	Source
British Columbia	A Fisher Management Strategy for British Columbia	Banci 1989
	Status of the Fisher in British Columbia	Weir 2003
	Fisher (<i>Martes pennanti</i>) British Columbia: Population Science Assessment Review	Lofroth 2004
Southeast British Columbia	East Kootenay Fisher Assessment	Weir et al. 2003
Western United States	Fisher in The Scientific Basis for Conserving Forest Carnivores—American Marten, Fisher, Lynx and Wolverine	Powell and Zielinski 1994
	Fisher Biology and Management in the Western United States: A Literature Review and Adaptive Management Strategy	Heinemeyer and Jones 1994
Idaho	Habitat Conservation Assessments and Strategies for Forest Carnivores in Idaho	Idaho Department of Fish and Game, Nez Perce Tribe, and Sawtooth National Forest 1995
Washington	Washington State Status Report for the Fisher	Lewis and Stinson 1998
	Feasibility Assessment for Reintroducing Fishers (<i>Martes pennanti</i>) to Washington	Lewis and Hayes 2004
	Washington State Recovery Plan for the Fisher	Hayes and Lewis 2006
California	Status Assessment of the Pacific Fisher (<i>Martes pennanti</i>) in California—DRAFT	Nichol 2006
Sierra Nevada, California	A Conservation Assessment for Fishers (<i>Martes pennanti</i>) in the Sierra Nevada of California	Green et al. 2008

(producing many reports and publications) has been conducted on fishers in British Columbia, Oregon, California, Idaho, and Montana since these documents were written. In this conservation assessment (henceforth Assessment), we build upon previous reviews and relevant literature to provide a current synthesis and evaluation of fisher science. This Assessment will provide biologists and resource managers with updated information on fisher ecology, and will help inform an assessment of potential threats (Volume III) and development of a conservation strategy (Volume IV) to maintain and expand fisher populations in British Columbia, Washington, Oregon, and California.

1.2. Scope

The geographic scope of this Assessment (henceforth the Assessment Area; Fig. 1.1) includes the current

known and historical range of fishers in south-central British Columbia (Thompson Plateau, Western Okanagan Upland, Hozameen and Okanagan Ranges, and Cascade Range), western Washington (Cascade Range, Olympic Mountains, and Coast Range), western Oregon (Cascade Range, Coast Range, and Klamath-Siskiyou Mountains), and California (Klamath-Siskiyou Mountains, North Coast Ranges, and Sierra Nevada). We have synthesized information on fisher ecology from studies conducted within the Assessment Area as well as from studies conducted in adjacent regions (north-central and southeastern British Columbia, Idaho, and Montana; Fig. 1.2). Although the distance from study areas in adjacent regions to the boundary of the Assessment Area ranges from 200 km to 500 km, these study areas occur in regions with ecological conditions similar to portions of the Assessment Area,



Figure 1.1. Geographic extent of the Assessment Area in south-central British Columbia, western Washington, western Oregon, and California.



Figure 1.2. General location and number of fisher study areas within the Assessment Area and adjacent regions in western North America.

and, historically, there was likely some connectivity and genetic linkages to fisher populations in portions of the Assessment Area. We also draw upon results from studies conducted elsewhere in North America to demonstrate relevant similarities or differences in fisher biology and ecology, or when no information on a particular topic was available for the Assessment Area. The one exception is fisher habitat associations. Because of major differences in ecosystems (including climate, plant communities, natural disturbance regimes, and human land use patterns and management) between western coniferous forests and forests elsewhere in North America, and how these differences may influence fisher habitat relations, we only synthesized information from studies conducted in the Assessment Area and adjacent regions. We have tried to identify all information on fisher ecology and biology from studies conducted in the Assessment Area and adjacent regions that was available in the scientific literature or other documents (i.e., progress or final report, thesis, dissertation, peer-reviewed paper, etc.) prior to 1 July 2008. Information that became available after 1 July 2008, unpublished data (i.e., not available in the scientific literature or other documents), or anecdotal observations were not included in this Assessment. There were 3 exceptions to this: 1) Table 5.1 which is a modification of a table from Lewis (2006) that included personal communications regarding fisher translocations—information that was not available from any other source; 2) fisher harvest records in British Columbia were obtained from an unpublished database maintained by the British Columbia Ministry of Environment; and 3) in Figure 2.1, we included some unpublished data from British Columbia on the size of fishers in that region.

In this Assessment, we define a population (based on McCullough's [1996] definition) 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. We use the term "fisher habitat" to indicate the entire suite of environmental conditions that meet fisher life requisites including but not limited to mating opportunities, reproduction, protection from potential predators and extreme weather, and foraging. Fishers may find these conditions in a variety of forest plant communities and physical settings.

1.3. Objectives

The objectives of this Assessment are to:

1. Provide a comprehensive reference document for biologists and resource managers by summarizing the current scientific information regarding fisher classification and taxonomy (Chapter 2), historical range and current distribution and abundance in the Assessment Area (Chapter 5), biology and ecology (Chapter 6), and contemporary habitat associations in the Assessment Area and adjacent regions (Chapter 7).
2. Provide a general summary of the biophysical environment within the Assessment Area (Chapter 3), historical and current anthropogenic influences to that environment (Chapter 4), and important ecological processes that have a disproportionate influence on fisher habitat (Chapter 8).
3. Identify important implications for the conservation of fisher populations in the Assessment Area.
4. Provide a foundation of information that can be used subsequently to help identify potential threats to fishers and fisher habitat, and to inform development of conservation measures for maintaining and expanding fisher populations in the Assessment Area.



CHAPTER 2. CLASSIFICATION AND DESCRIPTION

2.1. Classification

The fisher is a member of the order Carnivora, family Mustelidae (weasels), genus *Martes* (martens, fishers, and sables; Buskirk 1994). It is the largest member of the genus *Martes*, and its geographic range overlaps extensively that of American marten (*Martes americana*), the only other *Martes* species in North America (Anderson 1994). Erxleben first described the fisher in 1777 based on accounts by Pennant in 1771 and Buffon in 1765 (Powell 1981, Douglas and Strickland 1987, Powell 1993). Erxleben (1777, as cited in Powell 1981 and 1993) referred to the species as *Mustela pennanti*. Subsequently, taxonomists Allen, Baird, Coues, Rhoads, and Smith independently agreed on *Martes pennanti* (Hagmeier 1959, Powell 1981). Stone and Cook (2002) suggested *Martes* and *Gulo* may be paraphyletic. Consistent with this, Koepfli et al. (2008) suggested that fishers may be ancestral to wolverines (*Gulo gulo*) and other *Martes* species.

Three subspecies of fisher have been recognized: 1) *M. p. pennanti* (Erxleben 1777) of northeastern and north-central North America; 2) *M. p. columbiana* (Goldman 1935) of central and western Canada and the northern Rocky Mountains of the United States; and 3) *M. p. pacifica* (Rhoads 1898) of southwestern British Columbia, Washington, Oregon, and California (Goldman 1935, Hall 1981). Grinnell et al. (1937) suggested the validity of subspecies *pacifica* was dubious based on physical characteristics and Hagmeier (1959) later suggested the three subspecies were difficult to distinguish based on skull characteristics. Drew et al. (2003) and Vinkey et al. (2006), however, documented substantive differences in haplotype frequencies between subspecies and regional populations. Several investigators have demonstrated that the genetic composition and structure of some fisher populations have been substantially altered by reintroduction

or augmentation programs (Kyle et al. 2001, Drew et al. 2003, Wisely et al. 2004, Vinkey et al. 2006, Schwartz 2007). Owing to translocations that have occurred since the 1950s, some fisher populations within the Assessment Area and adjacent regions include 2 or all 3 subspecies (Chapter 5). This may influence the ecology and biology of these populations if some subspecies are better adapted or have greater affinities to particular environmental conditions.

2.2. Description

The fisher is a large, stocky member of the weasel family similar in size to a large house cat. It has a pointed face, rounded ears, long slender body, and short legs (Plate 2.1). Its tail is about one-third its total length. This build gives it a long, low-to-the-ground appearance. Fisher pelage is generally dark brown, but the rump, tail, and legs are darker brown and the head and shoulders are often grizzled with gold or silver (Douglas and Strickland 1987). Fishers have light markings on their chest and abdomen (Plate 2.2). Females have finer, silkier fur than males, making female pelts more valuable (Douglas and Strickland 1987). Fishers molt annually in late summer and early fall, although shedding may start in late spring (Powell 1993).

Fishers have partially retractable claws that allow them to climb and maneuver in trees, and descend in a head-first position (Grinnell et al. 1937; Powell 1980, 1993) (Plate 2.2). They have large feet with 5 toes and walk using either their whole foot (plantigrade; Powell 1993) or just their toes (digitigrade; Strickland et al. 1982). Fishers run with an undulating gait typical of weasels. Fishers have plantar glands that may be used for scent marking (Powell 1993; Plate 2.2). Male fishers are approximately 1.5–2.0 times heavier than females





Plate 2.1. Fishers have a pointed face with rounded ears (A), a long slender body, and their tail is about one-third of their total body length (B–D). Their pelage is dark brown (darker on rump, tail, and legs), and frequently grizzled on the head and shoulders.



Plate 2.2. Fishers have light-colored ventral markings that vary in shape, number, and color among individuals (A–C). Fishers have plantar glands on their central pads that may be used for scent marking (D), and they have partially retractable claws that make them excellent tree-climbers (E).

(Fig. 2.1) and approximately 20% longer (Douglas and Strickland 1987, Truex et al. 1998). Fishers in northern parts of their range in western North America are heavier than those at the southern extent of their range (Fig. 2.1).

The fisher is commonly confused with the American marten, which is smaller, has more-pointed ears, is typically lighter brown (cinnamon) in color, and has a shorter tail (Plate 2.3). Fishers may also be confused with American mink (*Mustela vison*), northern river otter (*Lontra canadensis*), wolverine, foxes (*Vulpes* spp.), skunks (*Mephitis* spp.), and marmots (*Marmota* spp.).

2.3. Implications for Conservation

1. Sexual dimorphism in fishers is the basis for differences in a number of fundamental aspects of fisher biology. These include ecological parameters that may influence sex-specific energetics, prey availability, susceptibility to predation, daily movement, dispersal, and habitat use (Powell and Leonard 1983). An effective conservation strategy must consider and, where appropriate, tailor conservation recommendations that accommodate these differences.

2. Fisher body-size varies on a north to south gradient. These and other factors likely influence relative susceptibility to predation, competition for prey with other carnivores, movements including dispersal, habitat requirements, and home range size. As such, conservation recommendations may need to differ by latitude.
3. Physical similarities between fishers and other related species necessitate rigorous identification standards in survey and monitoring programs.
4. The relationships between fishers and sympatric species are not well understood. In particular the relative sizes of martens and fishers suggest potential for competition for resources, particularly prey. Consequently, evaluating how marten abundance, distribution, or behavior may be affected in areas where fishers recover, and whether marten presence may hinder fisher recovery (particularly if abundance of prey is limited), are key information needs.

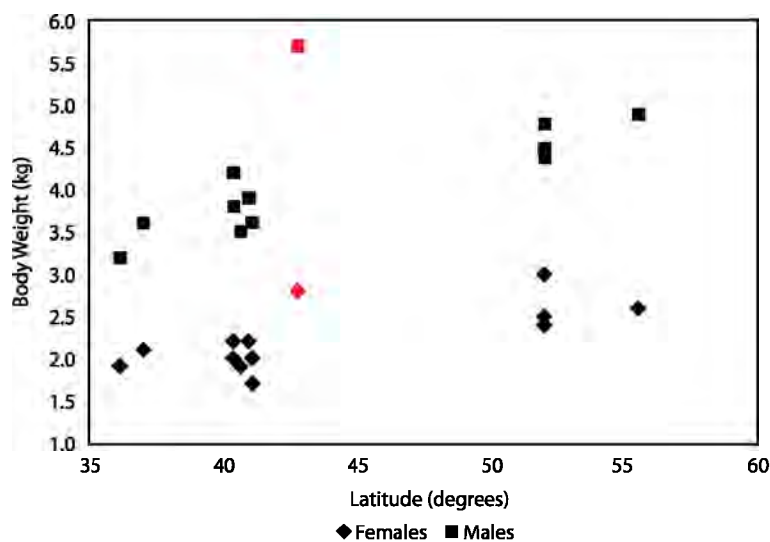


Figure 2.1. Mean body weights of fishers by latitude from studies in the Assessment Area and adjacent regions in western North America. Mean weights include data for juvenile and adult fishers from British Columbia (Fontana et al. 1999, Lewis and Happe 2008, Weir and Corbould 2008; L. Davis, Davis Environmental Ltd., unpublished data), Oregon (Aubry and Raley 2006, Aubry et al. 2004), and California (Buck et al. 1979, 1983; Buck 1982; Mullis 1985; Seglund 1995; Dark 1997; Truex et al. 1998; Self and Kerns 2001; Zielinski et al. 2004b; Reno et al. 2008; Boroski et al. 2002). Fishers in the Oregon study (red symbols) are the result of historical translocations from British Columbia (source locations 52–55° latitude) and Minnesota (source locations 47–48° latitude).



Plate 2.3. Fishers are most often confused with American martens (A–B) which are smaller, have more-pointed ears, are a lighter brown (cinnamon) color, and have an amber or cream-colored throat patch. Fishers may also be confused with northern river otter (C) and American mink (D).



CHAPTER 3. THE BIOPHYSICAL ENVIRONMENT

3.1. Geographic Extent

We used the generalized historical extent of fisher occurrence (Chapter 5), broad-scale ecological criteria (McNab and Avers 1994; Demarchi 1996, 2007*a, b, c*), and natural biophysical features to delineate the fisher conservation Assessment Area. The Assessment Area includes portions of British Columbia, Washington, Oregon, and California, extending from latitude 50° 46' in the north to 35° 01' in the south, and encompasses 359,152 km² (Fig. 1.1). In British Columbia, the Assessment Area includes mountain and plateau regions east of the Fraser River, south of the Thompson River, and west of the Okanagan Valley. In Washington and Oregon, the Assessment Area includes the Cascade Range and all lands west of that to the Pacific Ocean. In California, the Assessment Area includes the northern and north coastal California mountain regions and the Sierra Nevada. Elevation ranges from sea level to approximately 4,300 m. Elevation ranges are greatest in the Cascade Range and lowest in coastal regions of British Columbia, Washington, and Oregon.

3.2. The Physical Environment

The Assessment Area is predominantly mountainous, with most mountain ranges oriented north to south (Figs. 3.1, 3.2). Plateaus and lowlands of gentler terrain occur from the Willamette Valley in coastal Oregon north to the Fraser Valley in British Columbia, and in the Thompson Plateau and Guichon Upland of British Columbia (McNab and Avers 1994; Demarchi 1996, 2007*c*). Plateau and lowland landforms originated from combinations of volcanic, glacial, and flood events. The Cascade Range and Sierra Nevada are primarily volcanic in origin. Many volcanic peaks are still active with eruptions occurring about every 25 years (McNab and Avers 1994). The Klamath Ranges and coastal mountains of northern California, Oregon, and Washington are derived from various combinations of

volcanic, tectonic, and metamorphic events (McNab and Avers 1994). Effects of glaciations are strongest in the northern plateaus, northern Cascade Range, the Olympic Mountains, and the Sierra Nevada. This has resulted in U-shaped valleys, cirques, and highly dissected and eroded landscapes in the mountains and numerous lakes in plateau landscapes. Seismic activity has influenced landforms in the Northern California Mountains (McNab and Avers 1994).

The Assessment Area encompasses portions of many major watersheds including the Fraser River (British Columbia), Puget Sound (Washington), Columbia River (Washington and Oregon), and Central Valley (California), and many smaller watersheds that drain directly into the Pacific Ocean. Most watersheds on the eastern side of the southern portion of the Cascade Range and the Sierra Nevada terminate in interior desert basins. Perennial streams are abundant in mountainous regions and areas with typically wetter climates. Lakes of glacial origin are common in plateau landscapes of the northern part of the Assessment Area and glaciated areas elsewhere. Dunes and bogs are common in the highly eroded landscapes of the Oregon and Washington coasts.

Soils within the Assessment Area vary and reflect dominant geomorphic influences and resultant forces of erosion and deposition (wind, glaciers, fluvial) (McNab and Avers 1994; Demarchi 1996, 2007*a, b, c*). Soils are moister on western slopes of mountains and in coastal areas and drier in the rain shadows of the Olympic Mountains, the Coast Ranges of British Columbia, and on the eastern slopes of the Cascade Range and Sierra Nevada (McNab and Avers 1994; Demarchi 1996, 2007*a, b, c*). Soils are typically colder at higher elevations and range throughout the Assessment Area from old and weathered to relatively young depending on their origin and subsequent influences (McNab and Avers 1994; Demarchi 1996, 2007*a, b, c*).



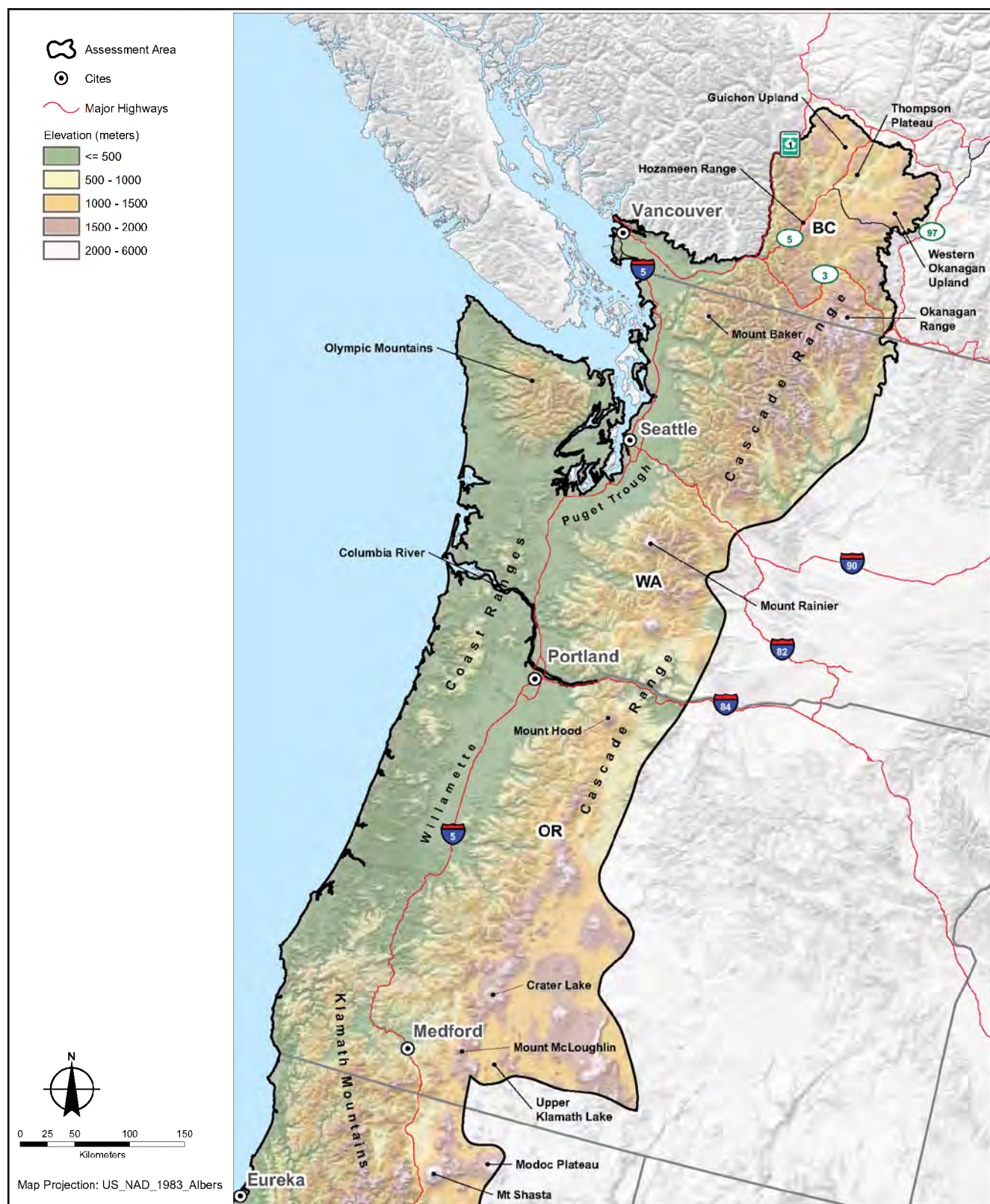


Figure 3.1. Geographic features of the northern portion of the Assessment Area (BC = British Columbia, WA = Washington, OR = Oregon).

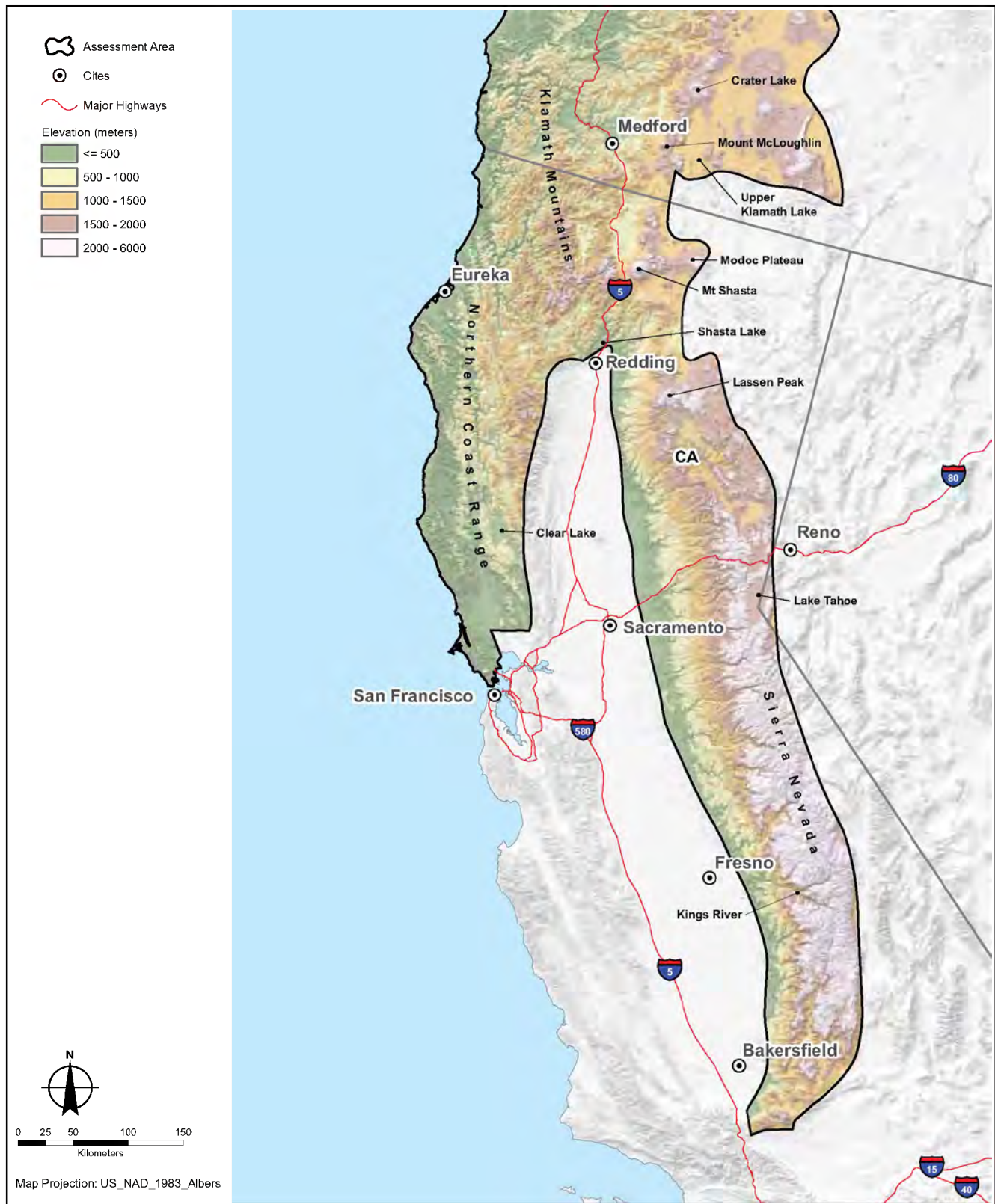


Figure 3.2. Geographic features of the southern portion of the Assessment Area (CA = California).

Variation in climate is largely correlated with elevation with the hottest driest areas occurring in major valley bottoms and drainage basins. Temperatures (Fig. 3.3) are colder and growing seasons are shorter in the north and at higher elevations. Precipitation is greatest in coastal areas and at higher elevations where most precipitation falls as snow (Fig. 3.4). Precipitation is much lower in rain shadow regions of the northern plateaus and on the east side of the Olympic Mountains, Cascade Range, and Sierra Nevada. Fog contributes to precipitation in the Northern Coast Ranges of California.

3.3. Plant Communities and Natural Disturbance

3.3.1. Plant Communities

The description that follows is based on Kuchler (1964), Meidinger and Pojar (1991), McNab and Avers (1994), and Demarchi (1996, 2007*a, b, c*). Plant communities vary on latitudinal, elevation, and moisture gradients (Figs. 3.5, 3.6). Tree species and plant community diversity tend to increase from north to south, but within ecological regions are more likely to decrease from lower to higher elevation. Plant communities within the Assessment Area range from Mediterranean in the south to montane and temperate rain forest in the north. Coniferous forests dominate the northern portions of the Assessment Area. Sitka spruce (*Picea sitchensis*), western redcedar (*Thuja plicata*), and western hemlock (*Tsuga heterophylla*) forests are common on lower slopes in wet coastal climates in the north. Douglas-fir (*Pseudotsuga menziesii*), western hemlock, and true fir (*Abies* spp.) forests are more abundant in intermediate climates and Douglas-fir and ponderosa pine (*Pinus ponderosa*) in drier regions. High-elevation forests are dominated by true firs and mountain hemlock (*Tsuga mertensiana*) in coastal areas and Engelmann spruce (*Picea engelmannii*) and true firs in interior regions. Deciduous stands of red alder (*Alnus rubra*), bigleaf maple (*Acer*

macrophyllum), trembling aspen (*Populus tremuloides*), or black cottonwood (*Populus balsamifera trichocarpa*) successional communities exist as minor forest components. Lodgepole pine (*Pinus contorta*) forests are common successional communities in interior regions. Forests are more typically mixed conifer (Douglas-fir, true firs, ponderosa pine, western hemlock) or mixed evergreen (oak [*Quercus* spp.], Pacific madrone [*Arbutus menziesii*], Douglas-fir) in the southern Cascade Range and Klamath Mountains. Juniper (*Juniperus* spp.) steppe forests are minor components of the eastern slopes of the Cascade Range in this region. Coast redwood (*Sequoia sempervirens*) forests are common on the seaward slopes of the northern California coastal region. Mixed evergreen forests are also present as well as a variety of natural hardwood communities (Pacific madrone, golden chinquapin [*Chrysolepis chrysophylla*], tanoak [*Lithocarpus densiflorus*], live oak [*Quercus* spp.], and California bay laurel [*Umbellularia californica*]). Plant communities in the southern portion of the Assessment Area are the most diverse. They include a variety of evergreen, hardwood, and chaparral communities (sagebrush [*Artemisia* spp.], live oak, manzanita [*Arctostaphylos* spp.], white alder [*Alnus rhombifolia*], mountain alder [*Alnus incana*], and trembling aspen) and mixed conifer forests (ponderosa pine, Douglas-fir, white fir [*Abies concolor*], red fir [*Abies magnifica*], Jeffrey pine [*Pinus jeffreyi*], and lodgepole pine). Grassland communities occur at low elevations in the warm valleys in the northern part of the Assessment Area and within the Willamette Valley and Puget Trough. The Willamette Valley also contains remnant oak woodland forests. Alpine heath plant communities occur at high elevations within the mountain regions.

3.3.2. Natural Disturbance

Disturbance events that shape vegetation communities and landscape patterns in the Assessment Area include fire, wind, insects, disease, landslides, floods and erosion, and volcanic activity (McNab and Avers 1994, Wong et al. 2003).

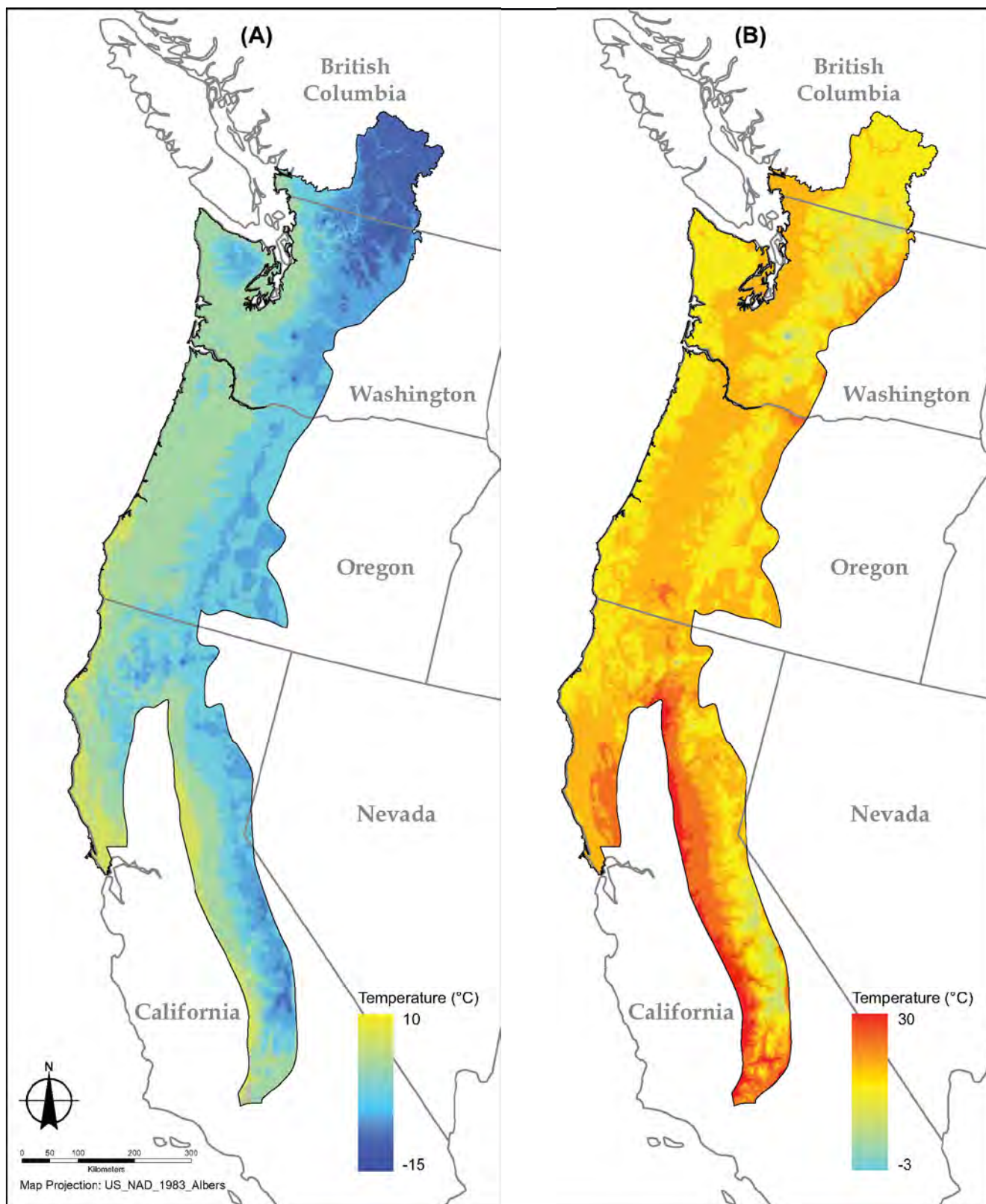


Figure 3.3. Mean daily temperatures for January (A) and July (B) within the Assessment Area. Temperatures were based on climate grids using PRISM (<http://www.ocs.orst.edu/prism/>) for British Columbia (Wang et al. 2006) and DAYMET (<http://www.daymet.org/>) for Washington, Oregon, and California.

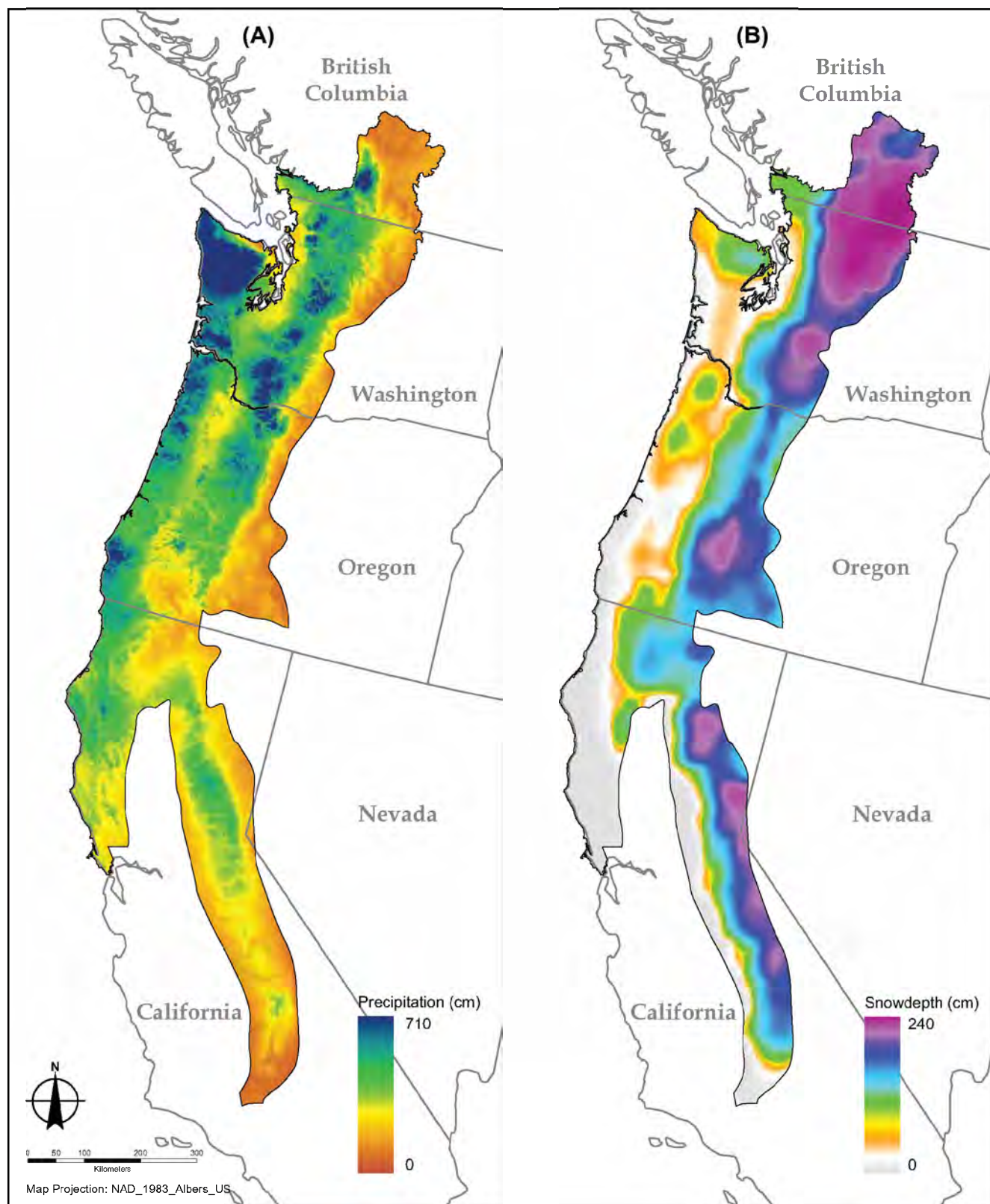


Figure 3.4. Mean annual precipitation (A) and mean maximum annual snow depth (B) within the Assessment Area. Precipitation data were based on climate grids using PRISM (<http://www.ocs.orst.edu/prism/>) for British Columbia (Wang et al. 2006) and DAYMET (<http://www.daymet.org/>) for Washington, Oregon, and California. Snow depth was modeled using gridded North American monthly snow-depth and snow-water equivalent data (Brown et al. 2003), and interpolated using snow-aging models (Sturm et al. 1995). The derived surface was then resampled to a smaller pixel size in multiple steps, applying a bilinear interpolation at each step to derive a final smoothed snow-depth surface at 1000-m resolution.

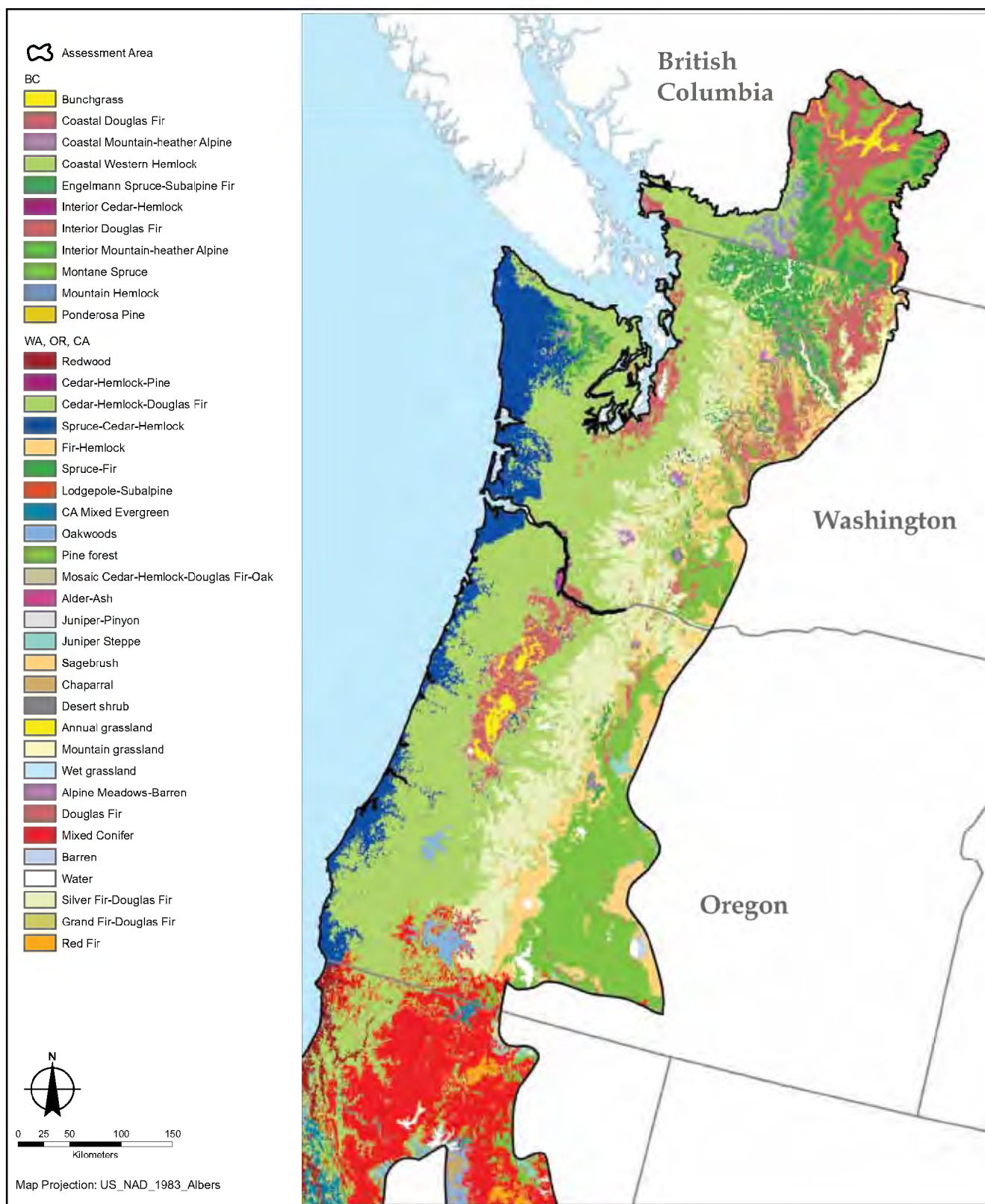


Figure 3.5. Potential natural vegetation of the northern portion of the Assessment Area. Coverage for British Columbia was based on Meidinger and Pojar (1991). Coverage for Washington and Oregon was based on Kuchler (1964).

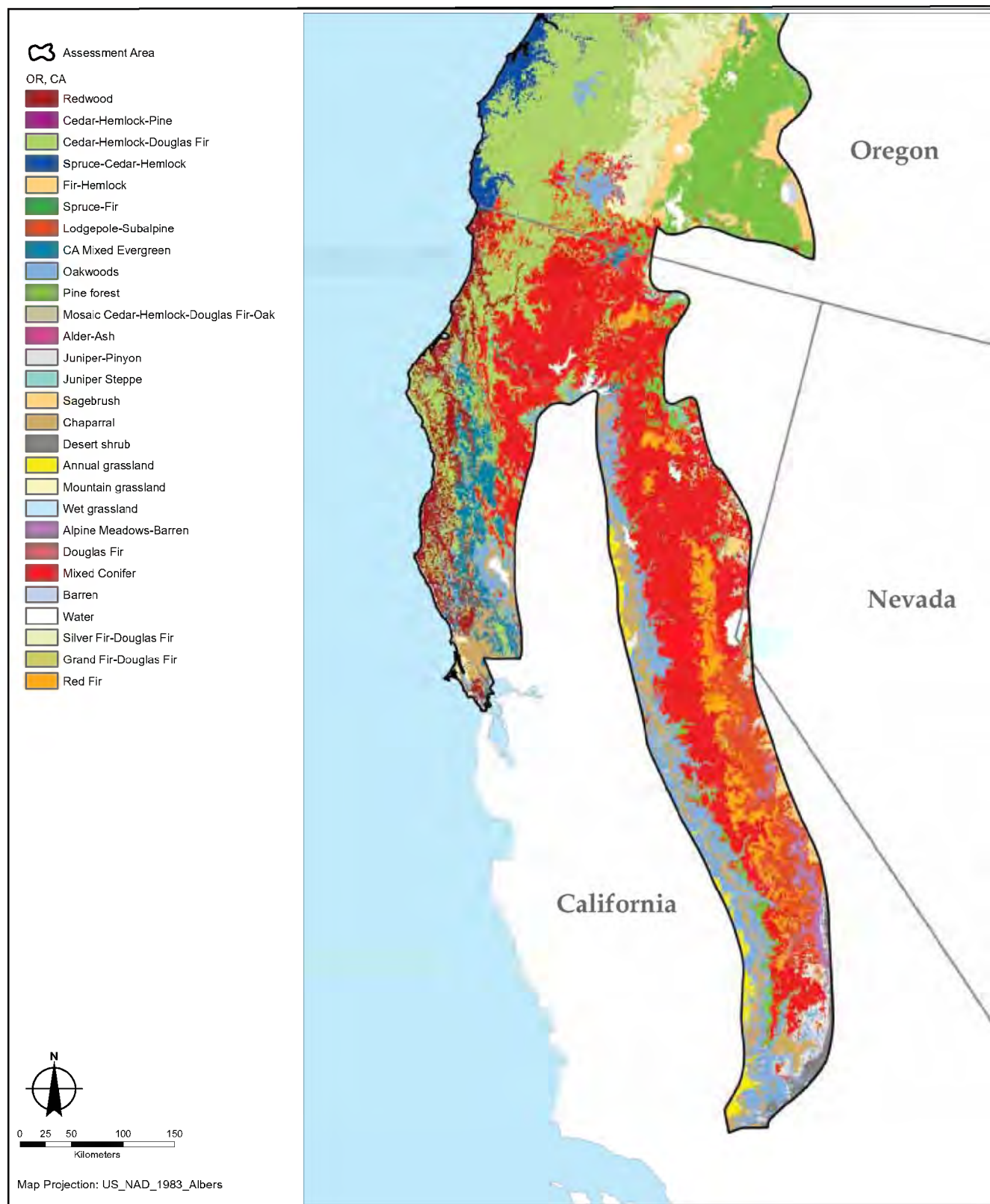


Figure 3.6. Potential natural vegetation of the southern portion of the Assessment Area. Coverage was based on Kuchler (1964).

Disturbance events affect forest ecosystems at multiple temporal and spatial scales (Spies et al. 1990, Lertzman et al. 1996) and can have a profound effect and even control species composition, succession, nutrient cycling, and forest structure (Spies et al. 1990, Agee 1993). The magnitude, frequency, and intensity of natural disturbances in the Assessment Area differ by disturbance type and are consistent with north-south and west-east variations in climate, soils, topography, and vegetation (Figs. 3.3, 3.4, 3.5, 3.6).

Fire was, and continues to be, an important and dominant large-scale disturbance agent influencing forest ecosystems within the Assessment Area. Fire regimes (frequency, intensity, and magnitude) and their relative importance as a natural disturbance agent vary north to south, west to east, and with increasing elevation and moisture (Fig. 3.7; McNab and Avers 1994, Wong et al. 2003, Moeur et al. 2005). Fires are most prevalent as a disturbance agent in the Assessment Area in the warm, dry climates of the north, on the eastern and southern slopes of the Cascade Range, and throughout California (Agee 1993, McNab and Avers 1994, USDA Forest Service and USDI Bureau of Land Management 1994, USDA Forest Service 2000, Wong et al. 2003, Moeur et al. 2005, Oregon Department of Fish and Wildlife 2005). Fire, although present, is a less common and less prevalent disturbance agent in the western Cascade Range, the Coast Ranges of Washington and Oregon, and in the intervening lowlands. Forests west of the Cascade crest, and those in cool, moist climates historically experienced infrequent fires, ranging from moderate to stand-replacing severity (Agee 1993, Moeur et al. 2005, Wong et al. 2003). Mean fire-return intervals vary with both latitude and elevation. Fire-return intervals are as short as <1 year to 35 years at low elevations in the north and central parts of the Assessment Area and in much of the southern Assessment Area (Figs. 3.7, 3.8; Agee 1993, McNab and Avers 1994, Wong et al. 2003, Moeur et al. 2005). Intermediate frequencies (35–100-yr

return intervals) are more common at mid-elevations in the north and central portions of the Assessment Area and at higher elevations in the south (Agee 1993, McNab and Avers 1994, Wong et al. 2003, Moeur et al. 2005). At high elevations in the north and in the western regions of the Assessment Area, fire-return intervals are typically longer and more variable and range from 90 to >1,000 years (Agee 1993, McNab and Avers 1994, Wong et al. 2003, Moeur et al. 2005).

Fire exclusion (via suppression activities), in concert with other forest management activities (Chapter 4), has changed fire regimes within portions of the Assessment Area over the past half century (Agee 1993, Spies et al. 2006). Prior to this, fire regimes typically resulted in forests composed of various age classes of fire-resistant tree species, including large old trees, and multilayered canopies, particularly in drier ecosystems (Agee 1993). This change has resulted in forests with significant fuel accumulation, shifts in species composition, and changes in stand structure (Agee 1993). These changes have increased susceptibility of forests to larger scale fires and insect outbreaks (Wong et al. 2003). Fire regimes in much of the Assessment Area have changed (or are changing) from frequent low- to high-intensity surface fires, or small-scale stand-level fires, to infrequent moderate- to high-intensity stand-replacing fires and large landscape-scale fires (Fig. 3.7; Agee 1993, McKelvey et al. 1996, Wong et al. 2003, Moeur et al. 2005). These changes have been more pronounced in warmer drier climates than in cooler wetter climates and, as such, fires become more prevalent from west to east, north to south and from higher to lower elevations (Agee 1994, McNab and Avers 1994, McKelvey et al. 1996).

Insects vary in importance as a natural disturbance agent and are more prevalent in ecosystems in the northern and eastern portions of the Assessment Area. Mountain pine beetle (*Dendroctonus ponderosae*) infestations have had significant effects

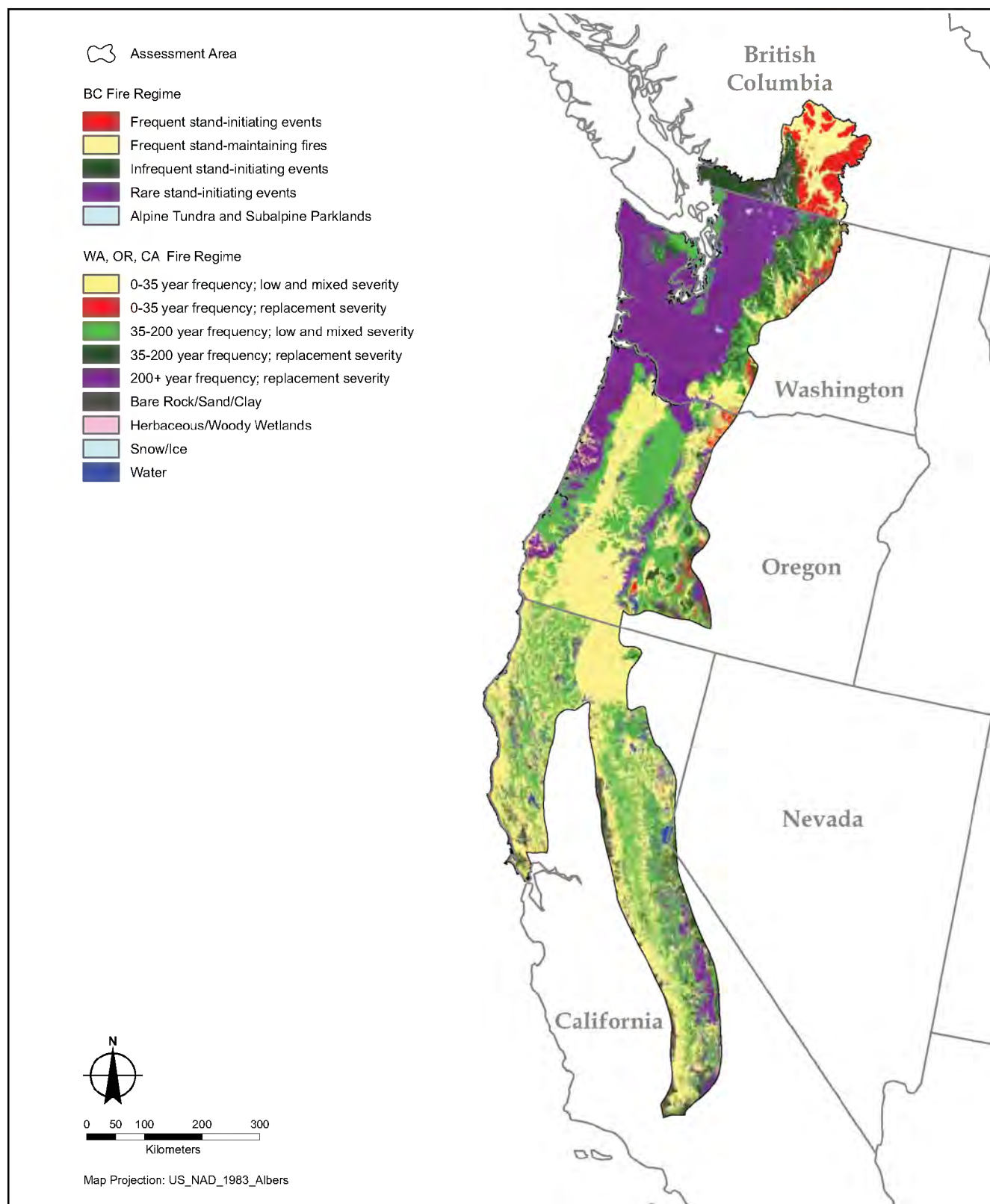


Figure 3.7. Natural disturbance types (British Columbia) and reference fire regimes (Washington, Oregon, and California) for the Assessment Area. For British Columbia, the natural disturbance regime data were from British Columbia Ministry of Forests (<http://www.for.gov.bc.ca/hre/becweb/resources/maps/>). Reference fire regime data were derived from LANDFIRE (http://www.landfire.gov/products_national.php) using LANDSUM (Keane et al. 1996) for Washington, Oregon, and California.

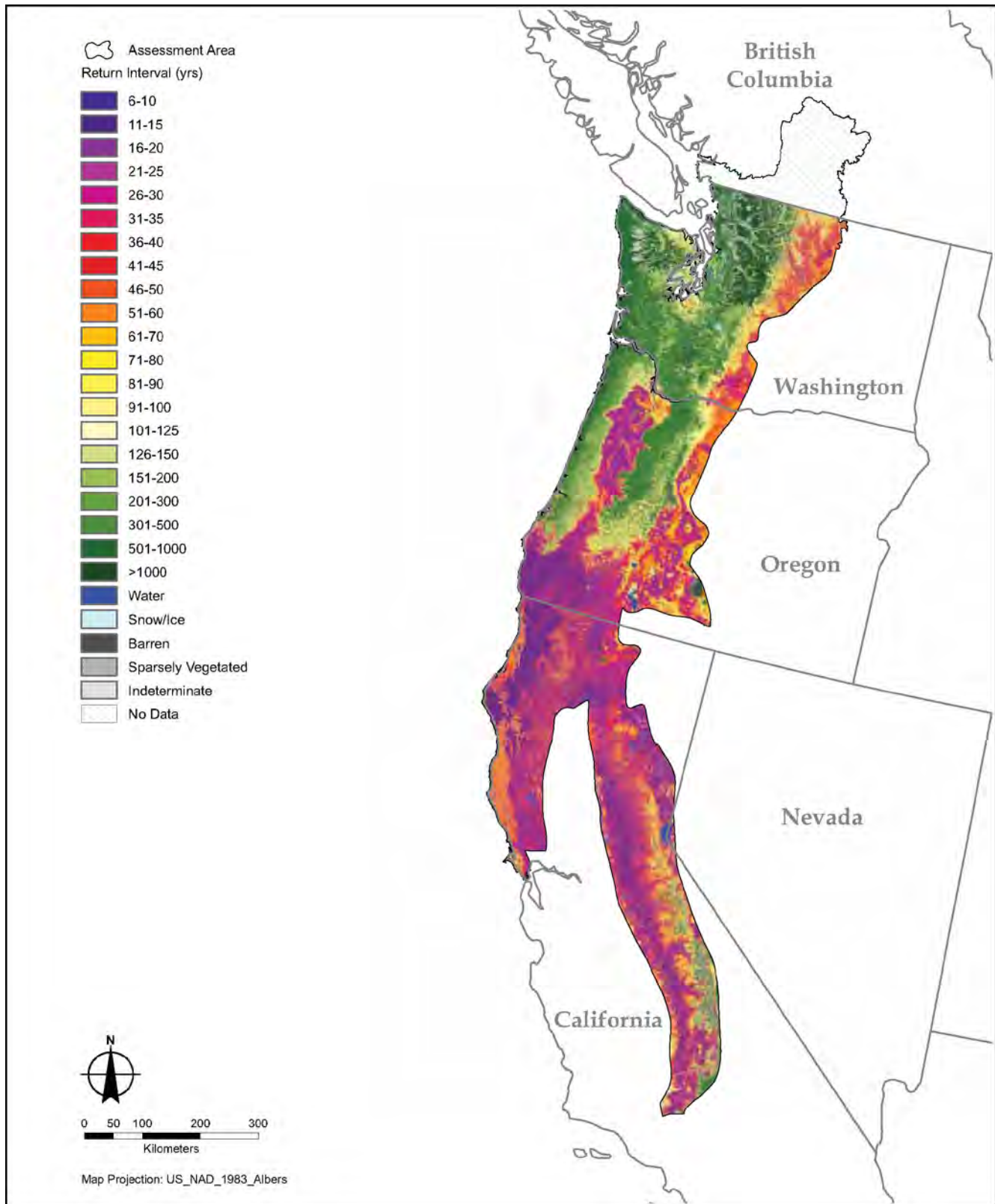


Figure 3.8. Mean fire return intervals for the Assessment Area. Fire return interval data were derived from LANDFIRE (http://www.landfire.gov/products_national.php) using LANDSUM (Keane et al. 1996) for Washington, Oregon, and California.

in the northern portion of the Assessment area and the eastern Cascades (Wong et al. 2003, USDA Forest Service 2006a). In British Columbia, such infestations have caused up to 80% mortality of the populations of *Pinus* species (Walton et al. 2007). Other insect infestations (primarily bark beetles) have resulted in widespread tree and stand mortalities in portions of the eastern Cascade Range and eastern Sierra Nevada (USDA Forest Service 2006a). Insect outbreaks are less extensive in other portions of the Assessment Area. However, western hemlock looper (*Lambdina fiscellaria lugubrosa*) can cause significant mortality especially in late-successional stands and, in the 1960s and 1970s, the introduced balsam woolly adelgid (*Adelges piceae*) caused extensive mortality of true firs (it currently occurs at chronic low levels; USDA Forest Service 2006a).

Disease agents of natural disturbance vary across the Assessment Area but, for the most part, affect forests at the scale of individual stems or small pockets, propagating gap replacement dynamics in forests (Wong et al. 2003). In the northern half of the Assessment Area, root diseases (e.g., *Armillaria* spp. and *Annosus* spp.) and hemlock dwarf mistletoe (*Arceuthobium tsugense*) may be locally common and, in association with windthrow, can result in significant tree mortality rates (Campbell et al. 1996, Wong et al. 2003, USDA Forest Service 2006a). Port Orford root rot (*Phytophthora lateralis*) is a localized disease which affects only Port Orford cedar (*Chamaecyparis lawsoniana*) but has high mortality rates (USDA Forest Service 2006a). In the southern portion of the Assessment Area, sudden oak death (*Phytophthora ramorum*) is an important and potentially wide-scale mortality agent of numerous oak species (USDA Forest Service 2006a).

Windthrow is a much less common natural disturbance agent in the Assessment Area but can influence vegetation patterns and ecosystems in localized areas (McNab and Avers 1994, Wong et al. 2003). Windthrow events are often associated with

severe winter storms of 25-yr to 100-yr intervals and tend to be most common in the Oregon and Washington Coast Ranges and the western Cascade Range (Ruth and Harris 1979, Henderson et al. 1989, McNab and Avers 1994, Wong et al. 2003).

Geomorphic events (volcanic eruptions, landslides) and floods are episodic disturbances of typically very low frequency that result in extreme vegetation changes. These are most evident in the Cascade Range and in the wet, steep coastal mountains of the northern parts of the Assessment Area (McNab and Avers 1994, Wong et al. 2003).

3.4. Climate Change

Vegetation dynamics, disturbance regimes and agents, climate, and their interactions are key elements in predicting the future condition of ecosystems and landscapes and the vulnerability of species and populations to climatic change. Factors such as temperature, precipitation, and wind patterns are among many factors that influence vegetative structure and composition, fire behavior, and wildlife habitat, including fisher habitat.

Solomon et al. (2007) provided a general overview of the types and intensities of changes expected with climate change. There is little scientific disagreement that global warming is occurring at an accelerating rate and that human activity (e.g., greenhouse gas emission) has contributed to this phenomenon. There is greater confidence in model predictions at larger scales than at smaller scales, more confidence in predictions related to temperature, and lower confidence in predictions for variables such as precipitation. Uncertainty exists as to the magnitude of these effects in relation to natural variation and how feedback mechanisms (increased water vapor, reduced snow cover) influence the extent and magnitude of climate change patterns and trends. Predicted patterns relevant to the Assessment Area are increased risk of extreme weather events such as heat waves, droughts, and floods (Solomon et al. 2007).

These are expected to increase in both frequency and severity. The northern portion of the Assessment Area (approximately Oregon-California border and north) is also expected to have increased winter precipitation, whereas most of the Assessment Area will experience decreased precipitation in the summer months.

These changes will likely be accompanied by other indirect effects of global warming, which may have beneficial or detrimental effects on fishers. McKenzie et al. (2004) projected that a warming climate will likely result in extended fire seasons and increases in total area burned. As a result, significant changes in the distribution and abundance of dominant plant species in some ecosystems may occur. Some species sensitive to fire may decline, whereas the distribution and abundance of species favored by fire may be enhanced. Climate change has also already had direct effects on forest insect infestations (Carroll et al. 2003, Taylor and Carroll 2003) with potentially substantial changes in natural disturbance regimes.

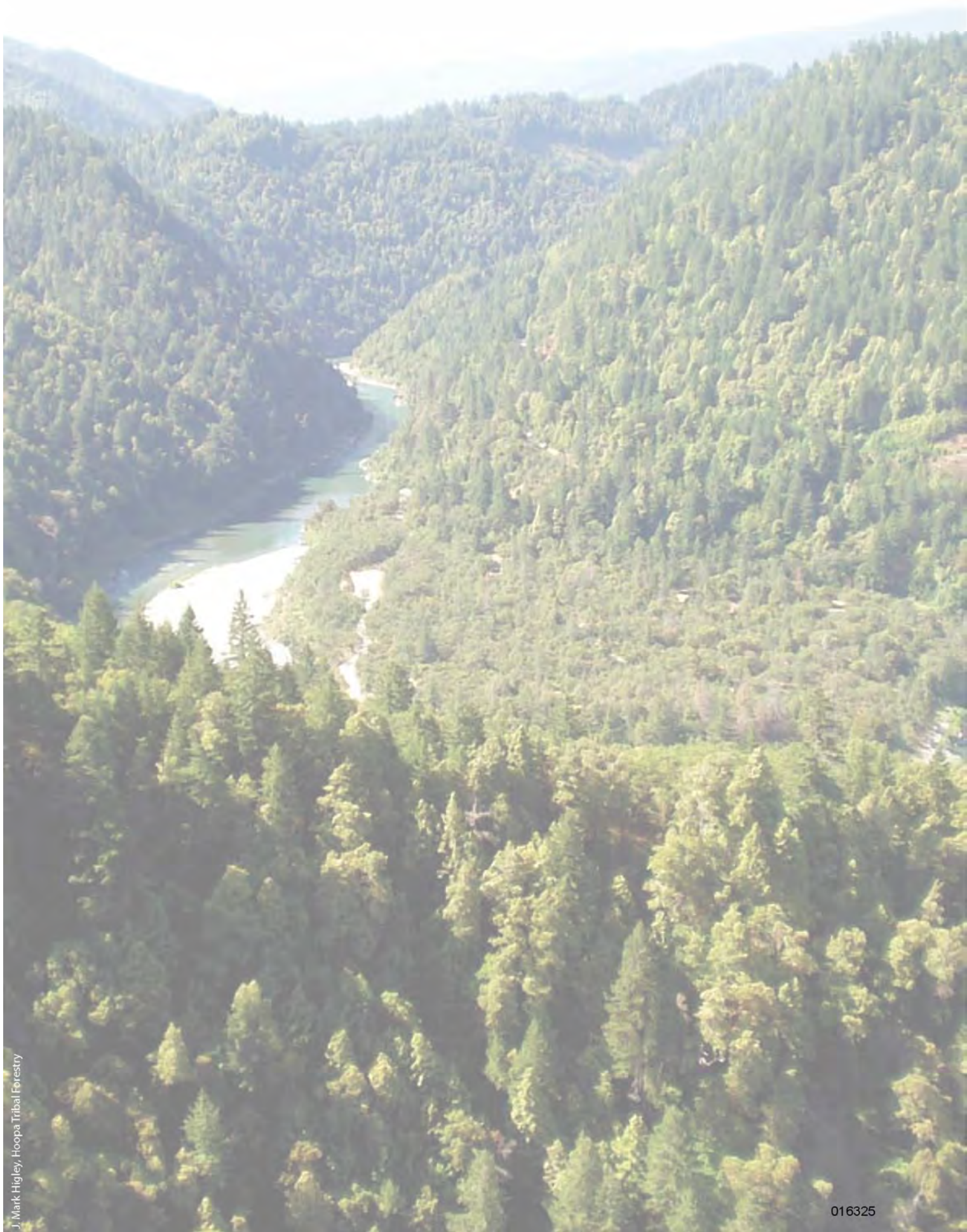
At large scales, climate change, through changes in vegetation, may result in elevational or latitudinal changes in mammal distribution (Kerr and Packer 1998). Because effects of climate change are occurring over relatively long periods, the effects on fishers over the short term (10–15 yr) and at smaller scales are less clear (Lawler et al. 2006). More focused research is needed on the effect of climate change on species, such as fishers, to more accurately predict specific effects of climate change on the west coast.

3.5. Implications for Conservation

1. The Assessment Area is biophysically extremely diverse. Conservation measures for fisher must be developed within the context of this variability. Measures to ameliorate threats (e.g., restore habitat conditions) must be crafted within the context (opportunities and constraints) associated with local and regional conditions. A successful conservation strategy should be built based on

this inherent variability and tailored to a logical biophysical unit.

2. A successful fisher conservation strategy must incorporate management approaches at relevant ecological scales. These should be informed by the frequency, intensity, and magnitude of natural disturbances and be developed at ecological scales appropriate for management purposes. Thus, it will be necessary to vary management approaches throughout the Assessment Area to correspond to local ecological scales.
3. The inherent capacity and resiliency of ecosystems varies across the Assessment Area. This must be incorporated into any strategic approach to conservation (e.g., restoration). Regionally specific site capacities present different opportunities for restoration and inherently different baseline levels of stability, resiliency, and recovery rates.
4. The consequences of climate change for fisher habitat at local and regional scales are unclear. Consequently, any conservation strategy should incorporate redundancy and resiliency into proposed approaches, particularly as they pertain to maintaining population connectivity and facilitating dispersal.



CHAPTER 4. HUMAN MODIFICATIONS TO THE ENVIRONMENT

4.1. Indigenous People and Early Europeans

Native Americans and First Nations have inhabited the Assessment Area for >10,000 years (Anderson and Moratto 1996, Ames and Maschner 1999). Populations in portions of the Assessment Area were relatively large and distributed among many tribes and nations (Duff 1973, Denevan 1992, Anderson and Moratto 1996). Native Americans and First Nations actively managed the natural environment to enhance resource availability and accessibility, although their techniques and the resulting effects to the environment varied considerably (Anderson and Moratto 1996, Lepofsky and Lertzman 2008). Although numerous practices including burning, pruning, selective harvesting, and planting were used to influence plant and animal communities, burning was the most commonly used practice for significant landscape-scale modification and management (Anderson and Moratto 1996, Tuchmann et al. 1996, Keeley 2002, Deur and Turner 2005, Litman and Nakamura 2007). Its use to initiate conversion of vegetation types, remove brush and ground material, create browse, and influence understory species composition had considerable impacts on plant community structure and composition (Anderson and Moratto 1996).

Early European settlement in the Assessment Area began during the 16th century with exploration of the Pacific Coast by the Spanish Conquistadors and subsequently by British explorers in British Columbia, Washington, and Oregon (Hayes 1999). Settlement and exploration accelerated during the 18th and 19th centuries as trading posts and fur brigade trails were established and fur trapping expanded throughout British Columbia, Washington,

Oregon, northern California, and the Rocky Mountains (Nicola Valley Archives Association 1989). Within the Assessment Area, the Hudson's Bay Company established settlements at Forts Langley and Kamloops in British Columbia, and at Forts Colville, Dalles, Okanagan, Steilacoom, Vancouver, and Astoria in Washington. Resource management activities such as timber harvest, agriculture, and grazing began during this time (Tisdale 1947, Tisdale et al. 1954, Tuchmann et al. 1996, Lewis and Stinson 1998, Beesley 2004), although these activities were presumably modest in scope and intensity. Major population centers within the Assessment Area were founded in the middle of the 19th century: Vancouver, British Columbia, in 1886; Seattle, Washington, in 1853; Vancouver, Washington, in 1857; Portland, Oregon, in 1851.

4.2. European Settlement and Use and Management of Natural Resources

Establishment of overland routes during the mid-19th century from the eastern United States into Oregon, and discovery of gold in the central Sierra Nevada in 1848, initiated new settlements and substantial population increases followed by various environmental impacts that accompany growth of permanent communities and “boom and bust” mining cycles (Beesley 2004, Litman and Nakamura 2007). Although the intensity of the California gold rush waned considerably within 20 years of its onset, the environmental effects were dramatic: hydraulic mining permanently denuded large areas of forests and woodlands in the Sierra Nevada, runoff from mining operations poisoned streams, and wildlife populations were impacted by hunting and trapping (Beesley 2004). The discovery of gold in the Sierra



Nevada prompted northward expansion of mineral exploration, which led to discoveries of numerous mineral deposits in northern California and southern Oregon (Shumway et al. 1980). Permanent European settlement of southern interior British Columbia began in the mid-1800s with the discovery of gold along the Fraser River in 1858 (Tisdale 1947, McLean 1982). Mining for other precious metals and coal began as early as 1875 (Nicola Valley Archives Association 1989). Settlement and the associated transportation and ranching infrastructure followed the gold strikes (McLean 1982).

Throughout the boom and bust mining cycles of the 19th century, large tracts of timber were routinely cleared to provide building material and fuel for mining operations and settlements. In the late 1850s to 1870s, the need for wood caused the first extensive cutting of forests in the Sierra Nevada (Litman and Nakamura 2007). Logging of the coast redwood forests started in the late 1800s and generally resulted in the clearing of entire watersheds extending from the coast forests into interior areas (Litman and Nakamura 2007). Water was regularly diverted to supply timber and mining operations.

During this period, cattle and sheep grazing became more widespread, and agriculture expanded to support the growing population. The livestock industry in British Columbia started in 1846 when the Hudson's Bay Company moved their stock of 22,000 head of cattle from Fort Vancouver to Forts Kamloops and Alexandria (McLean 1982). Livestock grazing from the early 1800s to the mid-1900s had significant impacts to vegetation in the Sierra Nevada (McKelvey and Johnston 1992, Litman and Nakamura 2007). Although agriculture activities were generally focused on lower elevations, cattle and sheep grazed forests and high-elevation meadows, affecting plant species composition and regeneration (McLean 1982, Litman and Nakamura 2007).

In the late 19th and early 20th centuries, demand for natural resources continued to grow with increasing population, although few regulatory mechanisms existed to control resource extraction or limit environmental impacts. Although mining operations continued, and grazing and agriculture industries grew, it is unlikely these activities had the extensive effects that timber harvest did on the environment (McKelvey and Johnston 1992). Railroad logging, dependent on timber supplies to build tracks and fuel engines, became prevalent in many regions of the Assessment Area. This allowed more efficient logging operations to occur over larger areas facilitating a substantial growth in the logging industry from 1890 to the 1920s (Marchak 1983, McKelvey and Johnston 1992, Drushka 1998, Litman and Nakamura 2007).

Mechanisms to regulate timber harvest in the United States began to appear from the late 19th to early 20th centuries. In the United States, the Forest Reserve Act of 1891 withdrew land from the public domain, and established forest reserves and national and state parks. In 1905, the U.S. Forest Service was established (Conway and Wells 1994). The designation of some lands within the Assessment Area as reserves temporarily slowed the rate of landscape change (Bolsinger and Waddell 1993). In British Columbia, legislation governing use and allocation of forested Crown lands was in place by 1870 and the first Forest Act was passed in 1912, which established forest reserves designated for timber harvest (Vance 1990). The first provincial park in British Columbia was protected by legislation in 1911.

Both World Wars I and II significantly affected the demand for lumber and other forest products, resulting in large increases in timber production (Drushka 1998, Litman and Nakamura 2007). Concurrent with the increased demand for lumber was a demand for water and hydroelectric power

resulting in the construction of numerous dams, particularly in the Sierra Nevada, the Columbia Basin, and the Cascade Range (Kirn and Marts 1986, Beesley 2004, Center for Columbia River History 2009). In 1942, logging and sawmilling were classified as essential industries in British Columbia (Drushka 1998). Following World War II, increasing human population and the post-war housing boom increased demands for lumber, and harvesting of forests increased with advancing technology (Conway and Wells 1994, Helms and Tappeiner 1996). Many second-growth forests that had regenerated from earlier cutting were harvested again during and after World War II (Litman and Nakamura 2007). Timber harvest on public lands in the Assessment Area continued to increase throughout much of the second half of the 20th century, generally peaking in the 1960s and 1970s. In British Columbia, 6.7 million m³ (1 m³ = 424 board feet) of timber was harvested during 1912. Timber harvest rose gradually to 34 million m³ in 1960, then rose quickly to peak in 1990 at 74.3 million m³ (British Columbia Ministry of Forests, 1980*a, b*, 1990, 2000). Timber harvests in Washington peaked in the late 1960s and early 1970s (Hall 1972). Between 1954 and 1991, annual timber harvests in Oregon peaked in 1968 at 22.9 million m³ and were at their lowest in 1982 at 13.5 million m³ (Conway and Wells 1994). In California, timber harvests increased progressively from the late 19th century until the 1950s in the Sierra Nevada and the 1960s in the north coast region (McKelvey and Johnston 1992). Total timber volume harvested was consistently higher for the north coast (maximum annual volume ~7.8 million m³) than for the Sierra Nevada (maximum annual volume ~4.5 million m³; McKelvey and Johnston 1992).

Forest management has reduced the amount of late-successional forests within the Assessment Area during the last 150 years. In British Columbia, the amount of late-successional forest declined in the mid- to late-1800s, primarily because of extensive

wildfire, and then began to increase subsequent to 1918 owing to implementation of fire suppression policies (MacKinnon and Vold 1998). By the 1990s, this trend had reversed as harvesting more than offset the effects of fire suppression (MacKinnon and Vold 1998). Most remaining late-successional forests in British Columbia were in very wet coastal environments or at higher elevations. Only 0.7–30% of lower elevation and drier forested environments within the British Columbia portion of the Assessment Area were late-successional (MacKinnon and Vold 1998). Between the periods 1934–1944 and 1980–1992, the extent of late-successional forests in Washington, Oregon, and California declined by 69% from 13.3 to 4.2 million ha (Bolsinger and Waddell 1993). The percentage of productive forests (federal, state, tribal, and private ownerships) that contained late-successional stands declined across the 3 states from 49% to 18%, and >85% of remaining late-successional forest occurred on federal and state lands (Bolsinger and Waddell 1993).

In addition to the direct removal of trees by timber harvest, management practices and policies have had many indirect effects on forested landscapes. Various silviculture systems have been used throughout the Assessment Area, ranging from single-tree selection to clearcutting, and some areas have had multiple techniques employed during the past 150 years (Helms and Tappeiner 1996). Even-aged silviculture using clearcutting, however, has been the dominant system employed in the Assessment Area until recently (Helms and Tappeiner 1996). Silviculture systems and subsequent management have substantially simplified species composition and forest structure (Helms and Tappeiner 1996, Coates and Burton 1997, Curtis 1997, Franklin et al. 2002, Thompson et al. 2003, Wisdom and Bate 2008).

Fire regimes (frequency, intensity, and total area burned) within the Assessment Area have changed substantially since European settlement, particularly

since the broad-scale implementation of fire suppression (Everett et al. 2000). Fire exclusion has resulted in widespread accumulation of forest fuels, increases in stem density, and a general shift in disturbance regimes from relatively small, low-intensity fires to larger, more complex, high-intensity fires (Agee 1993, Anderson and Moratto 1996, Everett et al. 2000). The cessation of burning by indigenous peoples and the implementation of subsequent fire suppression policies negatively affected many forests, most particularly those in the Sierra Nevada (Anderson and Moratto 1996, Bunn et al. 2007, Litman and Nakamura 2007). Changes in plant species composition were common (Hessburg et al. 2005, Litman and Nakamura 2007), but effective fire suppression policies also reduced productivity, forest structural heterogeneity, and forest community diversity (Weatherspoon 1996, Wright and Agee 2004, Hessburg et al. 2005, Hicke et al. 2007, Litman and Nakamura 2007). Fire suppression has also increased susceptibility of forests to insect infestations (Raffa et al. 2008). Beetle (pine, spruce, and ips) outbreaks of epidemic proportions have been facilitated by forest management trends that result in more homogeneous landscapes (tree species and ages) compared to historically heterogeneous forests (Raffa and Berryman 1987, Safranyik and Carroll 2006). During the past 20 years, land managers have recognized the importance of fire in maintaining ecosystem structure and function and have slowly begun to take steps to reintroduce fire as an important ecological process (Husari and McKelvey 1996, Wright and Agee 2004).

Land ownership, human settlement, and timber harvesting patterns have significantly influenced forest landscapes in the Assessment Area (Figs. 4.1, 4.2, 4.3, 4.4). By the 1960s, the forest industry in British Columbia was increasingly dominated by large corporations with access to large tracts of timber, although ownership of the land base remained with the Crown (Drushka 1998). In

the Assessment Area in British Columbia, recent harvesting of beetle-killed trees has resulted in large, relatively contiguous landscapes of newly regenerating forest (British Columbia Ministry of Forests 2005). In the Pacific states, portions of the forested landscape became a fragmented checkerboard pattern of ownerships and forest ages, largely resulting from historical railway land grants. These lands are interspersed with large blocks of federal and state lands (forest and parks; Figs. 4.3, 4.4; Conway and Wells 1994, Bunn et al. 2007, Litman and Nakamura 2007). In many parts of Washington, Oregon, and California, landscapes are a complex mosaic of different forest ages interspersed with recently logged areas (Bolsinger and Waddell 1993). At lower elevations, forests are intermingled with farms, pastures, towns, and reservoirs (Bolsinger and Waddell 1993). In many parts of the Assessment Area, forests are further fragmented by highways, industrial roads, railroads, reservoirs, power lines, pipelines, and increasingly by residential development (Figs. 4.1, 4.2, 4.3, 4.4; Bolsinger and Waddell 1993, Lewis and Stinson 1998).

4.3. Current Human Population and Infrastructure

The human population density within the Assessment Area varies considerably, with the largest population centers in the lower Fraser Valley of British Columbia, Puget Sound in Washington (from Bellingham south to Olympia), Willamette Valley in Oregon (particularly the Portland area), and the Sierra Nevada in California (Figs. 4.1, 4.2; Duane 1996, U.S. Census Bureau 2008, British Columbia Stats 2009a). Throughout much of the rest of the Assessment Area, population density is generally low and settlements consist of smaller, rural communities. Population growth during the next 20–40 years is generally expected to follow existing patterns with the greatest growth in and adjacent to existing population centers (Bunn et al. 2007, British Columbia Stats 2009b).

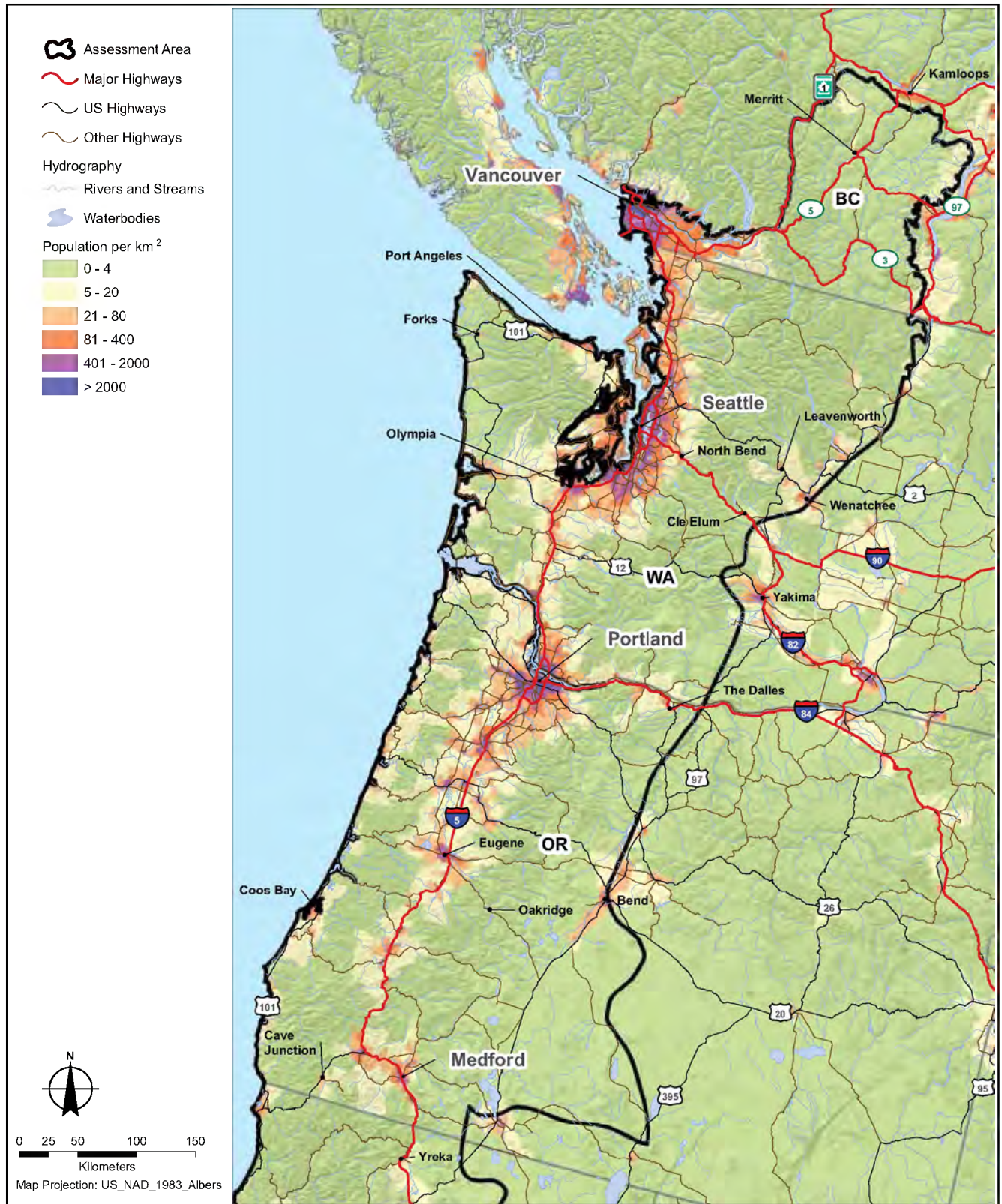


Figure 4.1. Human population densities in the northern portion of the Assessment Area (BC = British Columbia, WA = Washington, OR = Oregon). Population density data were from ESRI census data for Canada (for the year 2000) and the United States (for the year 2004).

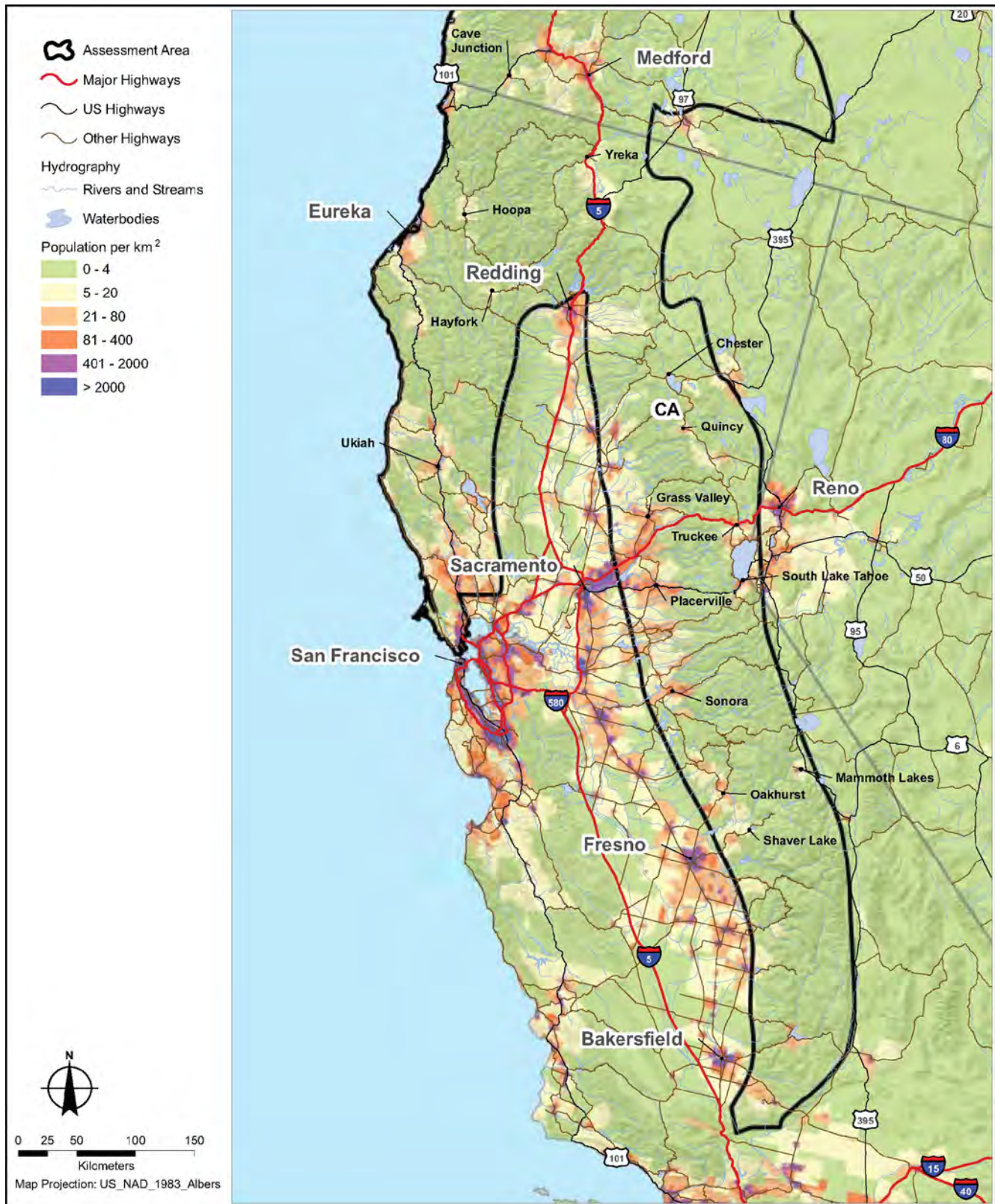


Figure 4.2. Human population densities in the southern portion of the Assessment Area (CA = California). Population density data were from ESRI census data for the United States (for the year 2004).

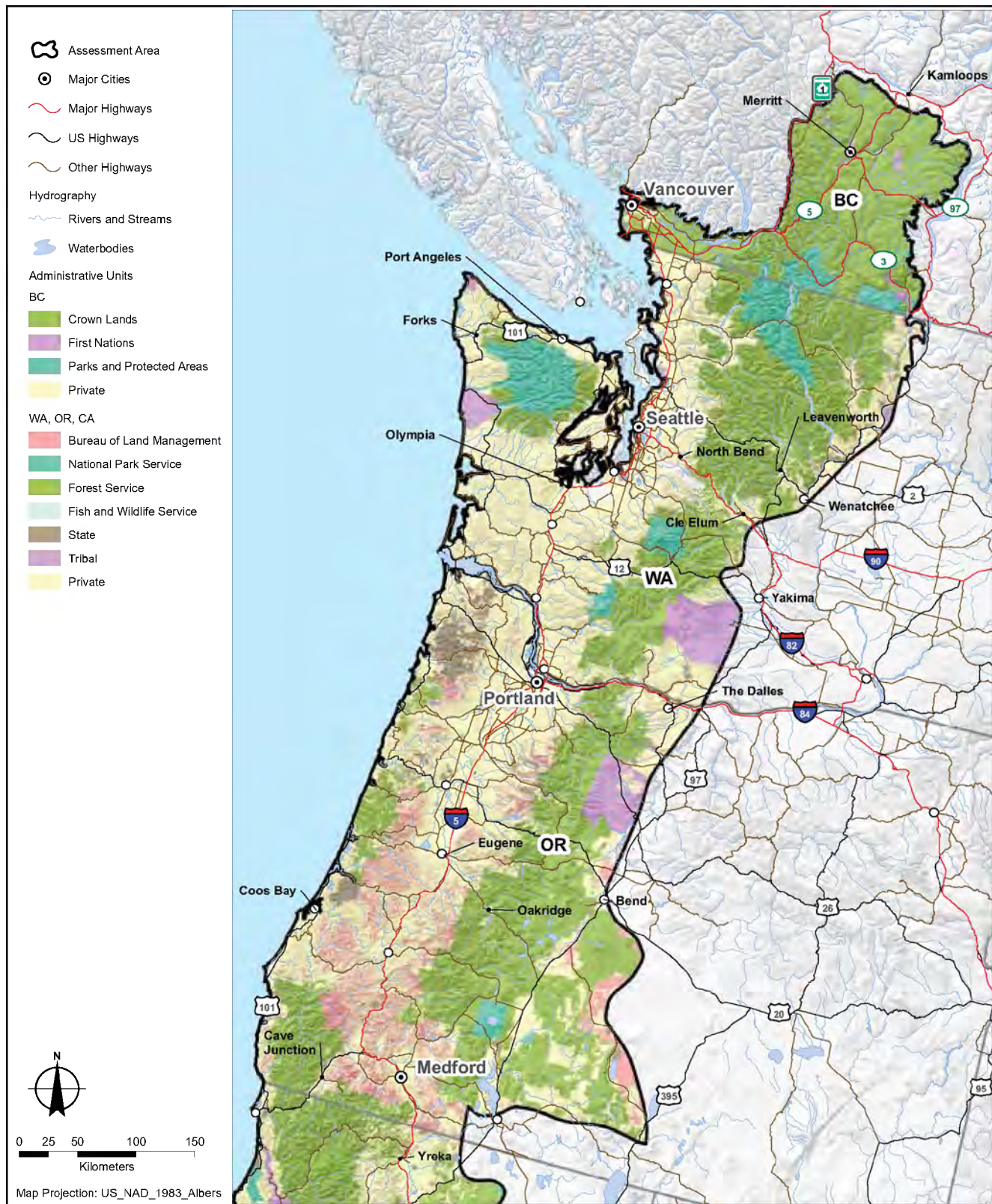


Figure 4.3. Administrative units within the northern portion of the Assessment Area (BC = British Columbia, WA = Washington, OR = Oregon).

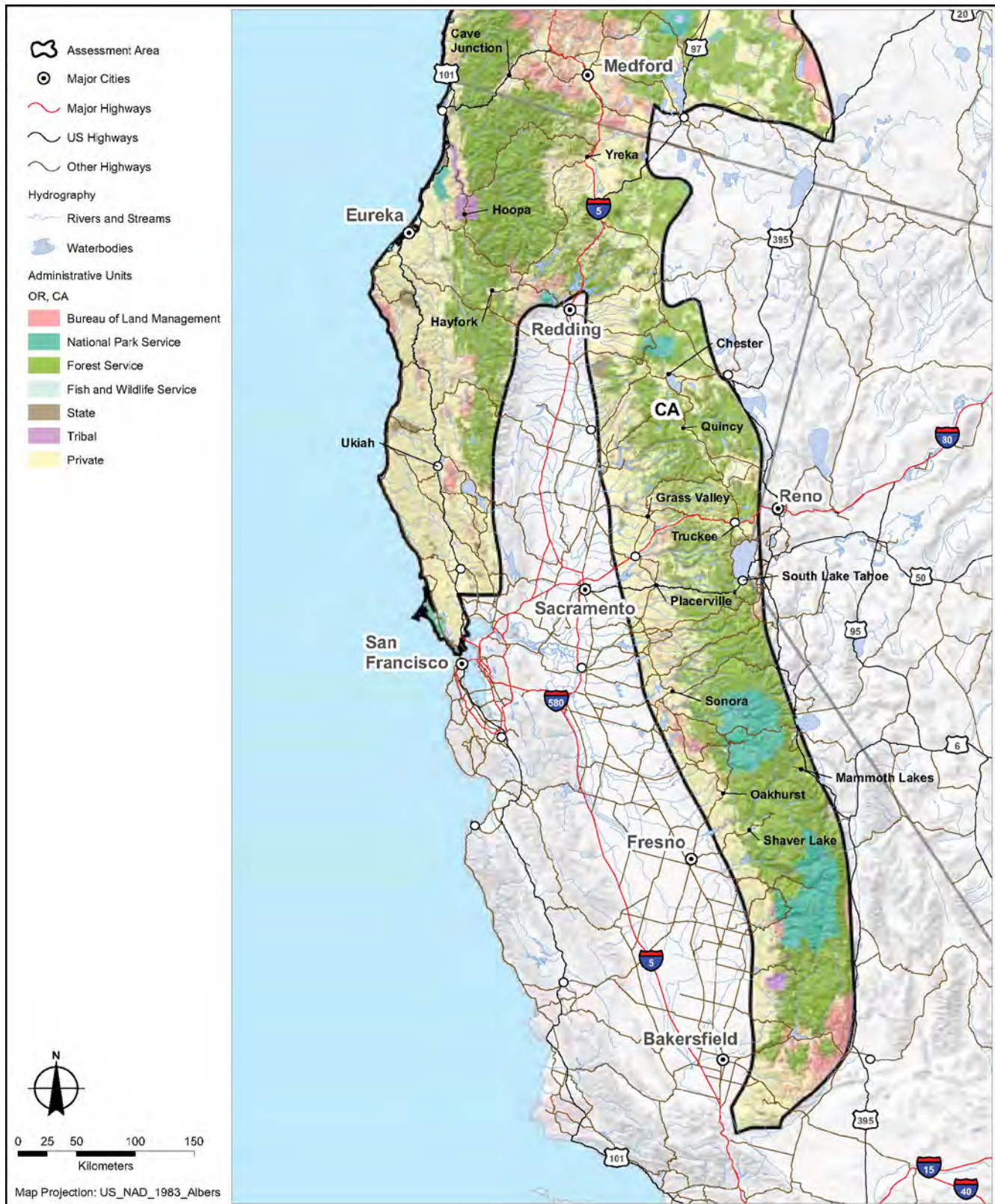


Figure 4.4. Administrative units within the southern portion of the Assessment Area (CA = California).

There are extensive road networks within the Assessment Area. British Columbia has 3 major traffic corridors (Fig. 4.1): Highway 1 (2- to 4-lane divided route) bisects the lower Fraser Valley and subsequently borders the western boundary of the Assessment Area; Highway 5 (4- to 6-lane divided route) bisects the region from the southwest to the north; and Highway 3 (2- to 4-lane route) extends from Hope eastward through the Similkameen Valley. Within Washington, Oregon, and California the Assessment Area is bisected north to south by Interstate 5 (4- to 6-lane divided route; Figs. 4.1, 4.2). In the Pacific states, U.S. Highway 101 (2- to 4-lane route) largely follows the Pacific Coast although it veers inland in northern California. Several major U.S. Interstates (4- to 6-lane routes) bisect the Assessment Area from west to east: Interstate 90 in central Washington, Interstate 84 in northern Oregon, and Interstate 80 in the central Sierra Nevada of California. Smaller 2-lane state and provincial highways occur throughout the Assessment Area linking rural communities, recreation areas, and public lands to the larger urban centers. Smaller highways generally remain open year-round; however, most state highways that cross the Sierra Nevada and some routes across the Cascade Range in Washington and Oregon experience winter closures owing to snow. Small paved and industrial roads are common throughout the Assessment Area although their density ranges considerably.

Land use patterns vary throughout the Assessment Area (Figs. 4.3, 4.4). The Assessment Area in British Columbia is primarily Crown land (Fig. 4.3). Most private land occurs at lower elevations. Private lands primarily support urban centers and agriculture. On most Crown lands, with the exceptions of First Nations lands and protected areas, cattle grazing and forestry are predominant land uses in lower elevation ponderosa pine and Douglas-fir forests, and forestry dominates land use at higher elevations. Large copper mines (active or undergoing remediation) occur in the Highland Valley near Logan Lake and south of

Princeton. Three large protected areas (Skagit Valley, Manning, and Cathedral Provincial Parks) occur in the south, adjacent to the United States border.

In Washington, commercial forestry, urban, industrial, agriculture, conservation, and livestock grazing are important land uses (USDA NRCS 2001, Washington Department of Natural Resources 2009). Commercial forestry, conservation, recreation, and livestock grazing are dominant land uses in the Cascade and Olympic Recovery Areas as delineated in Washington State's fisher recovery plan (Hayes and Lewis 2006). The USDA Forest Service is the largest federal landowner (23.6% of the state) and the Washington Department of Natural Resources is the largest state landowner (13% of the state; Fig. 4.3). Loss of forested land to other uses through land conversion is of increasing concern (Washington Department of Natural Resources 2009). Large protected areas are contained within Olympic, North Cascades, and Mount Rainier National Parks (Fig. 4.3).

Land ownership patterns and land use vary by region in Oregon and include large areas of private land in the Willamette Valley and portions of the Oregon coast, extensive public lands in the Cascade Range and Klamath Mountains, and a patchwork ownership in a large portion of southwestern Oregon resulting from the Oregon and California Lands Act of 1937 (Fig. 4.3; Oregon Department of Fish and Wildlife 2005). Private lands make up 44% of Oregon; the remaining lands are under federal, state, or tribal ownership (Oregon Big Look Task Force 2009). Land use on nonfederal lands in Oregon includes wildland forest (37%); wildland range (32%); mixed forest, range, and agriculture (6%); intensive agriculture (20%); and low-density residential and urban (6%; Oregon Big Look Task Force 2009). Public lands are primarily forest lands; there is 1 national park (Crater Lake) in Oregon (Fig. 4.3).

Land uses within the Assessment Area in California include forestry, agriculture, recreation, water

impoundments, mining, housing, and industrial corridors such as power lines (Bunn et al. 2007). Most (76%) of the land in the northern coastal areas is privately owned (Fig. 4.4). The remainder includes lands administered by the USDA Forest Service and USDI Bureau of Land Management (9%) and Redwood National and State Parks. Federal lands cover 64% of the area in the Klamath Mountains (Moeur et al. 2005). Sixty percent of the land in the Sierra Nevada is federally administered; the remainder is primarily privately owned (Bunn et al. 2007). Three National Parks occur in the Sierra Nevada (Fig. 4.4): from north to south they are Lassen Volcanic, Yosemite, and Sequoia/Kings Canyon. Conversion of natural areas, farmland, and forest lands to other uses is increasing (Bunn et al. 2007, Stein et al. 2007). Urbanization has closely followed the early agricultural development in concentrated areas along the important transportation corridors, particularly Interstate 5 where most of the region's population lives (Fig. 4.2). Housing density continues to increase within forest, agriculture, and mixed forest-agriculture dominant use areas (Bunn et al. 2007, Stein et al. 2007).

4.4. Implications for Conservation

1. Densely populated urban centers and associated infrastructure are extensive within portions of the Assessment Area. For fisher populations, these lands are permanently alienated, and in some situations may act as barriers to long-distance movements or population expansion into suitable areas. Furthermore, projected human population growth in areas adjacent to existing urban centers, as well as in more rural communities, will continue to convert forested environments into potentially unsuitable habitat for fishers. To successfully conserve fishers, a conservation strategy must recognize these limitations, be applied across large geographic areas, and provide measures for maintaining population connectivity and facilitating dispersal.
2. Patterns and intensity of landscape use and development pressures vary across the Assessment Area. To successfully conserve fishers, a conservation strategy must recognize this when prioritizing the spatial and temporal implementation of management actions.
3. Historically, many resource-use industries have altered forested environments within the Assessment Area, likely influencing the abundance and distribution of fishers and their habitat. Compared to other resource use industries, both past and present forest management activities have been the most extensive and have resulted in loss and fragmentation of late-successional forests over large portions of the Assessment Area. Conservation strategies for fishers must be developed to benefit from remaining areas of late-successional conditions.
4. Fire suppression policies have had substantive effects on forested ecosystems and the resiliency of those systems to wildfire and other disturbances (and potentially climate change). Fisher conservation measures must include adoption of management approaches that move current disturbance regimes closer to the ecological equilibrium for any given ecosystem. This should increase system resiliency and provide greater opportunities for successful fisher conservation.
5. Historical land use and land ownership patterns have dramatically influenced current distribution and condition of forest ecosystems in the Assessment Area. In addition to this level of fragmentation, road networks associated with human settlements create additional anthropogenic stressors on fishers owing to the synergistic effects associated with human access to remote forest ecosystems (Wisdom and Bate 2008). Resource developments (e.g., mining, recreation, hydroelectric, transportation) in

forested environments have the potential to further fragment fisher habitat and limit fisher conservation opportunities. Fisher conservation efforts will benefit from coordinated approaches to land management that recognize the constraints of a fragmented landscape and work to ameliorate existing fragmentation.



CHAPTER 5. RANGE, DISTRIBUTION, AND POPULATION GENETICS

5.1. Historical Distribution

Fishers occur only in North America and first appeared in the fossil record ~30,000 years ago in the eastern United States (Anderson 1994). Evidence from the fossil record suggests fisher distribution during the final Pleistocene glacial period (~12,000 years before present) was limited to the Appalachian Mountains in the eastern United States extending as far south as Georgia (Graham and Graham 1994). Following retreat of the last major Pleistocene ice sheets and subsequent changes in vegetation, fishers expanded to more northern latitudes in eastern North America (Graham and Graham 1994). Evidence of fishers first appeared in the fossil record in western North America during the late Holocene (<5,000 years before present; Graham and Graham 1994). Based on several lines of paleontological and genetic evidence, Wisely et al. (2004) hypothesized that fishers expanded relatively recently (<5,000 years ago) from Canada southward and colonized forested mountains of the Pacific Coast. Limited *Martes* fossil evidence is available for central Canada, although fishers presumably expanded westward and northward concurrently with the development and evolution of forests following the retreat of continental ice sheets in Canada (Graham and Graham 1994).

Prior to European settlement of North America (ca. 1600), fishers presumably ranged throughout the boreal forest zone of Canada and extended south into the northeastern United States, Rocky Mountains, and Pacific states and provinces. Pre-European (hereafter referred to as historical) distribution of fishers has been described by numerous authors (e.g., Hagmeier 1956, Hall 1981). Although the boundaries of the presumed historical distributions vary, fishers were consistently described as associated

with boreal forests in Canada, mixed deciduous-evergreen forests in eastern North America, and coniferous forest ecosystems in western North America. Gibilisco (1994) summarized various historical North American range descriptions and concluded that fishers were broadly distributed in the Great Lakes states and New England, and throughout much of Canada from Nova Scotia to British Columbia (Fig. 5.1). In the western United States, historical distribution of fishers was much less widespread and included peninsular distributions extending south from British Columbia into the Sierra Nevada of California and the mountains of Wyoming and Utah (Fig. 5.1).

Accounts of fisher biology and distribution written by early naturalists describe historical occurrences in British Columbia (Rand 1944, Cowan and Guiguet 1956), Washington (Suckley and Cooper 1860, Scheffer 1938, Dalquest 1948), Oregon (Bailey 1936), and California (Grinnell et al. 1937). These accounts typically combined trapping information (either specimen locations verified by the authors or provided by trappers) and presumed habitat associations to develop range maps depicting range boundaries during the early 20th century. More recently, interpretations of trapping records, specimen records, and habitat distribution have been used to describe historical fisher occurrence in British Columbia (Banci 1989, Weir 2003) and Washington (Lewis and Stinson 1998). All of these accounts consistently describe fishers as broadly distributed throughout the Assessment Area, although generally rare. There are considerable inconsistencies in published accounts of historical fisher distribution (e.g., Bailey 1936, Grinnell et al. 1937, Hagmeier 1956, Hall and Kelson 1959, Strickland et al. 1982, Gibilisco 1994, Wisely et al.





Figure 5.1. Presumed historical range of fishers in North America (from Gibilisco 1994).

2004). Among the notable differences in western North America are the uncertain occurrence of fishers on the British Columbia coast (Cowan and Guiguet 1956, MacLeod 1950, Hagmeier 1956, Gibilisco 1994, Hatler et al. 2008), in the Blue Mountains of Washington and Oregon (and the question of whether fishers there were connected via the Columbia Valley to populations in coastal Washington and Oregon or east to populations in Idaho; Bailey 1936, Hagmeier 1956, Aubry and Houston 1992, Gibilisco 1994, Wisely et al. 2004), and in the northern Sierra Nevada (Grinnell et al. 1937, Hagmeier 1956, Gibilisco 1994, Zielinski et al. 2005).

Based on these accounts, we describe fisher occurrence within the Assessment Area during the late 19th and early 20th centuries, recognizing those regions where uncertainty exists. In British Columbia, fishers presumably occurred in the upland forests of the Thompson Plateau and Western Okanagan Upland, and in coastal interior transition

forests and dry interior forests of the eastern and western Cascade Range (Cowan and Guiguet 1956, Banci 1989, Weir 2003). In the Cascade Range of Washington and Oregon, fishers likely occurred in densely forested habitats on the east and west sides of the Cascade crest (Suckley and Cooper 1860, Dalquest 1948). Fishers occurred in coniferous forests of the Olympic Peninsula from sea level to timberline (Scheffer 1938). Historical occurrence of fishers in the southern Coast Range of Washington is uncertain (Aubry and Houston 1992). Locations of specimen records indicate that fishers primarily occurred at elevations <1,000 m west of the Cascade crest and >1,000 m east of the crest (Aubry and Houston 1992). Based on fieldwork conducted in Oregon by the Bureau of Biological Survey from 1888 to 1936, Bailey (1936) described the fisher as a boreal forest species that occupied the cool humid Coast Ranges, coniferous coastal forests, and the Cascade Range. In California, Grinnell et al. (1937) suggested that fishers historically occurred throughout the Sierra Nevada, Cascade Range, Klamath, Siskiyou and

Northern Coast Range mountains of California. They do not however indicate any verified fisher occurrence records in the northern Sierra Nevada. Fishers generally occurred in forested habitats from 1,050 m to 2,300 m elevation, although animals were trapped near sea level on the northern California coast and were observed at elevations >3,300 m in the Sierra Nevada (Grinnell et al. 1937).

Historical population sizes and densities of fishers are not known. Our perception of historical distribution is guided by accounts of natural historians of the early 20th century, general assumptions regarding fisher habitat associations and niche characteristics, and, to some extent, published genetic information. Distribution of forested landscapes capable of supporting fisher populations were subject to changes associated with climatic variation (e.g., the Little Ice Age) and large-scale disturbances and catastrophes (e.g., volcanic eruptions and extensive wildfires); thus the distribution of fishers undoubtedly varied over time and space owing to these and other ecological factors (Gibilisco 1994). Furthermore, genetic data suggest some population structure was evident (Kyle et al. 2001, Drew et al. 2003, Wisely et al. 2004), indicating that there were likely spatio-temporal discontinuities in fisher distribution in the Assessment Area and elsewhere within their historical range. Based on these various lines of evidence, we assume that fishers were historically distributed broadly throughout the Assessment Area but were not ubiquitous. Although maps of historical distribution typically portray large areas of continuous occurrence, it is likely that some areas within the range boundaries were rarely if ever occupied by fishers whereas others were consistently occupied. Energetic requirements and trophic position of fishers likely resulted in low population densities over much of their range, although some localities (e.g., the Olympic Peninsula; Scheffer 1995) appeared to promote high fisher densities.

5.2. Range Contraction

It is clear that fisher distribution in North America has undergone significant changes since European contact (Anderson 1934, Rand 1944, Douglas and Strickland 1987, Powell 1993, Gibilisco 1994, Powell and Zielinski 1994). Although the precise distribution of fishers prior to European contact is not well documented, the scale of documented changes post-contact is substantive (Hagmeier 1956, Gibilisco 1994). Most of the post-contact changes have been range contractions; however, fishers expanded their range in some areas of eastern North America subsequent to management intervention (Gibilisco 1994, Powell and Zielinski 1994; see Section 5.3). The primary evidence for range contractions are documented declines in trapping harvest and subsequent trapping closures because of perceived lack of fishers. Although, in many instances, trapping may have been the proximal cause for population and range changes, large-scale anthropogenic changes to fisher environments over this period (Anderson 1934, Gibilisco 1994) and predator control programs were also likely important factors (Chapter 4). The relative contributions of direct mortality and these other factors to fisher range contractions, however, are poorly understood.

The fisher's range across much of North America was greatly reduced in the 1800s and early 1900s (Hagmeier 1956, Douglas and Strickland 1987, Powell 1993, Powell and Zielinski 1994). Concern for declining fisher numbers across much of fisher range was voiced by Dixon (1925), Anderson (1934), Allen (1942), Rand (1944), followed by others. Fisher harvests were essentially unregulated in western North America prior to the establishment of provincial and state game management agencies in the early 1900s.

In British Columbia, fishers were likely trapped for personal use by First Nations prior to European

settlement and were subsequently trapped for commercial purposes for over 2 centuries (Novak et al. 1987, Weir 2003). From 1919 to 2004, annual fisher harvests in British Columbia averaged 650 and, in the 1970s, occasionally exceeded 1,000 animals. Annual fisher harvests from 1985 to 2007 averaged 280 and twice exceeded 400 animals (Weir 2003; British Columbia Ministry of Environment Wildfur Data System, unpublished data). Although fisher distribution in British Columbia has declined from historical levels, this has primarily been in the southern portion of the province; elsewhere in British Columbia, fishers currently occupy much of their historical range (Banfield 1974, Fontana and Teske 2000, Weir 2003, Weir et al. 2003, Lofroth 2004). Banfield (1974) suggested that fisher populations were extirpated in the East Kootenays and the British Columbia portion of the Assessment Area. Weir (2003) cited loss of habitat from forest harvesting, hydroelectric development, and land clearing as contributing factors to the decline of fishers in these regions. Fisher harvest in the mid-1800s may have been a significant factor (Lewis and Stinson 1998). Fisher trapping seasons were closed in the East Kootenay region in 1982. Fisher trapping seasons throughout all of British Columbia were closed during 1991 and 1992, and have remained closed since that time in the southeastern and southwestern portions of the Assessment Area. Trapping seasons in the northern portion of the Assessment Area were closed again in 2003 and have remained closed since that time. Whereas some fisher populations in British Columbia are contiguous with Alberta fisher populations, they may no longer be contiguous with extant populations in Idaho, Montana, or the Pacific states.

In Idaho, fisher populations were reported as having declined by the 1920s (Williams 1963). Jones (1991) suggested that overharvest and habitat changes owing to wildfire in the early part of the 20th century were proximal causes, but that logging and predator control programs may have also been significant contributing factors. Davis (1939) reported that

fishers were very rare in Idaho, and Idaho Fish and Game furbearer surveys from 1953 to 1958 failed to detect any fishers. Fisher populations in Montana were considered extirpated in the 1920s (Hawley 1968, Weckwerth and Wright 1968) and the trapping season was closed in 1930. Currently Montana and Idaho share 2 extant fisher populations, 1 in the Cabinet Mountains and 1 in the Bitterroot Mountains (Vinkey et al. 2006). The Cabinet population is the result of reintroductions, and the Bitterroot population is the result of reintroductions and the persistence of a native population (Vinkey et al. 2006; see Section 5.3).

Fisher populations declined in Washington beginning in the mid-1800s (Lewis and Stinson 1998). Between 1813 and 1814, 106 fisher pelts were delivered to the Northwest Fur Company in the inventories of the Astoria Trading Company (Astoria Inventories 1813–1814). From 1836 to 1852, 6,551 fisher pelts were traded at Hudson's Bay Company trading posts located in present-day Washington. Most of these (5,806) were traded at Fort Colville (near the city of Colville in northeastern Washington) which likely collected pelts from portions of British Columbia, Idaho, Montana, and eastern Washington (Lewis and Stinson 1998). There are few records of fisher harvest in most of Washington during the early 1900s although fisher harvests in the 1920s indicated that populations still existed on the Olympic Peninsula (Scheffer 1995). The commercial trapping season for fishers was closed in 1933 to protect remaining populations and promote fisher recovery (Lewis and Stinson 1998). Despite this protection, fishers have never recovered in Washington. The last verifiable evidence of a fisher in Washington was an incidental capture on the east side of the Olympic Peninsula in 1969 (Aubry and Houston 1992, Lewis and Stinson 1998). Despite extensive survey efforts within Washington, no verifiable records have been obtained and the fisher is currently considered extirpated from the state (Lewis and Stinson 1998, Aubry and Lewis 2003).

Records of trapped fishers in Oregon during the 20th century are sparse, but indicate that fisher populations were more widely distributed in the past (Gibilisco 1994, Aubry and Lewis 2003). Fisher harvest data from 1924 to 1936 indicate that few (\bar{x} = 8, range = 2–13) fishers were captured annually despite widespread commercial trapping pressure (Kebbe 1961*a*). Overtrapping was likely the cause of much of the contraction in fisher range in Oregon (Marshall 1996), however, Aubry and Lewis (2003) postulated that changes in forested habitat resulting from extensive logging may have been a significant contributing factor. Despite pelt price increases from \$25 to \$100–150 between 1913–1914 and 1920–1925, annual fisher harvests did not vary (9 in 1913–1914, 13 in 1924, 9 in 1925; Bailey 1936, Ingram 1973). Fisher trapping was prohibited beginning in 1937 (Aubry and Lewis 2003) and, despite that protection, fishers have not recovered. Harris et al. (1982) suggested that by the time of their publication, fishers were extirpated from western Oregon. Currently, there are 2 fisher populations in Oregon: a reintroduced population in the Cascade Range of southern Oregon, and a native population in the Siskiyou Mountains in the southwest corner of the state (Aubry and Lewis 2003).

Fisher populations in California may have experienced declines and range contractions as a result of habitat loss and modification (Chapter 4) in the 1800s, but there are few documented records to verify this. Annual fisher harvests in California declined steadily from 1919 to 1946 (\bar{x} = 18.5, range = 1–102; Lewis and Zielinski 1996), and restrictions on fisher harvest were being proposed as early as the 1920s (Dixon 1925). The fisher season was closed in California in 1946. Despite protection from commercial trapping, current fisher range is greatly reduced compared to that described by Grinnell et al. (1937) and shown by Zielinski et al. (1995*c*). Lewis and Zielinski (1996) suggested that incidental harvest by generalist trappers after fisher seasons were closed may have contributed to further declines. There are

still occasional tribal harvests of fishers in California where they may be used for dance regalia (Higley et al. 1998, Higley 2008). The current range of the fisher in California is less than 50% of the historical range described by Grinnell et al. (1937) and consists of 2 isolated native populations: one in the northwestern portion of the state that extends into southwestern Oregon, and the other in the southern Sierra Nevada (Zielinski et al. 1995*c*, 2005).

5.3. Translocations

Translocations, including reintroductions and augmentations, have been used as an effective conservation tool for reestablishing fishers in various regions of North America where native populations were believed to have been extirpated. Since the late 1940s, translocations succeeded in reestablishing or aiding in the reestablishment of fisher populations in at least 6 provinces and 10 states (Table 5.1; Lewis 2006).

Loss of fisher populations within much of their historical range in the Assessment Area prompted reintroduction efforts in Oregon and Washington (Table 5.1; Plate 5.1). In 1961, 24 fishers were translocated from north of Kamloops, British Columbia, to 2 locations in Oregon: 11 were released near Klamath Falls in the southeastern Cascade Range, and 13 were released near La Grande in the Wallowa Mountains in northeast Oregon (Kebbe 1961*a*, Aubry and Lewis 2003). The primary goal of reintroduction efforts was to control porcupines (*Erethizon dorsatum*) that were causing damage to commercial timber. Neither effort succeeded in reestablishing fishers (Aubry and Lewis 2003). From 1977 to 1981, fishers were again reintroduced in Oregon to control porcupines: 17 fishers from south-central British Columbia and 13 fishers from northern Minnesota were released in various locations <45 km from Crater Lake (Aubry and Lewis 2003). Consistent verifiable detections of fishers since 1981 indicate that these efforts were successful in reestablishing fishers to the Cascade

Table 5.1. Characteristics of fisher translocations conducted from 1947–2008 in the Assessment Area and adjacent regions, and elsewhere in North America (modified from Lewis 2006). Translocations were classified into 3 groups: reintroductions (R), augmentations (A), and introductions (I). The status of each translocation effort was classified as one of the following: successful (S), failed (F), outcome unknown (U), translocation status undetermined (TSU) because not enough time has elapsed to evaluate success, or ongoing project (OP).

Release location	Source population	Year	No. fishers	Type	Status	Source
Assessment Area						
Oregon	British Columbia	1961	24	R	F	Kebbe 1961 <i>a,b</i> ; Aubry and Lewis 2003
	British Columbia, Minnesota	1977–1981	30	R	S	Aubry and Lewis 2003
Washington	British Columbia	2008–	18	R	OP	USDi National Park Service 2008
Adjacent regions						
British Columbia	British Columbia	1990–1991	16	i	F	E. Lofroth, pers. comm.; R. Weir, pers. comm.
		1990–1992	15	A	S	Weir 1995
		1996–1998	60	R	F	Fontana et al. 1999, Weir et al. 2003
Idaho	British Columbia	1962–1963	39	A	S	Williams 1962, 1963; Berg 1982; Luque 1984
Montana	British Columbia	1959–1960	36	A	S	Weckwerth and Wright 1968, Roy 1991, Heinemeyer 1993, Vinkey 2003, Vinkey et al. 2006
	Minnesota, Wisconsin	1988–1991	110	R	S	Roy 1991, Heinemeyer 1993
Other regions						
Alberta	Alberta	1981–1983	32	R	F	Davie 1984, Proulx et al. 1994; J. Jorgenson, pers. comm.
	Manitoba, Ontario	1990	17	R	S	Proulx et al. 1994, Proulx 2005
Manitoba	Manitoba	1972	4	R	F	Berg 1982; R. Baird, pers. comm.
		1994–1995	45	R	S	Baird and Frey 2000; R. Baird, pers. comm.
New Brunswick	New Brunswick	1966–1968	25	R	S	Dilworth 1974, Drew et al. 2003; T. Dilworth, pers. comm.
Nova Scotia	Unknown	1947–1948	12	R	S	Benson 1959, Dodds and Martell 1971
	Maine	1963–1966	80	R	S	Dodds and Martell 1971
	Nova Scotia	1993–1995	14	A	S	Potter 2002; M. Boudreau, pers. comm.; J. Mills, pers. comm.; D. Potter, pers. comm.
		1999–2004	?	A	TSU	M. Boudreau, pers. comm.; D. Potter, pers. comm.
Ontario	Ontario	1956	25	R	U	Berg 1982; M. Novak, pers. comm.
		1956–1963	97	R	S	
		1979–1981	55	R	S	Kyle et al. 2001; J. Baker, pers. comm.; M. Novak pers. comm.
		1979–1982	29	R	S	
Colorado	Unknown	1978 or 1979	2	i	F	J. Apker, pers. comm.
Connecticut	New Hampshire, Vermont	1989–1990	32	R	S	Rego 1989, 1990, 1991; P. Rego, pers. comm.
Maine	Maine	1972	7	R	U	Berg 1982; Maine Fish and Wildlife unpublished data
Michigan	Minnesota	1961–1963	61	R	S	Irvine et al. 1964, Brander and Brooks 1973; R. Earle, pers. comm.
	Michigan	1988–1992	189	R	S	R. Earle, pers. comm.
Minnesota	Minnesota	1968	15	R	F	Berg 1982; W. Berg, pers. comm.

Table 5.1. continued.

Release location	Source population	Year	No. fishers	Type	Status	Source
Other regions						
New York	New York	1976–1979	43	R	S	Wallace and Henry 1985; R. Henry, pers. comm.
Pennsylvania	New Hampshire, New York	1994–1998	190	R	S	Serfass et al. 2001
Tennessee	Wisconsin	2001–2003	40	R	TSU	Anderson 2002
Vermont	Maine	1959–1967	124	R	S	Berg 1982; K. Royar, pers. comm.
West Virginia	New Hampshire	1969	23	R	S	Wood 1977, Pack and Cromer 1981
Wisconsin	Minnesota, New York	1956–1963	60	R	S	Bradle 1957, Irvine et al. 1964, Dodge 1977, Peterson et al. 1977, Kohn et al. 1993
	Minnesota	1966–1967	60	R	S	Dodge 1977, Peterson et al. 1977, Kohn et al. 1993

Range in southern Oregon (Aubry and Lewis 2003). Genetic analyses demonstrated that fishers sampled in this region during the late 1990s were descendants of source populations in both British Columbia and Minnesota (Drew et al. 2003). In 2008, following a feasibility assessment (Lewis and Hayes 2004) and implementation planning (Lewis 2006), 18 fishers were released in Olympic National Park in western Washington (USDI National Park Service 2008). This was the first of several planned releases in an effort to establish a founder population of 100 fishers on the Olympic Peninsula (USDI National Park Service 2008). Post-release monitoring will determine whether this reintroduction effort has been successful (Lewis 2006, USDI National Park Service 2008).

Since 1959, several fisher reintroductions occurred in regions adjacent to the Assessment Area (Table 5.1). During 1959 and 1960, fishers from central British Columbia were released in the mountains of northwest and west-central Montana (Weckwerth and Wright 1968). Additional fishers were translocated from British Columbia to the Clearwater Range of Idaho during 1962 and 1963 (Williams 1962). From 1989 to 1991, fishers were translocated from Minnesota and Wisconsin to the Cabinet Mountains in northwest Montana (Roy 1991, Heinemeyer 1993). Although these 3 separate

efforts were considered successful (Lewis 2006), recent genetic analyses revealed that translocations of fishers to the mountains of west-central Montana were augmentations and not reintroductions (Vinkey et al. 2006). The presence of a unique haplotype in recently sampled fishers in west-central Montana suggests that native fishers in this region, and possibly nearby Idaho, had not been extirpated as originally believed (Vinkey et al. 2006).

Several translocations were conducted in regions adjacent to the Assessment Area in British Columbia (Table 5.1). In the early 1990s, there was an unsuccessful attempt to introduce fishers to control porcupines in coastal forests of Khutzeymateen Inlet (Weir 2003, Lewis 2006). In the mid-1990s, apparently successful translocations within central British Columbia augmented fisher populations in the eastern Cariboo region (Weir 1995, Lewis 2006). In the late 1990s, fishers were translocated from central to southeastern British Columbia to reestablish populations in the East Kootenay region (Fontana et al. 1999, Fontana and Teske 2000). This effort was not successful. Field surveys in the winter of 2002–2003 failed to find evidence of a self-sustaining fisher population in the East Kootenay (Weir et al. 2003).

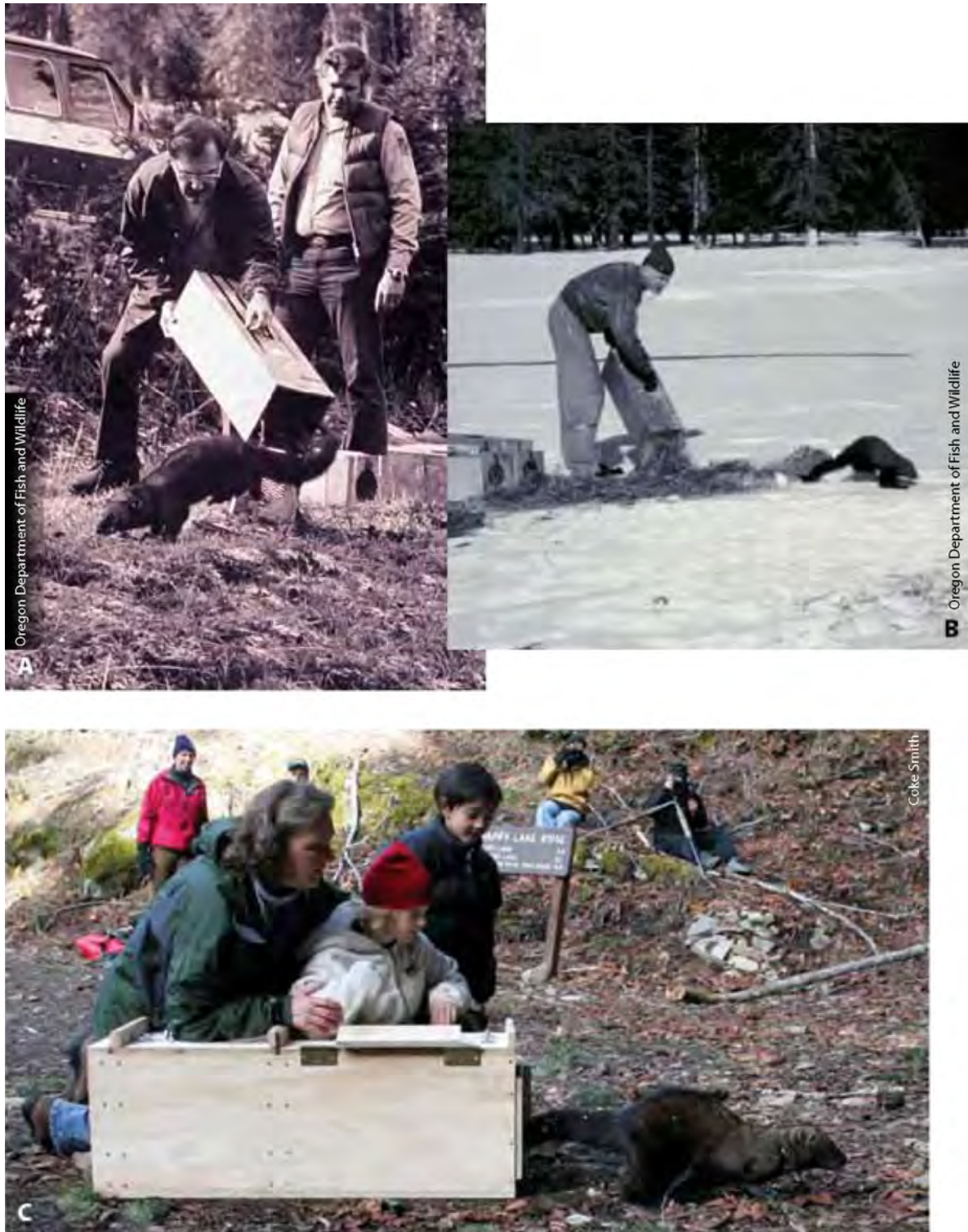


Plate 5.1. Fishers from British Columbia and Minnesota were released in the Cascade Range of southern Oregon from 1977 to 1981 in an effort to reestablish fishers and control porcupines (A–B). In 2008, fishers from British Columbia were released in Olympic National Park during the first of a 3-year reintroduction effort to reestablish fisher populations in Washington (C).

5.4. Current Distribution in the Assessment Area

We have used various sources of empirical information to describe the current geographic extent of fisher populations within the Assessment Area and adjacent regions (Fig. 5.2) including: 1) results from standardized detection surveys (e.g., track-plate, live capture, or remote camera surveys); 2) information from radiotelemetry studies; and 3) other verifiable occurrence records (e.g., opportunistic photos, track-plate impressions, genetic confirmation of species identification from scats or hair collected in the field, road kills, trapping records, and specimen records). We also used results from habitat modeling to describe variation in fisher distribution within an extant population. In the South Thompson Similkameen region of British Columbia, we used fisher trapping and specimen records (Cowan and Guiguet 1956, Hatler et al. 2008; British Columbia Ministry of Environment Wildfur Data System, unpublished data) to describe the geographic extent of fishers and a habitat model (Weir 2003) to describe their potential distribution. In the Cascade Range of Oregon, we used verifiable occurrence records obtained from camera surveys (USDI Bureau of Land Management 2000, 2001, 2004; USDA Forest Service 2009) and information collected during a 6-year radiotelemetry study (Aubry and Raley 2006). In southwestern Oregon and northern California we used the results of extensive detection surveys (Beyer and Golightly 1996; Dark 1997; Klug 1997; Zielinski et al. 1997c, 2005; Slauson and Zielinski 2001, 2003, 2007; Lindstrand 2006; Thompson 2008; USDA Forest Service 2009). Systematic surveys conducted by Zielinski et al. (2005) covered much of the historical distribution in California as described by Grinnell et al. (1937). We were informed by regional habitat models predicting fisher occurrence in northern California (Carroll 1997, Carroll et al. 1999, Carroll 2005, Davis et al. 2007) that were developed using results from extensive survey programs. We used the results of extensive surveys (Laymon et al. 1991; Zielinski et



Figure 5.2. Contemporary distribution of fishers within the Assessment Area and adjacent regions in western North America compared to the historical distribution as depicted by Gibilisco (1994).

al. 1997c, 2005; Boroski et al. 2002; USDA Forest Service 2006b; Green 2007; Jordan 2007; USDA Forest Service 2009) to identify the geographic extent of the southern Sierra Nevada fisher population and regional habitat models (Davis et al. 2007, Spencer et al. 2008) to describe the variation in fisher distribution within this population.

Using these data, we considered an extant population to be present in a geographic area if there had been consistent fisher detections during the past 2 decades. Our descriptions of the geographic extent of fisher populations are approximate and are not intended to delineate population boundaries or imply that fishers do not occasionally occur in other localities (hereafter referred to as extra-limital records).

South Thompson Similkameen, British Columbia—The status of this population is currently undetermined. Eighty-eight fishers were legally harvested in this region from 1928 to 2007; 13 since 1985. Currently, it is uncertain if these records are indicative of a breeding population or are extra-limital records. This area has not been surveyed by any rigorous inventory program. The South Thompson Similkameen includes all or portions of the Nicola Basin, Guichon Upland, Western Okanagan Upland, Northwest Cascades, Hozameen Range, Pavillion Ranges, and Okanagan Range ecosections (Fig. 5.2; Demarchi 1996, 2007*a, b, c*).¹ The geographic extent is defined as east of the Fraser River; south and east of the Thompson River, south of the Trans-Canada Highway, west of the Shuswap River, and west of the Okanagan Valley.

Cascade Range, Oregon—This fisher population occupies areas within portions of 3 ecological subregion sections: the Western, Eastern, and Southern Cascades (McNab and Avers 1994).¹ This population is primarily located in the Upper Rogue River drainage basin on the west slope of the Cascade Range in Douglas and Jackson Counties, and occupies forests from 610 m to 1,525 m elevation (Fig. 5.2). The population extends north and west to the divide between the Rogue and Umpqua Rivers, south to Mount McLoughlin, and east across the Cascade crest to approximately the western boundaries of the Wood River Valley and Upper Klamath Lake in Klamath County. Infrequently, fishers have been detected farther north near Lemolo and Crescent Lakes on the Umpqua and Deschutes National Forests, and more recently (winters of 2006 and 2007) fishers were detected south of Mount McLoughlin near Hyatt Reservoir.

This is a reintroduced population with genetic affinities to source populations in British Columbia

(primarily) and Minnesota (Drew et al. 2003, Wisely et al. 2004). Although this population was reestablished >25 years ago, and is about 75 km from a native population of fishers in southwestern Oregon and northern California, no genetic exchange between the 2 populations has been documented (Aubry et al. 2004, Wisely et al. 2004). Fishers in the Cascade Range of Oregon may be geographically isolated from those in southwestern Oregon because of ecological (extensive areas of open grassland and oak savannahs) and anthropogenic (Interstate 5 corridor, urban and agricultural development) barriers in the intervening area (Aubry et al. 2004).

There are no reliable estimates of population size. Nevertheless, based on verifiable occurrence records since the 1977-1981 reintroductions, it appears that this population has not expanded its range much beyond a relatively small area (Aubry and Lewis 2003) of about 2,500 km² (Aubry and Raley 2006).

Northern California-Southwestern Oregon—Based on available information, this population occurs primarily in 3 ecological subregion sections: the Klamath Mountains, Northern California Coast Ranges, and the Northern California Coast (McNab and Avers 1994). This population likely extends into 2 additional ecological sections: the Southern Cascades and the Northern California Interior Coast Ranges (McNab and Avers 1994).

In California, this population occurs from east of Interstate 5 in the Pit River watershed west through the Klamath Mountains and Coast Ranges, and north into the Siskiyou Mountains and southernmost portion of the Rogue River watershed in southwestern Oregon (Fig. 5.2). There is no evidence that this population extends east of Interstate 5 in southwestern Oregon. Fisher occurrence has been verified near the coast of northern California and

¹ Ecosections as defined by Demarchi (1996, 2007*a, b, c*) for British Columbia are comparable to ecological subregion sections defined by McNab and Avers (1994) for the United States.

recent surveys verified fisher occurrence south of the Snow Mountain Wilderness on the Mendocino National Forest. Limited survey effort has occurred in the southernmost portion of the historical distribution described by Grinnell et al. (1937), thus the range boundaries in this area remain uncertain. Regional habitat models predicting occurrence can help refine distributional understandings and provide an index of habitat quality, but do not necessarily indicate an area is currently occupied by fishers. Systematic surveys detected fishers at 27% of sites surveyed (Zielinski et al. 2000) and regional habitat models predicting fisher occurrence (Carroll et al. 1999, Davis et al. 2007) suggest fisher distribution is patchy.

The northern portion of this population is about 75 km from the Cascade Range population in Oregon (Aubry et al. 2004) and the southern portion is about 350 km (Zielinski et al. 1995*c*, 1997*c*, 2005) from the Southern Sierra Nevada population in California. There is no evidence of genetic exchange with either neighboring population, and mitochondrial haplotypes indicate this is a native population (Drew et al. 2003). The Northern California-Southwestern Oregon population has lower genetic diversity than native fishers in British Columbia, but retains a unique haplotype (Drew et al. 2003, Wisely et al. 2004).

Southern Sierra Nevada—Based on available information, this population occurs in 2 ecological subregion sections: the Sierra Nevada and Sierra Nevada Foothills (McNab and Avers 1994). This population currently occupies the west slope of the southern Sierra Nevada from the Merced River drainage in Yosemite National Park south through the Greenhorn Mountains at the southern end of the Sierra Nevada, and the Kern Plateau in the eastern Sierra Nevada (Fig. 5.2; Zielinski et al. 1995*c*, 2005). The current extent of occurrence records includes portions of several major river systems: South Fork Merced, San Joaquin, Kings, Kaweah, Tule, and Kern and fishers are generally found in

mid-elevation forests between 1,200 m and 2,800 m (USDA Forest Service 2006*b*). At its southern periphery, this population extends east to include the Kern Plateau between the Great Western Divide and the main crest of the Sierra Nevada. Regional habitat models predicting occurrence are consistent with survey results and suggest that fishers occur along relatively narrow elevation bands (Davis et al. 2007, Spencer et al. 2008). A systematic inventory of this population detected fishers at about 32% of sites surveyed (Zielinski et al. 2000). A regional monitoring program using an approach similar to that of Zielinski et al. (2000, 2005) detected fishers at 23–27% of sites surveyed annually (USDA Forest Service 2006*b*).

The Southern Sierra Nevada population is physically isolated from the Northern California-Southwestern Oregon population by about 350 km (Zielinski et al. 1995*c*, 1997*c*, 2005). The intervening area is largely forested but includes extensive human infrastructure (Chapter 4). This population has been isolated long enough to lose 1 of 2 haplotypes present in the Northern California-Southwestern Oregon population (Drew et al. 2003), and shows considerable genetic distance from it (Wisely et al. 2004). The Southern Sierra Nevada population has low genetic diversity; it retains only a single haplotype common to the Northern California-Southwestern Oregon population and populations in British Columbia, Idaho, and Montana (Drew et al. 2003). The Southern Sierra Nevada population appears to have lower heterozygosity and allelic richness than other populations in California, Oregon, and British Columbia (Wisely et al. 2004).

5.5. Population Size and Density in the Assessment Area

There have been no systematic or rigorous efforts to estimate population size and density of fishers for the South Thompson Similkameen, British Columbia, and Cascade Range, Oregon, populations. Two studies conducted in northern California estimated

fisher density and other demographic parameters using spatially intensive capture-mark-recapture techniques (Matthews et al. 2008, Thompson 2008). Matthews et al. (2008) reported a density of 0.27–0.39 fishers/km² in their Hoopa Valley study area. Thompson (2008) reported density estimates in coastal northern California of 0.05–0.22 females/km² and 0.05–0.09 males/km² during 2002 and 2003. Using camera traps in the Kings River drainage of the southern Sierra Nevada, Jordan (2007) estimated fisher densities from 2002 to 2004 at 0.095–0.134 fishers/km².

Several population estimates have been developed for the Southern Sierra population, and 1 has been developed for the Northern California-Southwestern Oregon population. Lamberson et al. (2000) used expert opinion to develop a population estimate of 100–500 fishers to parameterize a population viability analysis for the Southern Sierra Nevada population. Spencer et al. (2008) estimated population size by linking a regional habitat suitability model to life history attributes using program PATCH (Schumaker 1998). They also extrapolated density estimates from Jordan (2007) based on habitat suitability, and estimated population size using annual occupancy estimates from the USDA Forest Service regional population monitoring program (USDA Forest Service 2006b). Based on these 3 approaches, Spencer et al. (2008) estimated 160–350 fishers in the Southern Sierra Nevada population, of which 55–120 were adult females. Self et al. (2008) used deterministic-expert and regression approaches that related density estimates derived for small geographic areas to biotic features and applied this relationship uniformly across the Southern Sierra Nevada. They repeated this procedure for the Northern California-Southwestern Oregon population. The deterministic approach yielded estimates of 598 fishers in the Southern Sierra Nevada and 4,616 in the Northern California-Southwestern Oregon population, whereas the linear regression approach produced slightly lower estimates

(Self et al. 2008). The linear regression model relied on rainfall, hardwood cover, and shrub cover as predictor variables; however, it predicted 8.04 fishers/100 km² in the absence of any of these features.

Fishers are being systematically monitored in the Southern Sierra Nevada population using the proportion of sites occupied by fishers during noninvasive surveys (USDA Forest Service 2006b, Truex et al. 2008). From 2002 to 2006, fishers were detected at 23–28% of sites sampled and occupancy rates on the west slope of Sequoia National Forest were twice those on the Kern Plateau of the Sierra National Forest (USDA Forest Service 2008). Although population trend has not yet been analyzed using occupancy modeling techniques (sensu Mackenzie et al. 2006), there has been little change in the index of abundance during the first 5 years of monitoring (USDA Forest Service 2008).

5.6. Current Distribution in Adjacent Regions

Several additional fisher populations exist in regions adjacent to the Assessment Area: 2 in British Columbia and 2 in the Rocky Mountains of Idaho and Montana. We used trapping and specimen records from British Columbia (Cowan and Guiguet 1956, Hatler et al. 2008; British Columbia Ministry of Environment Wildfur Data System, unpublished data), fisher radiotelemetry research (Weir 1995, Weir and Harestad 1997, Davis 2007, Weir and Corbould 2008), and habitat models (Weir 2003) to describe the approximate geographic location and distribution of British Columbia populations. We used information from verifiable occurrence records and radiotelemetry studies (Roy 1991, Heinemeyer 1993, Vinkey 2003) to describe the geographic extent of fishers in northwest Montana. We used information from verifiable occurrence records and radiotelemetry, genetic, and detection studies (Jones 1991, Vinkey 2003, Vinkey et al. 2006, Idaho Conservation League 2009) to describe the general

extent of fishers in north-central Idaho and west-central Montana.

Western Plateaus and Valleys, British Columbia—The Western Plateaus and Valleys fisher population occurs in all or portions of numerous ecoregions within the Fraser River Plateau, Fraser Basin, Omineca Mountains, and Coastal Gap Ecoregions (Demarchi 1996). It is defined as west and north of the Fraser River; east to the height of land on the Coast Range and down the valley bottom of the Skeena River Drainage to Scotia River drainage; north to the north end of Williston Lake and east to the Rocky Mountains (Hart and Missinchinka Ranges; Fig. 5.2). It is unlikely, given the ecological variability encompassed within this area, that fishers are evenly distributed on the landscape.

Cariboo, British Columbia—The Cariboo includes all or portions of the Cariboo Plateau and Quesnel Lowlands ecoregions (Demarchi 1996). It is defined as east of the Fraser River; north of the South Thompson River; west of Adams lake, Adams River and the Cariboo Mountains; and south of the Fraser River in the northernmost part of the region (Fig. 5.2). It is unlikely, given the ecological variability encompassed within this area, that fishers in this population are evenly distributed on the landscape.

Northwestern Montana—Fishers occupy areas within 2 ecological subregion sections: the Bitterroot Mountains and Flathead Valley (McNab and Avers 1994). Fishers occur primarily in the Cabinet Mountains north of the Clark Fork River, and may extend into northeastern Idaho (Fig. 5.2). Although fishers were reintroduced into the Cabinets from 1989 to 1991, the current extent and distribution of fishers in this region is unclear.

North-Central Idaho and West-Central Montana—Fishers occupy areas within portions of the Bitterroot Mountains and the Idaho Batholith ecological subregion sections (McNab and Avers 1994). In

north-central Idaho, fishers occur primarily south of Interstate 90 and north of the Salmon River; however, distribution within this area appears to be patchy. Fishers occur within portions of the Clearwater, St. Joe, Lochsa, Selway, and Southfork Clearwater river drainages. In west-central Montana, fishers occur primarily in the Bitterroot Mountains along the Idaho-Montana border south of Interstate 90 and west of the Clark Fork and Bitterroot Rivers (Fig. 5.2). There appear to be few verifiable records in the southernmost part of the Bitterroot Mountains. Fishers in this region, especially west-central Montana, are an admix of native fishers and British Columbia fishers that were translocated to Idaho in the early 1960s (Vinkey et al. 2006).

During the past 35 years, there have been scattered verifiable occurrence records of fishers in other areas in southeastern British Columbia, north-central Idaho, and west-central Montana. Recent records in British Columbia are not believed to be indicative of an extant population (Weir et al. 2003). Although fishers have been detected north of Interstate 90 (Couer D'Alene Mountains) in Idaho and east of Flathead Lake in Montana (Mission, Swan, and Whitefish ranges; Vinkey 2003), it is unknown if these areas currently support fisher populations. Several fishers were detected in the Selkirk Mountains of northern Idaho during a DNA survey from 2003 to 2005 (Cushman et al. 2008). The individuals sampled appeared to be descendents of midwestern fishers that were translocated to the Cabinet Mountains from 1989 to 1991, although 1 sample had a haplotype associated with native fishers (Cushman et al. 2008). It is not clear if these detections represent a small self-sustaining population or extra-limital records, and the current extent and distribution of fishers in this region is unknown.

5.7. Implications for Conservation

1. Despite uncertainties in the historical record, there is strong evidence that the range and distribution of fishers in the Assessment Area

has been greatly reduced since the time of European settlement. There are 3, and possibly 4 (South Thompson Similkameen, British Columbia) extant populations. Two of the known populations (Northern California-Southwestern Oregon and Southern Sierra Nevada) are native and one (Cascade Range, Oregon) is reintroduced. The Southern Sierra Nevada and Cascade Range, Oregon, populations are geographically small and potentially vulnerable and isolated from all other populations. The most effective conservation strategy to buffer these populations against stochastic events and the uncertain effects of climate change is to expand populations through changes in distribution or additional translocations.

2. Conservation and recovery of fishers should not be constrained by current understanding or uncertainty of pre-European fisher distribution. To successfully conserve the species, measures must be applied across large geographic extents, and will require creating networks of self-sustaining populations to maintain current genetic diversity, promote genetic interchange, and maintain the ability of fishers to adapt to changing environments.
3. Several anthropogenic factors have been implicated as contributing to the decline of fishers since European settlement. Fur harvest, timber harvest, predator control, and urbanization have had the greatest impacts. Although fisher populations persist in some areas, human population growth and landscape modifications have created new challenges and successful conservation will require mitigating multiple stressors.
4. Extant populations within the Assessment Area are all isolated to some degree by distance and anthropogenic and ecological barriers (e.g., large urban and agricultural areas, major

transportation and development corridors, major water impoundments, and natural grasslands) that, in some cases, may be beyond the capacity of fishers to overcome. Thus, translocation of fishers to reestablish populations in some geographic areas may provide conservation benefits to fishers within the Assessment Area. However, well-planned translocations, such as the recent reintroduction of fishers to the Olympic Peninsula, should only be used when other management options will not meet conservation objectives. Genetic considerations must be taken into account when selecting source populations for translocations to improve the probability of success and conserve genetic integrity and regional adaptability of fisher populations within the Assessment Area (Storfer 1999, Taylor 1991, Pamilo and Savolainen 1999).

5. For conservation efforts to be successful and effective, we need a better understanding of the extent and distribution of the South Thompson Similkameen, British Columbia, and Cascade Range, Oregon, populations. Regional surveys and long-term monitoring of all extant populations will be necessary to identify stable, expanding, and declining populations and help prioritize appropriate conservation measures.
6. Fishers have been absent from a large portion of their historical range for over half a century. Conservation efforts, especially those to restore a little-known species like the fisher, are more likely to succeed if they include public education and involve multiple partners and collaboration.



CHAPTER 6. BIOLOGY AND ECOLOGY

6.1. Life History

6.1.1. Reproduction

Some of the earliest information on fisher reproductive biology came from fur farmers and revealed that parturition and mating occurred from late winter to early spring, and that the gestation period lasted almost an entire year (Hodgson 1937, Hall 1942). The long gestation period in female fishers is the result of delayed implantation; instead of attaching to the uterus wall, a newly fertilized egg (blastocyst) goes into embryonic diapause for 10–11 months (Powell 1993, Frost and Krohn 1997, Frost et al. 1997). After this delay, the blastocyst implants and embryonic development resumes with parturition occurring in about 36 days (Frost et al. 1997). Reproductive females typically give birth to kits from mid-March to early April. The earliest and latest parturition dates observed in western North America were 9 March (Higley and Matthews 2006) and 12 April (Weir and Corbould 2008). Fishers mate within approximately 10 days following parturition, thus adult females can be pregnant most of the year (Fig. 6.1; Hodgson 1937, Hall 1942, Powell 1993).

Typically, fishers are not reproductive until 2 years of age and may not breed every year once they have reached sexual maturity. Although male fishers can produce sperm at 1 year of age, evidence suggests that the baculum may not be developed enough to induce ovulation in females (Wright and Coulter 1967, Douglas and Strickland 1987, Frost 1994, Frost et al. 1997). Therefore, male fishers may not become effective breeders until 2 years of age. Female fishers can breed at 1 year of age (Hall 1942, Wright and Coulter 1967, Powell 1993) but, owing to delayed implantation, will not give birth to kits until they are at least 2 years old. Not all adult females (≥ 2 years in

age) in a given population give birth to kits every year (e.g. Aubry and Raley 2006, Higley and Matthews 2006, Weir and Corbould 2008).

Field studies conducted on wild fisher populations have reported 1–4 kits in a single litter and mean litter sizes of 1.8–2.8 kits (Paragi et al. 1994b, 1996; York 1996; Aubry and Raley 2006; Higley and Matthews 2006). Other studies have estimated average litter size in wild populations to range from 2.3–3.7 kits based on laboratory examination of corpora lutea in the ovaries of harvested females (Eadie and Hamilton 1958, Wright and Coulter 1967, Kelly 1977, Leonard 1986, Douglas and Strickland 1987, Crowley et al. 1990, Weir 2003). Although these data provide important information on fisher reproductive potential, the number of corpora lutea tends to overestimate the actual number of kits born live (Crowley et al. 1990, Powell 1993). Observations of fisher kits born in captivity and in the wild indicate that some kits may die soon after birth. During a 3-year study, 10 of 38 (26%) kits born in captivity died within a week after birth (Frost and Krohn 1997). Studies of wild populations have reported mortality of some kits in a litter (e.g., kit found dead near a den site), and have documented den abandonment by reproductive females indicating that all kits were either born dead or died sometime soon after birth (York 1996, Aubry and Raley 2006, Higley and Matthews 2006).

Although sample sizes were small and variation among years high, the average annual reproductive rate of adult female fishers (proportion that denned) in western North American populations was 64% (range = 39–89; Table 6.1). An additional study in northern California reported a 51% average annual denning rate for 2 study areas combined over a 2-yr period (22% of collared fishers in year 1 and 80% of



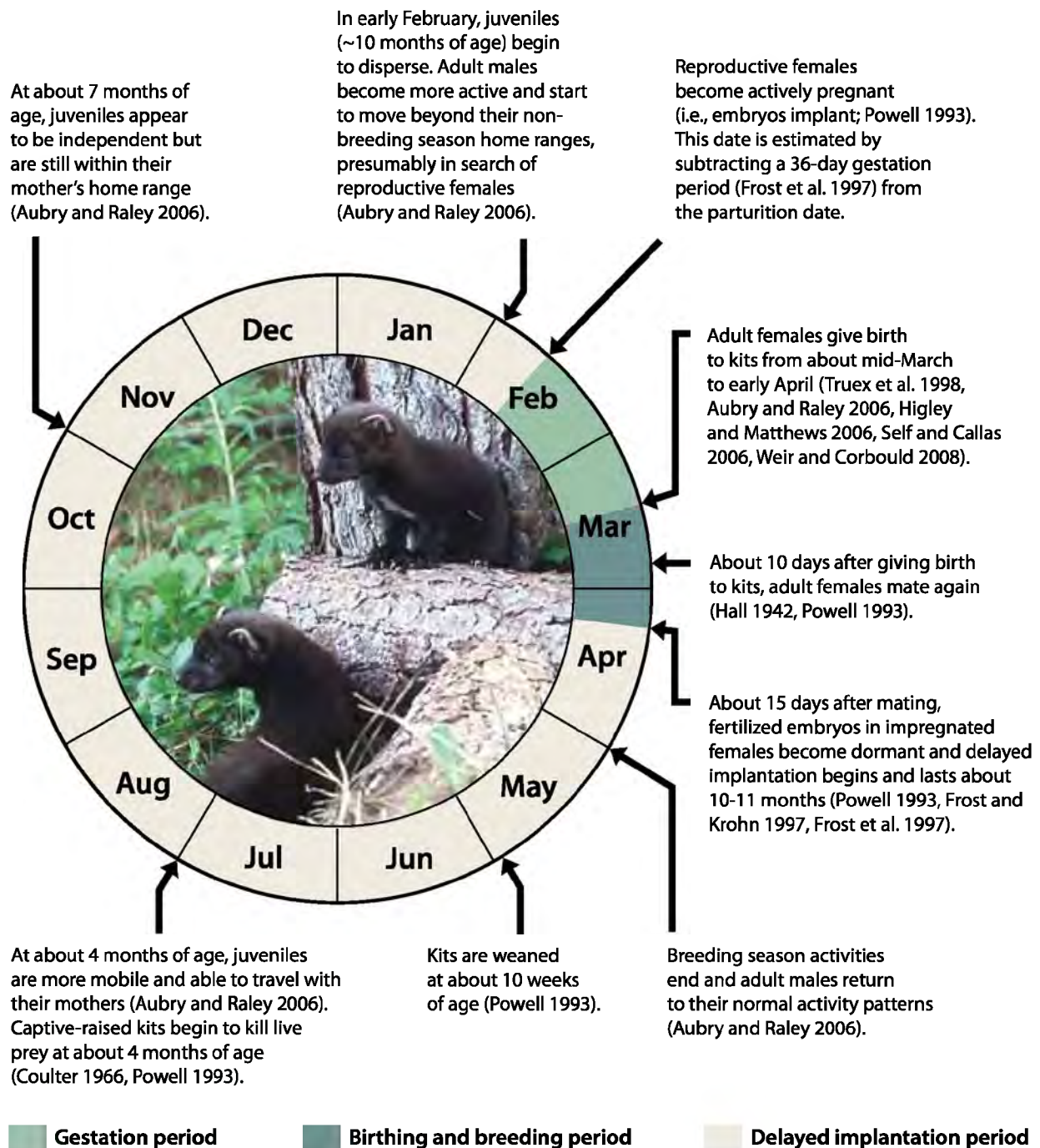


Figure 6.1. Reproductive and seasonal activities of fishers in the Assessment Area and adjacent regions in western North America. The timing of various events is approximate and based on field observations of radio-collared adult and juvenile fishers and general information on the reproductive cycle (e.g., delayed implantation, gestation, and birthing periods) of adult females. Figure is adapted from Powell (1993) and Aubry and Raley (2006).

Table 6.1. Annual reproductive rate (no. of denning females/no. of adult females monitored during a single reproductive season) for wild fisher populations in the Assessment Area and adjacent regions in western North America. Reproduction was determined to have occurred if an adult (≥ 2 yr old) female exhibited denning behavior (D^a), was observed with kits (K^b), or was lactating (L^c).

Fisher population	Annual reproductive rate							Method	Source
	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7		
Western Plateaus and Valleys	4/6	3/3	3/5	2/4				D	Weir and Corbould 2008
Cariboo	0/3	2/4	2/3					D	Weir 1995
Cascade Range, Oregon	2/2	2/2	1/3	2/4	1/3	1/2	2/4	D, K, L	Aubry and Raley 2006
Northern California-Southwestern Oregon	7/8	9/11	10/12	15/15				D, K	Higley and Matthews 2006; Matthews 2007, 2008
	3/4	7/7						K, L	Higley et al. 1998
	8/11	1/7						L	Truex et al. 1998
Southern Sierra Nevada	6/12	6/10	3/6					L	Truex et al. 1998

^a During the early spring, the behavior of adult females changed abruptly from their normal activity pattern and use of numerous rest sites within their home range to restricted use of a single structure for an extended period of time.

^b ≥ 1 kits observed at den site or with adult female.

^c When live-captured, adult female was examined and showed evidence of lactation.

collared fishers in year 2; Reno et al. 2008). Average annual reproductive rates $>70\%$ have only been documented in 1 study area in northern California (Table 6.1) (Higley et al. 1998; Higley and Matthews 2006; Matthews 2007, 2008). Average reproductive rates observed for fishers in eastern North America were similar to those observed in western North America (range = 0.45–0.65; Arthur and Krohn 1991, Paragi et al. 1994a, York 1996). Recent information suggests that reproductive rates in adult female fishers may be related to age. In central interior British Columbia, adult females 5–7 years of age ($n = 4$) gave birth to kits 100% of the years monitored, whereas females 2–4 years of age ($n = 5$) gave birth only 50% of the time (Weir and Corbould 2008). Not all reproductive efforts are successful. The annual reproductive rate during 7 breeding seasons in a study in southern Oregon was 59% but, on average, only 44% of females monitored ($n = 2$ –4 in any given year) successfully weaned ≥ 1 kit (Aubry and Raley 2006). Similarly, the average annual denning

rate of adult females in northern California was 88%, yet only 61% of the females monitored ($n = 8$ –15 in any given year over a 4-yr period) successfully weaned ≥ 1 kit (Higley and Matthews 2006; Matthews 2007, 2008).

Fisher kits are altricial when born: they are blind, their ears are tightly closed, and they have only a sparse growth of fine hair (Plate 6.1; Hall 1942, Coulter 1966, Powell 1993, Frost 1994). Their eyes and ear canals open at approximately 7–8 weeks, and shortly thereafter the mother begins bringing them solid food (Coulter 1966, Powell 1993, Frost 1994). Powell (1993) observed that hand-reared fisher kits started taking small amounts of solid food at 8 weeks of age and were weaned by 10 weeks. By about 9 weeks, kits became more coordinated and mobile (Coulter 1966, Powell 1993) and, at 3 months, litter mates aggressively competed for food (Coulter 1966). However, hand-reared kits were not able to kill live prey until they were about 4 months old (Coulter



Plate 6.1. Fisher kits are altricial when born: they are blind and their ear canals are closed (A: 3-week-old kit; B: 6–7-week-old kit) until they are 7–8 weeks of age. They are weaned at about 10 weeks (C), but their mobility is still limited (D: 12-week-old kits) until about 4 months of age.

1966, Powell 1993). Footage from remote video cameras placed at den sites in the wild revealed that fisher kits 3–4 months of age were still learning to climb trees and handle prey that the adult female had captured (Aubry and Raley 2006).

Across their range, female fishers give birth to kits in cavities in live or dead trees (Leonard 1980, Paragi 1990, Paragi et al. 1996, Truex et al. 1998, Weir 2003, Aubry and Raley 2006, Higley and Matthews 2006, Self and Callas 2006, Weir and Corbould 2008; see Section 7.2.7). Reproductive females may use more than 1 tree cavity from the time they give birth to kits until the kits are weaned (about a 10-week period; Arthur and Krohn 1991, Paragi et al. 1996, Truex et al. 1998, Aubry and Raley 2006, Higley and Matthews 2006; Plate 6.2). After the kits are weaned, adult females and kits become more mobile but often use cavities in live or dead trees, hollow logs, log piles, or other types of structures for prolonged periods of time (≥ 2 days; Truex et al. 1998, Aubry and Raley 2006, Higley and Matthews 2006). Researchers have used varied nomenclature to describe the tree cavity where parturition occurs and subsequent structures used by adult females with kits (Table 6.2). Because fisher kits are vulnerable until they are at least 4 months old, we believe it is important to define structures used by reproductive females according to the developmental stage of their kits. Hereafter, we use the following 4 terms: 1) natal den = the tree cavity in which parturition occurs, 2) pre-weaning den = any subsequent structure used after the natal den but before the kits are weaned, 3) post-weaning den = any structure used after the kits are weaned, and 4) reproductive den = a general term that we will use when the developmental stage of the kits was unknown or to refer to all dens (i.e., natal, pre- and post-weaning) used by a female during a single reproductive effort.

6.1.2. Survivorship

Life expectancy of fishers is believed to be about 10 years of age (Powell 1993); however, a fisher in

British Columbia was 12 years old when trapped (Weir 2003). Although fisher age can be estimated by analyzing cementum annuli of an extracted tooth, few studies have employed this method. In central interior British Columbia, 3 of 18 live-captured fishers were >6 years of age at first capture, and none survived beyond 8.7 years of age (Weir and Corbould 2008). Of 62 fishers live-captured in northern California, only 4 were >6 years of age and no animals were older than 8 years (Brown et al. 2006, Reno et al. 2008). Similarly, there are very few data on the age structure of wild, unharvested fisher populations. Most existing information comes from fur harvest data and does not reflect the true age structure of fisher populations, as young animals are more vulnerable to trapping (Krohn et al. 1994). Two recent studies in northern California provide limited information on the age structure of unharvested fisher populations in that region. In coastal northern California, 45% of fishers sampled were not yet of reproductive age (<2 years), 52% were 2–6 years of age, and only 1 animal was >6 years of age (Table 6.3; Brown et al. 2006). Similarly, on average, most (55%) fishers sampled in an inland study area were not yet of reproductive age, 37% were 2–6 years of age, and only 8% were >6 years of age (Table 6.3; Reno et al. 2008). Because live trapping was used to sample these populations, results may be biased toward younger animals. Regardless, the age structures of *Martes* populations are affected by many factors including age-specific survivorship, population density, and prey availability and will rarely be stable among years (Powell and Zielinski 1983, Powell 1994a).

Estimates of annual survival rates for fishers vary across the species' range in North America and appear to be influenced in part by the presence or absence of commercial trapping seasons. Where legal harvest of fishers occurs, and gender-specific rates were calculated, survival rates for adult males were on average 34% lower than those for adult females (Table 6.4). In Maine, the average survival rate of



Plate 6.2. Reproductive females may use more than 1 den cavity prior to the kits being weaned. Investigators often place remotely-triggered cameras near natal or pre-weaning dens to document when a female moves her kits (A–D) and how many kits are alive at the time of the move.

Table 6.2. Nomenclature used by researchers to describe sites used by reproductive female fishers with kits.

Source	Term	Definition
Paragi et al. 1996	Natal den	The cavity where parturition was assumed to have taken place plus all subsequent dens used within the denning period (~71-day period following parturition). Use of the same cavity on >2 consecutive days by adult females during spring was assumed to indicate establishment of natal den and birth of kits.
York 1996	Maternal den	The den site where female fishers gave birth to kits. Maternal den sites were identified when adult females consistently rested in the same tree cavity during the denning season.
Powell et al. 1997b	Maternal den	Site repeatedly used by an adult female and her kits when the kits were still dependent on the mother for food.
Truex et al. 1998	Natal den	Site where parturition was assumed to have occurred. Natal dens were identified when adult females exhibited a distinct behavioral change in the spring and switched from using numerous rest sites per week to occupying a single structure repeatedly for at least 3 consecutive weeks.
	Maternal den	Any rest site where an adult female was observed with ≥ 1 kit following the natal den occupancy and prior to juvenile dispersal.
Schumacher 2000 ^a	Natal den	Site used by females with kits from parturition until kits begin to eat solid food.
	Maternal den	Site used by females with kits after the kits begin to eat solid food.
Aubry and Raley 2006	Natal den	Structure used by adult females for birthing and nursing kits until weaning at about 8-10 weeks of age. Adult females were considered to have initiated denning and given birth to kits when they began to repeatedly use the same structure in early spring.
	Maternal den	After occupying natal den, other site used by adult female and kits during the period when kits were still dependent on the female for food, which was determined to be through July.
Higley and Matthews 2006	Natal-parturition den	Where parturition occurred. Determined when adult females suddenly changed from using numerous rest sites per week to repeated use of the same structure for ≥ 3 days.
	Natal pre-weaning den	Den used after parturition but before kits were weaned (kits considered weaned at 10 weeks of age).
	Maternal den	Den used after weaning but before kits could actively follow the mother.
Self and Callas 2006	Natal den	Where parturition occurred.
	Maternal den	Where females moved kits after parturition.
Reno et al. 2008	Natal den	The place of parturition. In the field, natal dens were identified as the first structure in which a female was found exhibiting denning behavior.
	Maternal den	Any structure used after the natal den while the female was still exhibiting denning behavior.
Weir and Corbould 2008	Natal den	The first den used by a reproductive female (i.e., den where young were born).
	Maternal den	Any subsequent structure used consistently by an adult female with kits until mid-June (i.e., end of the rearing season).

^a Definitions were developed for American marten, but author proposed that they be adopted for all *Martes* including fishers.

Table 6.3. Age distribution of live-captured fishers from 2 study areas in northern California. Age was determined by analyzing cementum annuli of the first upper premolar extracted from each animal.

Year sampled	Sex	Age (year)										n	Source
		0	1	2	3	4	5	6	7	8			
2004–2005	F	1	4	3	3	0	1	1	0	0	18	Brown et al. 2006	
	M	4	5	2	0	3	1	2	0	1	13		
2006	F	0	3	3	0	0	0	0	1	1	8	Reno et al. 2008	
	M	1	7	2	0	0	1	0	1	0	12		
2007	F	0	1	1	0	1	0	0	0	0	3	Reno et al. 2008	
	M	3	2	2	0	0	0	1	0	0	8		

Table 6.4. Average annual survival rates (percent of individuals surviving from one breeding season to the next) documented during radiotelemetry studies of established fisher populations (i.e., data from recently translocated animals were not included).

Fisher population	Adult			Juvenile			Number		Source
	All	F	M	All	F	M	Fishers	Years	
Assessment Area and adjacent regions									
Western Plateaus and Valleys ^a	0.71						14	3	Weir and Corbould 2008
Cascade Range, Oregon ^b	0.82	0.78	0.85				19	6	Aubry and Raley 2006
Northern California-Southwestern Oregon ^b		0.84	0.84				22	4	Truex et al. 1998
		0.73	0.86				22	5	Truex et al. 1998
		0.72					18	1	Higley and Mathews 2006
Southern Sierra Nevada ^b		0.61	0.73				23	2	Truex et al. 1998
Elsewhere in North America									
Ontario ^a		0.63	0.33				59 ^c	1	Koen et al. 2007a
		0.81	0.45				59 ^c	1	Koen et al. 2007a
Maine ^a	0.89 ^{d,e}			0.72 ^{d,e}			76	6	Krohn et al. 1994
		0.79 ^f	0.57 ^f	0.38 ^{e,f}			76	6	Krohn et al. 1994
Massachusetts ^a		0.90	0.77		0.84	0.77	97	3	York 1996

^a Fishers can be legally harvested; however, trapping pressure varies among populations and regions.

^b No legal trapping season for fishers.

^c Survival estimates were for a single year but the reported sample size was for 2 years combined.

^d Average survival estimated for the non-trapping period rather than annually.

^e Data were pooled because there was no difference in survival rates between females and males.

^f Average survival estimated for the trapping period rather than annually.

juveniles declined from 72% during the nontrapping period to 38% during the trapping season (Table 6.4). The overall mean annual survival rate for 3 untrapped populations in the Assessment Area was 0.74 (range = 0.61–0.84) for adult females and 0.82 (range = 0.73–0.86) for adult males (Table 6.4).

Although females had lower survival rates than males in 3 studies, it is not clear whether these differences were real or an artifact of small sample sizes. In the southern Sierra Nevada, survival estimates for females and males had large and overlapping confidence intervals (Truex et al. 1998); other studies have not

reported confidence limits. In the southern Sierra Nevada, Jordan (2007) used a modeling approach to estimate survival rates from mark-recapture data. During a 3-year period, there was no difference in average annual survival rate of adult females (\bar{x} = 0.88, 95% CI = 0.59–0.97) and adult males (\bar{x} = 0.88, 95% CI = 0.54–0.98; Jordan 2007).

Anthropogenic sources of mortality accounted for an average of 21% of all fisher deaths documented during 8 studies in the Assessment Area and adjacent regions compared to an average of 68% during 3 studies in eastern North America (Table 6.5). In eastern North America, the primary source of human-caused fisher mortality was trapping (Douglas and Strickland 1987, Powell 1993) and a comparison of 2 studies suggests that mortality rates may vary with trapping pressure. Trapping accounted for 85% of all human-caused fisher mortalities observed in a heavily harvested population in Maine (Krohn et al. 1994) compared to only 50% in a lightly trapped population in Massachusetts (York 1996). Adult females were least vulnerable to trapping; adult males and juveniles of both sexes were most vulnerable (Krohn et al. 1994, Strickland 1994). Regardless of whether fishers can legally be trapped in an area, mortality from trapping can still occur because fishers are attracted to traps set for other species (Weckwerth and Wright 1968, Lewis and Zielinski 1996, Weir and Corbould 2008). In central interior British Columbia, 3 of 9 radio-collared fishers that died were caught in traps targeting marten or river otter; a fourth untagged fisher was also found dead in a kill-trap (Weir and Corbould 2008). Most studies of radio-collared fishers have documented various other sources of anthropogenic mortality including vehicle collisions, poaching, fatal injuries inflicted by domestic dogs, and death in water-storage structures (Table 6.5).

Natural sources of mortality accounted for an average of 54% of all fisher deaths documented during 8 studies in the Assessment Area and adjacent regions

compared to 20% in 3 eastern studies (Table 6.5). Predation was the most frequently (79%) observed source of natural mortality in all 8 western studies (Table 6.5). Results from necropsies, which involved examination of wounding patterns and other evidence found at kill sites (Plate 6.3), determined that fishers had most likely been killed by cougar (*Puma concolor*), coyote (*Canis latrans*), Canada lynx (*Lynx canadensis*), bobcat (*Lynx rufus*), and wolverine (Truex et al. 1998, Higley and Matthews 2006, Weir and Corbould 2008). It is unknown whether some of these deaths were actually predation or interspecific conflicts (e.g., cougar defending a deer kill on which a fisher was scavenging) as the fisher was not always consumed. Several studies have documented both male and female fishers dying from injuries sustained during apparent intraspecific conflicts (Buck et al. 1983, Mazzoni 2002, Weir et al. 2005, Weir and Corbould 2008). Two studies in California documented potential predation on fishers by raptors: great-horned owl (*Bubo virginianus*; Buck et al. 1983) and an unknown species of raptor (Truex et al. 1998). Other natural sources of fisher mortality include choking on food items, disease, and starvation (Table 6.5). In some instances the proximate cause of death may have been disease or starvation but the ultimate cause was old age or injuries that prevented animals from foraging or being able to digest food properly (Aubry and Raley 2006, Weir and Corbould 2008).

6.1.3. Recruitment

Recruitment of new individuals into a population is a function of births, deaths, immigration, and emigration. Most fisher populations within the Assessment Area are isolated and there is little evidence to suggest that immigration or emigration have a substantive effect on recruitment rates. Although we presented various indices associated with fisher reproduction and survival in the previous 2 sections, additional information on age-specific survival rates, especially survival of young, is necessary to determine recruitment rates. These are

Table 6.5. Anthropogenic and natural sources of mortality in established fisher populations (i.e., data from recently translocated animals were not included). Sources of mortality included: legal or incidental trapping (T), poaching (PO), collisions with vehicles (V), other anthropogenic sources (attack by domestic dogs, drowning in cisterns, research-related mortality), predation (PR), starvation (S), other natural sources (choking, disease, drowning, fatal injuries from falling trees), and unknown (UN).

Fisher population	Number monitored	Number died								Source
		Anthropogenic				Natural				
		T	PO	V	other	PR ^a	S	other	UN	
Assessment Area and adjacent regions										
Western Valleys and Plateaus ^b	20	3 ^c			1	1	2 ^d	1	1	Weir and Corbould 2008
Cascade Range, Oregon	20		1		1	2	1 ^e	3	1	Aubry and Raley 2006
Northern California-	21					4			3	Buck et al. 1983
Southwestern Oregon	22		2			2			2	Truex et al. 1998
	22			2		3			2	Truex et al. 1998
	16	2				5				Higley et al. 1998, Higley and Matthews 2006
	18 ^f					3		1	1	Higley and Mathews 2006
Southern Sierra Nevada	23				1	4			6	Truex et al. 1998
Elsewhere in North America										
Ontario ^b	59	9			3 ^g	2		6 ^h	8	Koen et al 2007 <i>a</i>
Maine ^b	76	40	3	2	2	1		2		Krohn et al. 1994
Massachusetts ^b	97	4	1	3		2		1	1	York 1996

^a Includes predation and fatal wounds from interspecific, and potentially some intraspecific, conflicts.

^b Fishers can be legally harvested; however, trapping pressure varies among populations and regions.

^c Animals were caught by trappers targeting marten or river otter.

^d For 1 mortality, a porcupine quill in the animal's throat became infected and the animal subsequently starved.

^e Starvation was likely due to old age; the animal's teeth were worn to the gum line.

^f Only adult females were monitored.

^g Different types of anthropogenic mortality were not distinguished; this includes road-killed animals.

^h Different types of natural mortality were not distinguished; this includes emaciation, disease, drowning, and infections.

very challenging data to collect and are lacking for most studies in western North America. In central interior British Columbia, researchers estimated that the average fall recruitment rate of juveniles per adult female was 0.58, suggesting very little recruitment of new individuals into that population (Weir and Corbould 2008). Although such estimates provide potential insights on population growth in a given area, they must be viewed with caution as they are typically derived by piecing together various information sources (e.g., denning rates of

adult females, telemetry and live-capture data, aging data, and anecdotal field observations) and making assumptions about age-specific survival rates (e.g., Weir and Corbould 2008). Evaluating recruitment or population growth estimates derived for fisher populations in eastern North America (e.g., Paragi et al. 1994b) provides few insights on the dynamics of western populations because legal harvest of fishers in the east directly affects gender and age-specific survival rates (Section 6.1.2).



Plate 6.3. A necropsy confirmed that this male fisher was killed by a bobcat (A: punctures in the skull of the male fisher; B: both the upper and lower canines of a female bobcat [skull on right] fit the punctures in the fisher skull [left]).

6.1.4. Diseases and Parasites

Relatively little is known about diseases of fishers and there have been no documented cases of disease in wild populations causing widespread mortality and subsequent population declines (Powell 1993; Philippa et al. 2004; Brown et al. 2006, 2008). Nevertheless, high mortality rates and even extirpation from disease have been documented for other mustelid species. In Wyoming, an epizootic of canine distemper virus (CDV) in 1985 led to the extirpation of black-footed ferrets (*Mustela nigripes*) from the wild (Thorne and Williams 1988). In clinical studies, many mustelid species appear to be susceptible to infections of CDV, and severe disease has been observed in American badgers (*Taxidea taxus*), northern river otters, American mink, and black-footed ferrets (Deem et al. 2000, Williams 2001, Langlois 2005). Canine distemper virus is recognized as a worldwide problem for all families of terrestrial carnivores including many threatened and endangered species (Deem et al. 2000, Williams 2001). Rabies virus (Ruprecht et al. 2001) and parvoviruses (PV), such as Aleutian disease of mink

(ADV) and mink enteritis virus (MEV; Barker and Parrish 2001, Langlois 2005) are also known to cause severe disease in mustelids. In North America, rabies has been documented in fishers, as well as American badgers, northern river otters, American mink, and *Mustela* spp. (Krebs et al. 2003). Some studies have suggested that ADV may be the cause of declining European mink (*Mustela lutreola*) populations (Manas et al. 2001, Yamaguchi and Macdonald 2001, Frolich et al. 2005). In North America and elsewhere, MEV has caused high mortality in the mink-farming industry but so far it has not been reported in wild minks (Barker and Parrish 2001). Recently, a wild stone marten (*Martes foina*) in Germany was found to be infected with a highly pathogenic avian influenza virus (Klopfleisch et al. 2007). These and other disease agents (e.g., parasitic mites that cause sarcoptic mange, bacteria that cause plague, protozoa that cause toxoplasmosis, etc.) may cause morbidity or mortality of individual fishers (Brown et al. 2006, 2008), however, the impacts they have on fisher population dynamics within the Assessment Area are unknown at this time.

Although no comprehensive studies have been conducted on the prevalence and severity of diseases in wild fisher populations, several studies have reported data on exposure of fishers to a variety of pathogens including CDV, PV, rabies, and others (Table 6.6, Appendix 6.1). Differences in exposure rates among study areas may be related to several factors including differences in fisher population densities, density of vectors (e.g., ticks, fleas), and the distribution of other wildlife species and domestic animals that may act as reservoirs for infection (Table 6.6; Philippa et al. 2004, Brown et al. 2008). For example, greater densities of fishers in northwestern California compared to north-central

California, and a potentially more diverse carnivore community, may be related to the higher exposure rates observed for most of the pathogens tested for in that study area (Table 6.6; Brown et al. 2008). None of the fecal samples from 33 fishers in the southern Sierra Nevada tested positive for exposure to canine parvovirus, whereas 18% of fecal samples (18/98) from fishers in Hoopa, California tested positive (Brown et al. 2008). It is possible that isolated and more geographically remote fisher populations, like the one in the southern Sierra Nevada, are less likely to be exposed to sources of infection (Philippa et al. 2004, Brown et al. 2008). Although results from surveys such as these do not provide information

Table 6.6. Prevalence of antibodies to pathogens in blood samples collected from wild fishers in British Columbia (Philippa et al. 2004) and in 2 California study areas (Brown et al. 2008). Blank cells indicate that samples were not tested for a particular pathogen and zeros indicate that all samples tested were negative.

Pathogen	British Columbia		Northwestern California		North-central California	
	Number		Number		Number	
	positive	<i>n</i>	positive	<i>n</i>	positive	<i>n</i>
Virus						
Canine adenovirus	4	28	4 ^a	95	1 ^a	19
Canine coronavirus	4	28				
Canine distemper	0	28	5	98	0	19
Canine hepatitis virus			5	96	0	19
Canine parvovirus			28	90	2	19
Dolphin morbillivirus	0	28				
Parainfluenza virus type 3	4	28				
Phocine distemper virus	0	28				
Rabies virus	4	28				
West Nile virus			4	99	3	19
Bacteria						
<i>Bartonella</i> spp. ^b			0	35	0	15
Granulocytic anaplasmosis			60	79	5	19
Lyme borreliosis			24	102	1	19
Plague			0	34	0	12
Rocky Mountain spotted fever ^c			28	55	6	19
Protozoa						
Toxoplasmosis	18	28	45	77	6	13

^a Canine adenovirus type 2.

^b Several species cause disease in humans, and evidence from California suggests that infected wildlife (e.g., coyotes) may act as a reservoir for these human pathogens (Chang et al. 1999, 2000).

^c Includes any positive results for *Rickettsia* spp.

on severity of illness or death that may result from exposure to various pathogens (Philippa et al. 2004, Brown et al. 2008), they do provide necessary baseline information that can be used to guide future studies on the potential impact of infectious diseases on wild fisher populations.

6.2. Spacing Patterns and Movements

6.2.1. Territoriality and Home Range

Fishers are solitary animals, interacting with other fishers only during breeding, kit rearing (adult female and kits only; males do not participate in the rearing of young), and territorial defense (Powell 1993). Fishers exhibit intrasexual territoriality; adults of the same sex typically have non-overlapping home ranges whereas home ranges of males overlap those of multiple females (Fig. 6.2) (Powell 1993, 1994a; Powell and Zielinski 1994). Fishers may establish home ranges based on availability and vulnerability of prey (Powell and Zielinski 1994) and to reduce competition for food (Arthur et al. 1989b). Powell (1994a) hypothesized that fishers maintain a territory to prevent other fishers from hunting and possibly conditioning prey to be more wary, rather than actual competition for resources.

On average, fisher home ranges in the Assessment Area and adjacent regions were 18.8 km² for females and 53.4 km² for males (Table 6.7). Compared to western studies, fisher home range estimates from 6 eastern studies were somewhat smaller: 9.8 km² for females (range = 4–19) and 22.6 km² for males (range = 9–49; Kelly 1977, Johnson 1984, Arthur et al. 1989a, York 1996, Garant and Crete 1997, Koen et al. 2007b). However, there was considerable variation in home range estimates among all studies owing, in part, to differences in sampling effort (e.g., season and duration of monitoring, and number of relocation points collected for each animal) and analytical methods (e.g., minimum convex polygon, fixed or adaptive kernel, harmonic mean, etc.). Thus,

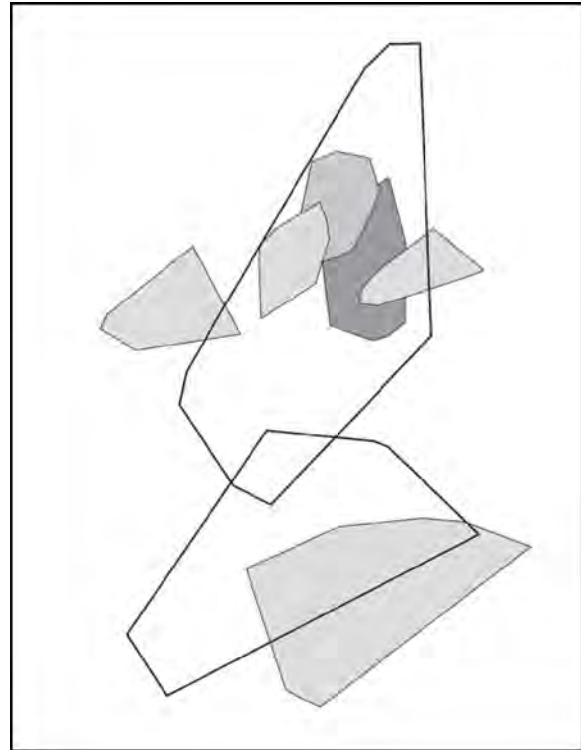


Figure 6.2. An example of the spatial distribution of home ranges for adult male and female fishers. Typically, adult fishers of the same sex have non-overlapping home ranges, but the home ranges of adult males overlap >1 adult female home ranges. Although there is some overlap in the 100% minimum convex polygons among females (gray-shaded polygons) and among males (polygons outlined with a thick black line) in this example, less than 5% of the locations for a single individual occurred in a neighboring territory occupied by a fisher of the same sex. Nevertheless, spatial distribution of fishers in a population, and overlap among and between sexes, will likely vary by region, season, and habitat quality. This figure was adapted from Aubry et al. (2004).

it is difficult to compare these data among geographic regions or studies. Nevertheless, 2 consistent patterns have emerged from analyses of fisher home range sizes: male home ranges were larger than female home ranges and, in the Assessment Area and adjacent regions, home range size generally increased from southern to northern latitudes (Fig. 6.3).

For 9 western studies where investigators estimated both male and female home range sizes, male home ranges were 3 times larger than those of females

Table 6.7. Home range estimates for fishers in the Assessment Area and adjacent regions in western North America. Only estimates that were derived from >2 animals and >10 relocation points were included in calculation of means; data from recently translocated animals were not included. MCP = minimum convex polygon; AK = adaptive kernel; HM = harmonic mean.

Fisher population	Mean home range size (km ²)				Method	Source
	Female	n	Male	n		
Western Valleys and Plateaus	59.0 ^a	6	177.5 ^b	2	100% MCP	Weir and Corbould 2008
Cariboo	26.4	5			90% ADK	Weir 1995, Weir and Harestad 2003
North-central Idaho and West-central Montana	40.5	4	88.6	5	90% HM	Jones 1991
Cascade Range, Oregon	25.0	7	62.0 ^c	4	95% MCP	Aubry and Raley 2006
Northern California-	1.7	7	7.4	2	100% MCP	Yaeger 2005
Southwestern Oregon	5.5	6			100% MCP	Simpson Resource Company 2003
	23.5	7	38.3	9	100% MCP	Yaeger 2005
			29.6	3	100% MCP	Self and Kerns 2001
	6.9 ^d	3			100% MCP	Reno et al. 2008
	10.4 ^e	6			100% MCP	Reno et al. 2008
	4.2	4	19.8	5	100% MCP	Buck et al. 1983
	15.0	7	58.1	2	100% MCP	Zielinski et al. 2004b
Southern Sierra Nevada	11.9	7	21.9	4	100% MCP	Mazzoni 2002
	5.3	8	30.0	4	100% MCP	Zielinski et al. 2004b

^a The mean 95% and 50% fixed-kernel distributions were 49.1 km² and 7.1 km², respectively.

^b The mean 95% and 50% fixed-kernel distributions were 218.9 km² and 46.9 km², respectively.

^c Non-breeding-season home range. The 95% MCP breeding season home range for males was 147 km² (n = 3).

^d The mean 95% MCP was 5.5 km²; the mean 95% and 50% fixed-kernel distributions were 8.7 km² and 1.6 km², respectively.

^e The mean 95% MCP was 8.9 km²; the mean 95% and 50% fixed-kernel distributions were 12.9 km² and 1.9 km², respectively.

(Table 6.7). Results were similar for eastern studies; overall, male home ranges were 2.7 times larger than those of females (Kelly 1977, Johnson 1984, Arthur et al. 1989a, York 1996, Garant and Crete 1997, Koen et al. 2007b). There is strong evidence that home range size of *Martes* spp. (Powell 1994a) and most terrestrial mammals (Harestad and Bunnell 1979, Lindstedt et al. 1986) increases with body size; thus, it is not surprising that male fishers would use larger areas than females. Based on energetic requirements associated with body size, however, one would expect male home ranges to be only 1.5–1.7 times larger than those of females (Powell and Zielinski 1994). Powell (1994a) and Powell and Zielinski (1994) proposed several additional factors that may contribute to the disproportionate size of male home ranges: 1) male fishers may have

disproportionately greater energetic requirements than those estimated by body size alone, thus requiring more space to meet their needs; 2) males and females may maintain home ranges to meet different biological needs, e.g., females may establish a territory to secure resources for raising young whereas males may defend a larger territory to maintain access to multiple reproductive females; and 3) compared to females, male home ranges may appear to be disproportionately large if extra-territorial movements during the breeding season are included in home range calculations. Although the latter is an important consideration, some evidence suggests that when breeding-season movements are eliminated from calculations, adult male home ranges were still 2.5 times larger than those of females (Table 6.7; Aubry and Raley 2006).

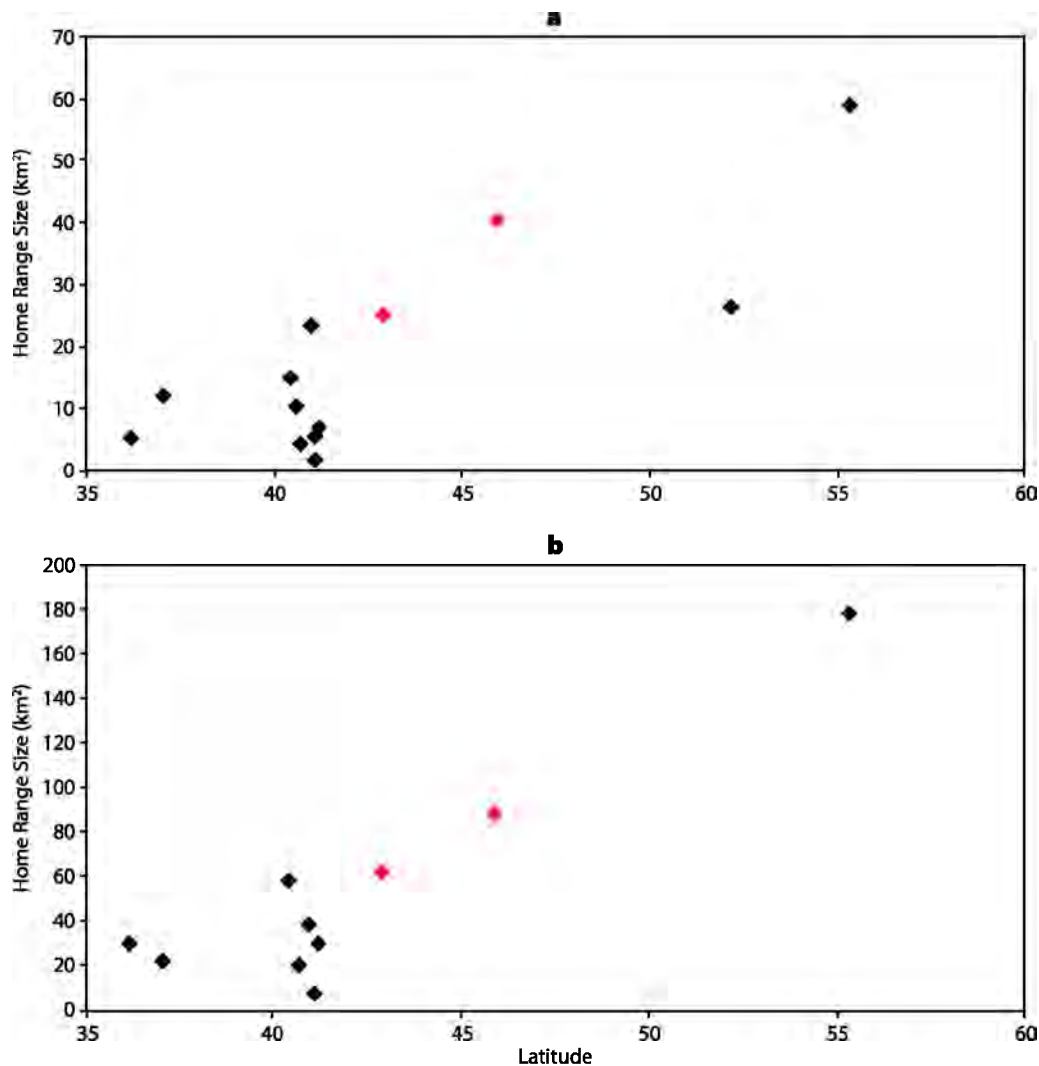


Figure 6.3. Mean female (a) and male (b) fisher home range sizes by latitude within the Assessment Area and adjacent regions in western North America. Data indicated by red symbols are for fisher populations resulting from historical translocations to Idaho (from British Columbia source locations 52–55° latitude) and Oregon (from British Columbia source locations 52–55° latitude and Minnesota source locations 47–48° latitude).

In the Assessment Area and adjacent regions, home range size most likely increases with increasing latitude because female and male fishers are about 1.5 times larger in the north as their counterparts farther south (Chapter 2) and, consequently, have greater energetic requirements. Although home range size of carnivores is positively correlated with body mass, productivity and biomass of food resources likely influence spatial needs as well (Lindstedt et al. 1986). For carnivores, home range size is expected to get larger as prey abundance or availability decreases

(Harestad and Bunnell 1979), and this pattern has been observed for American martens in Ontario (Thompson and Colgan 1987). Latitude, elevation, and precipitation are among the various geographic factors that influence productivity (Harestad and Bunnell 1979, Lindstedt et al. 1986) and may contribute to observed differences in home range sizes of fishers within the Assessment Area and adjacent regions. For example, Weir and Corbould (2008) speculated that prey availability may decrease with increasing latitude to explain the relative large home

ranges observed for fishers in central interior British Columbia. Compared to coastal coniferous forests in northern California, fisher home ranges were smaller in the southern Sierra Nevada, presumably because mixed-conifer forests which included an abundance of California black oak (*Quercus kelloggii*) in this region were more productive (thus providing better forage for prey and more rest and den sites for fishers; Zielinski et al. 2004b).

6.2.2. Breeding Season Movements

Fishers are polygynous with males typically seeking out females in estrus (Powell 1993). Field observations of radio-collared animals suggest that males may locate natal den trees of females with kits

and then wait for an opportunity to mate with the female when she leaves the den (Aubry and Raley 2006; Plate 6.4). Although most mating activity occurs during March and April, adult males may become more active and start making longer-distance excursions as early as February (Fig. 6.1). In the Assessment Area and adjacent regions, several studies have documented male fishers moving up to 22 km (straight-line distance between successive locations) within 48 hrs during the breeding season (Buck 1982, Jones 1991, Aubry and Raley 2006). Males may also abandon their territories at the onset of the breeding season, travel 7–30 km into new areas, and then return once mating is over (Jones 1991, Aubry and Raley 2006). In one study, areas covered by



Plate 6.4. Fishers are polygynous, and field observations indicate that males will locate the natal den trees of females with kits and then wait for an opportunity to mate with the female when she leaves the den cavity. Here, a male waits on a branch just a few feet from the entrance of a den cavity being used by a reproductive female.

males during the breeding season were approximately 2.4 times larger than their non-breeding-season home ranges (Aubry and Raley 2006). Studies conducted in eastern North America have also documented long-distance movements by male fishers during the breeding season (e.g., Leonard 1986, Arthur et al. 1989a).

Leonard (1986) suggested that male fishers might maximize their reproductive output by abandoning their territories during the breeding season and searching for as many receptive females as possible, rather than expending energy defending their territory against transient males. However, there is evidence that male fishers within the same population can exhibit either of these breeding strategies (Aubry et al. 2004). Using both radiotelemetry and genetic data, Aubry et al. (2004) demonstrated that a resident male (one who expanded but did not abandon his territory during the breeding season) appeared to be a more successful breeder than an encroaching male (one who abandoned his territory during the breeding season). Thus, males may adopt different breeding strategies depending on the availability of reproductive females in their immediate area. In contrast to males, adult females do not make pronounced breeding season movements and appear to maintain relatively consistent home ranges year-round (Arthur et al. 1993).

6.2.3. Activity Patterns and Daily Movements

Fisher activity patterns are typically determined by tracking radio-collared individuals and determining when the transmitter signal indicates movement (signal fluctuates in strength, direction, and location) or inactivity (signal is consistent in strength, direction, and location; e.g., Arthur and Krohn 1991, Weir and Corbould 2007). As such, the specific behavior of active fishers (e.g., foraging, territorial defense, traveling to a rest site) and rate of travel are typically unknown. Similarly, inactive (hereafter

resting) fishers may be engaged in various behaviors that do not involve travel including, but not limited to, resting and consuming recently captured prey.

Gender, reproductive condition, and season appear to influence fisher activity patterns (Powell and Leonard 1983, Arthur and Krohn 1991, Weir and Corbould 2007). As previously discussed, studies across North America have documented that male fishers were more active (e.g., Weir and Corbould 2007) and made longer movements (e.g., Arthur and Krohn 1991) during the breeding season when searching for mates than during other times of the year. Reproductive status also appears to influence female activity patterns. In central interior British Columbia, adult females with very young kits (primarily ≤ 4 weeks old) were less active than nonreproductive females, presumably because females with very young kits need to spend most of their time in the den cavity nursing kits and providing thermal and security protection (Weir and Corbould 2007). In Maine, females with kits ≤ 12 weeks old were more active than nonreproductive females (Arthur and Krohn 1991), and diurnal activity increased from the nursing period to weaning (Paragi et al. 1994a). The activity pattern of a reproductive female in Manitoba changed from spending ≤ 10 hours away from the den when kits were < 3 weeks old to > 20 hours away from the den once kits were ≥ 7 weeks old (Powell and Leonard 1983). These studies suggest that females with kits, although perhaps less active than nonreproductive females when kits are very young, become increasingly more active as the need to obtain food for growing kits increases. This is supported by energy estimates for reproduction in female fishers that include the costs of daily maintenance, hunting, and lactation (Powell and Leonard 1983). The estimated daily energy cost of a reproductive female increased linearly with age of kits and was 2.3 and 3.0 times that of a nonreproductive female when kits were 7 weeks and 10 weeks old, respectively (Powell and Leonard 1983).

Other factors, including snow conditions and ambient temperature, may also affect fisher activity patterns. In eastern North America, periods of deep, soft snow appeared to reduce fisher activity (Leonard 1980, Raine 1983), presumably because such snow conditions make travel and hunting difficult. Also, compared to summer, fishers may be less active in winter and during extreme cold because of the need to conserve body heat (Kelly 1977, Johnson 1984, Arthur and Krohn 1991, Powell 1993). In contrast to observations in eastern North America, fisher activity increased following fresh snowfall in central interior British Columbia (Weir and Corbould 2007). Weir and Corbould (2007) speculated that, compared to some regions, the combination of fresh snowfall followed by thawing and refreezing in their study area produced firmer snowpacks that facilitated fisher movements. Also, during the snow-free period, fisher activity increased with ambient temperature, perhaps in response to increased prey activity (Weir and Corbould 2007). Although snow conditions and ambient temperatures appear to influence fisher activity patterns in various ways, fishers may also be responding to other factors that are more difficult to measure, such as time since last meal, prey abundance and catchability, and habitat quality (Weir and Corbould 2007).

Fishers may be active day or night. Some studies have documented activity peaks around sunrise and sunset (Kelly 1977, Arthur and Krohn 1991, Powell 1993) whereas others found fishers to be active throughout the diurnal period (Weir and Corbould 2007). Fishers may have 1–3 activity periods during a 12-hour span and are capable of traveling long distances in relatively short periods of time (Powell 1993). Powell (1993) estimated that fishers averaged 2 activity periods per day, travelling an average of 2.5 km during each period. In central interior British Columbia, Weir and Corbould (2008) observed average maximum movement rates of 0.66 km/h for females and 0.76 km/h for males based on sequential radiotelemetry locations separated by <43 hours. Based on these rates, Weir and Corbould (2008)

estimated that a female was capable of traveling to any location within an average 35-km² home range in <10 hours and a male could reach any area within a 160-km² home range in <19 hours.

When fishers are not actively hunting or traveling, they use various structures (e.g., live and dead trees, logs, etc.) for resting. Rest sites (i.e., the structure and the immediate environment in which the structure occurs) may serve multiple functions including thermoregulation and protection from potential predators (Kilpatrick and Rego 1994, Weir et al. 2004, Zielinski et al. 2004a). Several researchers have speculated that fishers use multiple rest structures distributed across their home range to minimize the energetic costs of traveling between foraging areas or kill sites and resting sites (Kilpatrick and Rego 1994, Seglund 1995, Zielinski et al. 2004b). Fishers may remain inactive at a particular site for several hours or several days (de Vos 1952, Coulter 1966, Powell 1993).

6.2.4. Juvenile Dispersal

Only a few studies in the Assessment Area and adjacent regions (Aubry et al. 2004, Aubry and Raley 2006, Weir and Corbould 2008) and eastern North America (Arthur et al. 1993, York 1996) have investigated dispersal behavior in juvenile fishers. Arthur et al. (1993) proposed that the primary function of dispersal in fishers is to maintain intrasexual territories among adults. Juvenile fishers generally do not begin to disperse (i.e., make substantial movements away from their natal areas) until their first fall or winter when they are >7 months of age (based on a 1 April birth date). In the Cascade Range in southern Oregon, radio-collared juveniles began dispersing in early February when they were about 10 months old (Aubry and Raley 2006). In Maine, 50% (4/8) of radio-collared juvenile males started to disperse before December, whereas females began dispersing in January or February (Arthur et al. 1993). In Massachusetts, radio-collared juveniles of both sexes typically began dispersing in November (York 1996).

Duration of dispersal (i.e., the time it takes an individual to locate and establish their own home range) and dispersal distance (typically measured as the straight-line distance between an individual's natal area and their eventual home range) may be influenced by various factors including gender (Aubry et al. 2004), availability of unoccupied areas, turnover rates in the adult population (Arthur et al. 1993, York 1996, Weir and Corbould 2008), and the overall suitability of the landscape to support fisher populations (Weir and Corbould 2008). Evidence suggests that juvenile dispersal in fishers is male-biased. In the Cascade Range in southern Oregon, the average dispersal distance of juvenile males (\bar{x} = 29 km, range = 7–55, n = 3) was almost 5 times that of females (\bar{x} = 6 km, range = 0–17, n = 4; Aubry and Raley 2006). Genetic analyses also revealed significantly higher relatedness among adult females (n = 6) than among adult males (n = 5), providing further support for male-biased dispersal and female philopatry (Aubry et al. 2004). Only 3 dispersals were documented in central interior British Columbia (2 females dispersed 0.7 km and 32.7 km, 1 male dispersed 41.3 km; Weir and Corbould 2008). In eastern North America, Williams et al. (2000) speculated that the heterozygotic deficiencies they observed within 8 fisher populations in 8 states resulted from fine-scale social structuring consistent with female philopatry and random male dispersal. Although field studies in Maine (Arthur et al. 1993) and Massachusetts (York 1996) did not observe differences in dispersal distances between males (\bar{x} = 21 km, range = 4–60) and females (\bar{x} = 21 km, range = 4–60), legal harvest of fishers in both areas may have influenced dispersal behavior by decreasing adult survivorship and increasing the availability and proximity of unoccupied territories for dispersing males.

In most studies (Arthur et al. 1993, York 1996, Aubry and Raley 2006), male and female juvenile fishers established home ranges before they were 1 year of age. In contrast, study animals in central interior British Columbia were frequently transient

for >1 year and did not establish home ranges until almost 2 years of age (Weir and Corbould 2008). Much of the landscape in this study area appeared to be unoccupied and may not have been capable of supporting fishers, forcing juveniles to remain transient until adult animals died and territories became available (Weir and Corbould 2008). Furthermore, high mortality (55%) of transient fishers suggested that few juveniles in this study area successfully dispersed to establish home ranges (Weir and Corbould 2008).

Dispersing juveniles are capable of moving long distances and navigating across or around various landscape features including rivers, highways, and rural communities (York 1996, Aubry and Raley 2006, Weir and Corbould 2008). Nevertheless, dispersal is likely a vulnerable time for young animals and long-distance movements are not always successful. For example, in central interior British Columbia, a juvenile female traveled 135 km in 45 days crossing large rivers and covering a total area of 1,237 km² before dying of starvation (Weir and Corbould 2008).

6.2.5. Post-Translocation Movements

Several researchers have investigated movements and home-range establishment of translocated fishers in British Columbia (Weir 1995, Weir and Harestad 1997, Fontana et al. 1999) and Montana (Roy 1991, Heinemeyer 1993). In most cases, translocated fishers moved extensively from release locations for varying periods of time before establishing a home range. In central interior British Columbia, fishers released during winter remained transient for an average of 68 days (range = 9–197) and traversed areas averaging 443 km² for females (n = 7) and 1,438 km² for males (n = 2; Weir and Harestad 1997). Most fishers traveled >100 km total linear distance, some crossing large rivers and making 700-m changes in elevation, before establishing a home range (Weir 1995, Weir and Harestad 1997). Some of the longer distance movements

by translocated animals may have been related to the presence of resident fishers with established territories close to the release sites (Weir 1995). Translocated fishers in the East Kootenay region of British Columbia took approximately 2.1 months to establish home ranges (Fontana et al. 1999). During the first 2 years of a 4-year reintroduction study in northwestern Montana, fishers released during January–March had not established permanent home ranges by the end of the monitoring period in May–June (Roy 1991). Fishers were detected up to 163 km (female) and 71 km (male) from the release site (Roy 1991). During the final 2 years of the study, fishers released during the fall did not appear to establish permanent home ranges until after the following breeding season (Heinemeyer 1993). Although fishers settled into areas during winter that were 4–18 km from the release site, movements by both males and females increased during the breeding season and core activity areas (50% adaptive kernel utilization areas) shifted. Female core activity areas shifted again following the breeding season to reestablish intrasexually exclusive areas (Heinemeyer 1993). These observations suggest that movement patterns of translocated animals, and time until home range establishment, are likely influenced by many factors including age and reproductive status of animals being released, the presence and density of resident animals, and the time of year animals are released.

Studies of translocated fishers elsewhere in North America have also observed relatively long-distance movements and varying lengths of time before animals established home ranges. In West Virginia, translocated fishers moved an average of 44 km and a maximum of 90 km from the release site (Pack and Cromer 1981). Similarly, translocated fishers in Wisconsin moved up to 98 km from the release site (Olson 1966). In Alberta, fishers released during March moved further from the release site (\bar{x} = 23.1 km, range = 9.8–72.5) than those released in June (\bar{x} = 7.8 km, range = 0.9–16.0) during a 4-week monitoring period (Proulx et al. 1994). Fishers

translocated during summer appeared to establish home ranges closer to the release site than those released into a new area during the breeding season (March), presumably because they did not have to search for mates (Proulx et al. 1994). However, it was not known whether some of the fishers released during summer subsequently moved during the following winter and reestablished home ranges elsewhere.

6.3. Food Habits

Investigations of fisher food habits are more numerous, and were initiated earlier, in eastern North America than in western North America (see reviews in Powell 1993, Martin 1994). However, relatively recent studies in British Columbia (Weir et al. 2005), Oregon (Aubry and Raley 2006), and California (Zielinski et al. 1999, Golightly et al. 2006) have provided important contributions to our understanding of fisher food habits in the Assessment Area and adjacent regions (Table 6.8).

Studies of fisher food habits have typically involved analysis of food remains found in the feces (scats) or in the gastrointestinal tracts (stomachs and intestines) of recovered fishers (commercially trapped fishers or study mortalities). During field studies of radio-collared fishers, scats are commonly collected at fisher capture sites and near rest and den sites (Zielinski et al. 1999, Aubry and Raley 2006, Golightly et al. 2006). Individual scats may consist of 1 or more food items, and can be collected year-round. Gastrointestinal tracts are typically collected from fishers that have been commercially trapped (Weir et al. 2005), but may also be collected from fishers recovered during scientific study (Grenfell and Fasenfest 1979, Jones 1991). Gastrointestinal tracts of commercially trapped fishers provide information on food habits during the trapping season only, typically from late fall to mid-winter (Weir et al. 2005). Individual gastrointestinal tracts may contain more food items than individual scats, which can complicate comparisons of fisher diets among studies.

Table 6.8. Studies of fisher food habitats conducted in the Assessment Area and adjacent regions in western North America.

Fisher population	n	Method	Season	Source
Western Plateaus and Valleys, and Cariboo ^a	215	Stomachs	Winter	Weir et al. 2005
Northwestern Montana	80	Scats	Winter	Roy 1991
North-central Idaho and West-central Montana	7	G-I tracts	Winter	Jones 1991
	18	Scats	Winter	
Cascade Range, Oregon	387	Scats	Year-round	Aubry and Raley 2006
Northern California-Southwestern Oregon	8	Stomachs	Winter	Grenfell and Fasnfast 1979
	388	Scats	Year-round	
Southern Sierra Nevada	201	Scats	Year-round	Zielinski et al. 1999

^a Stomachs were collected from legally harvested fishers from south-central to northern British Columbia.

It is rarely possible to identify the species of all prey remains in scat samples because some diagnostic may be lost during digestion. Thus, prey remains collected at den and rest sites can provide additional insights into the diversity of prey captured by fishers. For example, Aubry and Raley (2006) examined prey remains at fisher den and rest sites and identified 9 species of birds, 7 species of mammals, and 1 species of snake; whereas analysis of food items in scats primarily provided order, family, or genus-level identifications.

In the Assessment Area, fishers appear to be dietary generalists that consume a variety of small and medium-sized mammals and birds, insects, reptiles, and (rarely) amphibians (Table 6.9). The proportion of mammalian food items detected in fisher diets varied among studies in the Assessment Area and adjacent regions (Table 6.9; Appendix 6.2), and can vary seasonally within a region, presumably in response to availability (Zielinski et al. 1999). Small and medium-sized mammals were the dominant components of fisher diets in Oregon and California, exceeding 70% frequency of occurrence in scats analyzed (Table 6.9). Larger mammalian prey (porcupine, snowshoe hares [*Lepus americanus*], rabbits [*Sylvilagus* spp.], and squirrels [Sciuridae]) were detected more frequently in fisher diets in British Columbia, Idaho, Montana, and Oregon than in California (Appendix 6.2). In contrast, there appeared to be a greater diversity of food items

in fisher diets in California than elsewhere in the Assessment Area and adjacent regions (Appendix 6.2).

Studies conducted during winter in British Columbia (Weir et al. 2005), Idaho (Jones 1991), and Montana (Roy 1991) reported almost exclusive use of mammals by fishers (Appendix 6.2). Consumption of ungulate carrion was widely reported in the Assessment Area and adjacent regions, especially during winter (Appendix 6.2). In northwestern California, the contents of 8 fisher stomachs collected during winter contained substantial amounts of fungi and plant material, but also contained the remains of ungulates, beetles, deer mouse (*Peromyscus* spp.), and other small and medium-sized mammals (Grenfell and Fasnfast 1979; Appendix 6.2). In the southern Sierra Nevada, Zielinski et al. (1999) found a greater percentage of mammals in fisher scats during winter, which appeared to be explained by increased use of deer (*Odocoileus* spp.) and cricetid rodents, and relatively high use of squirrels (Appendix 6.2).

In much of the fisher's range, snowshoe hare and porcupine are important prey items (Powell 1981). However, in California, the contemporary ranges of snowshoe hare (Bittner and Rongstad 1982) and porcupine (Dodge 1982) do not overlap extensively with areas where fisher food habit studies have been conducted or, where there is overlap, these species occur at low abundances (Zielinski et al. 1999). This likely explains why neither species was identified

Table 6.9. Frequency of occurrence (%) of vertebrate and invertebrate prey items in fisher scats that were collected year-round at trapping and resting sites during radiotelemetry studies in Oregon and California.

Prey	Cascade Range, Oregon ^a	Northern California ^b	Southern Sierra Nevada ^c
Mammals	82.6	93.0	78.6
Insectivora (shrews, moles)	5.2	20.9	4.5
Lagomorpha (rabbits, hares)	22.7	4.1	0.5
Rodentia (squirrels, mice, voles)	40.8	49.7	47.8
Carnivora (mustelids, canids)	2.6	22.4	21.4
Artiodactyla (deer, elk)	8.5	20.9	4.0
Birds	28.2	26.0	39.8
Reptiles	6.5	24.5	20.4
Amphibians		2.1	
Insects	25.6	55.2	55.7

^a Analysis of 387 fisher scats from males and females combined across all seasons (Aubry and Raley 2006).

^b Analysis of 388 fisher scats from males and females combined across all seasons; scats were collected from four study areas within the Klamath bioregion of northwestern California (Golightly et al. 2006).

^c Analysis of 201 fisher scats from males and females combined across all seasons (Zielinski et al. 1999).

in the diet of fishers in northwestern California (Golightly et al. 2006) or the southern Sierra Nevada (Zielinski et al. 1999). In the absence of snowshoe hares and porcupines, fishers feed opportunistically on a variety of other prey (Powell et al. 1997a) but within an optimal body-size range to efficiently meet energetic needs (e.g., in some California study areas, woodrat [*Neotoma* spp.] and squirrel-sized prey; Golightly et al. 2006). Compared to elsewhere in the Assessment Area and adjacent regions, the high diversity of prey consumed by fishers in California (Zielinski and Duncan 2004, Golightly et al. 2006) may reflect an opportunistic foraging strategy or a greater diversity of potential prey species at the southern extent of their range (Zielinski and Duncan 2004). Fishers are also smaller at the southern extent of their range than elsewhere in the Assessment Area and adjacent regions (Chapter 2). Thus observed differences among regions in the sizes and diversity of prey species consumed by fishers may be influenced, in part, by differences in average fisher body sizes, ability to capture and handle larger versus smaller prey, and overall energetic returns.

Sexual dimorphism may also influence fisher foraging ecology. Males may be more successful at killing

larger prey (e.g., porcupines and skunks [*Mephitis mephitis*, *Spilogale putorius*]), whereas females may avoid larger prey or may be more adept at catching smaller prey. Weir et al. (2005) reported that the stomachs of female fishers had a significantly greater proportion of small mammals than those of males. Aubry and Raley (2006) observed that only male fishers captured and consumed porcupines (evidence from kill sites and scats), and the remains of skunks were found in 10% of male scats compared to only 1% of female scats. Similarly, Zielinski et al. (1999) found that females had a greater proportion of small mammals and birds in their diet, and males had a greater proportion of carnivores.

6.4. Ecological Role of Fishers

Mesocarnivores, such as fishers, may play a more significant role in ecosystems than has been previously recognized, especially in regions where the carnivore community has become simplified by the loss of some or all large carnivores (Roemer et al. 2009). Within the Assessment Area, large carnivores such as grizzly bears (*Ursus arctos*), wolverines, and gray wolves (*Canis lupus*) have undergone considerable range contractions since the 19th century (e.g., Laliberte and Ripple 2004). Typically,

mesocarnivore communities are more diverse and occur at greater densities than large carnivore communities, and thus have the potential to influence the abundance and distribution of a variety of other species through predation and competition (Roemer et al. 2009). Furthermore, because fishers prey on many important seed predators in western coniferous forests (e.g., tree squirrels and other rodents that cache or hoard seeds) they may indirectly shape forest plant communities through their influence on the population dynamics of these species (e.g., Roemer et al. 2009).

Although fishers are predators of small to medium-sized mammals and birds, their ecological role extends beyond predation and includes competition, carrion feeding, seed and spore dispersal, prey for other carnivores, and host for parasites and pathogens (Douglas and Strickland 1987, Powell 1993, Aubry et al. 2003). As consumers of vertebrate and invertebrate prey and ungulate carrion, fishers contribute to nutrient cycling. Conversely, predation on fishers by other carnivores also contributes to nutrient cycling.

As predators, fishers appear to be somewhat opportunistic, but tend to consume mammalian prey more frequently than birds, invertebrates, reptiles, or amphibians (Roy 1991, Martin 1994, Zielinski et al. 1999, Weir et al. 2005, Golightly et al. 2006). Given the variety in their diet and their relatively low population densities, it has generally been thought that fishers are unlikely to regulate abundance of prey populations with the possible exception of porcupines in some regions (Brander and Brooks 1973, Powell and Brander 1977, Powell 1980). Monitoring efforts in Michigan documented a decline in porcupine abundance following a fisher reintroduction (Brander and Brooks 1973, Powell 1980) consistent with the observation that fishers tend to seek out porcupines (Powell 1993). Also in Michigan, Earle and Kramm (1982) documented

that porcupines were significantly less abundant in an area with fishers compared to an area with no fishers.

Depending on the region and community composition, fishers may potentially compete with a variety of other forest carnivores including coyotes, foxes, bobcats, lynx, American martens, weasels (*Mustela* spp.), and wolverines (Powell and Zielinski 1994, Dark 1997, Campbell 2004). Among mustelids, competition for food appears to be most pronounced in the genera *Martes* and *Mustela* (Powell and Zielinski 1983). Although there is no direct evidence, competition between fishers and American martens has been suggested by many because these 2 species are sympatric in many regions, are agile in trees, have similar body shapes and hunting behaviors, and exhibit some overlap in prey species (Powell and Zielinski 1994; Krohn et al. 1995, 1997, 2004; Zielinski and Duncan 2004). Dietary overlap was extensive in the Southern Sierra Nevada in California, where American martens and fishers are sympatric in the lowest elevation zones of marten range (Zielinski and Duncan 2004). Nevertheless, in western North America, martens tend to occur at a wider range of elevations (Buskirk and Ruggiero 1994, Powell and Zielinski 1994, Hatler et al. 2008). In Wisconsin, Gilbert and Keith (2001) investigated competition between fishers and bobcats following a fisher reintroduction. Although direct competition was not demonstrated, they observed that, compared to areas where fishers were scarce, bobcat kitten mortality was higher and bobcat population growth was lower in areas where fishers were common (Gilbert and Keith 2001).

Fishers most likely disperse plant seeds and fungal spores through direct consumption of berries, mast, and fungi or when they capture prey that have consumed these food items. Fungal spores found in fisher scats in California were likely in the stomachs of small mammals that fishers had consumed; however, it is possible that fishers consumed fungi

directly (Grenfell and Fasnacht 1979, Zielinski et al. 1999). Fishers may also facilitate the dispersal of seeds, spores, and perhaps pollen when these propagules become attached and are transported in their fur (Aubry et al. 2003). The dispersal of mistletoe seeds and rust spores may promote the development of brooms that provide resting and denning structures for fishers and other forest wildlife (Aubry et al. 2003, Weir and Corbould 2008).

6.5. Implications for Conservation

1. Because fishers have low reproductive rates (i.e., fishers of both sexes are not reproductive until 2 years of age, not all adult females reproduce each year, and females >4 yrs of age may be the most productive), and few individuals survive beyond about 8 years of age, population growth rates are low. Thus, expansion and recovery of populations in the Assessment Area will take many fisher generations. Similarly, populations may experience setbacks owing to future and unforeseen natural or anthropogenic disturbances. Conservation efforts must incorporate appropriate temporal and spatial scales to effect positive change and measure success.
2. Reproductive success is essential to conservation of fishers in the Assessment Area. Fisher kits are vulnerable and require a long period of maternal care. Adult females need to establish home ranges that provide denning and resting structures, security cover, and abundant food resources within relative proximity in order to meet high energetic requirements associated with producing and raising young. Conservation efforts will be most successful if they promote and maintain areas of high productivity that will facilitate successful reproduction. Although it is uncertain what effects industrial or other human activities may have on reproductive females, measures that minimize disturbances in areas identified as having high reproductive potential may benefit fishers.
3. Fishers are exposed to various sources of natural and anthropogenic mortality with annual survival rates as low as 0.61 in some areas. Although there is very limited harvest of fishers (for tribal dance regalia) within the Assessment Area, trapping for other furbearers (e.g., American martens, bobcats) still occurs and could potentially be an additional source of fisher mortality. Various human activities may exacerbate other sources of mortality; e.g., activities that temporarily or permanently displace fishers may increase their exposure to predators, or increase the risk of starvation. Conservation efforts that minimize mortality, especially of females and juveniles, will be important for the recovery of fishers in the Assessment Area.
4. Within the Assessment Area, fisher home ranges generally decrease in size from northern to southern latitudes. Larger area requirements in northern portions of the Assessment Area are likely related to multiple factors including larger body size of fishers in the north, and differences in forest productivity and prey availability. Conservation efforts will be most successful if they are applied at large spatial scales that account for regional differences in fisher morphology and forest productivity.
5. Spacing patterns and social structure are important considerations when designing an effective conservation strategy. Male fishers require large areas to meet energetic demands and to maintain access to multiple reproductive females. Females need to find all life requisites within smaller areas, including abundant food resources for raising young. Thus large landscapes are needed to sustain viable fisher populations.
6. During the breeding season, male fishers typically make long-distance movements to locate receptive females. Juvenile fishers need to move across the landscape to locate and establish home ranges in

suitable areas. These 2 processes are essential for population growth and expansion. Maintaining permeable forested landscapes that facilitate breeding opportunities, juvenile dispersal, and genetic interchange will be essential for sustained growth and expansion of fisher populations in the Assessment Area.

7. Because of sexual dimorphism, male and female fishers most likely have different foraging ecologies and different primary prey. Foraging ecology likely varies by latitude (owing both to differences in fisher body mass and forest productivity) and ecological zone (owing to differences in productivity resulting from other physiographic factors such as elevation and precipitation). Conservation efforts will be most effective if they recognize these differences and identify potential fisher food resources specific to geographic areas of interest.
8. Although there have been no documented cases of disease in fishers causing widespread mortality or population declines, the potential for adverse impacts should not be overlooked. Some diseases, such as canine distemper, become a more serious risk when carnivores are taken into captivity during translocation, rescue operations, or research projects (Williams 2001). Conservation efforts should promote use of appropriate and rigorous protocols for handling wild fishers during such efforts to eliminate potential transmission of disease.



CHAPTER 7. HABITAT ASSOCIATIONS

7.1. Fisher Habitat Studies

Many field studies have been conducted on extant populations of fishers in British Columbia, Idaho, Montana, Oregon, and California, most of which have focused on habitat associations at 1 or more spatial scales (Fig. 7.1; Table 7.1). Habitat use, preference, selection, and avoidance are fundamental concepts in establishing basic habitat associations for any species. Habitat use simply refers to the observation of an animal's occurrence in, or use of, a specific habitat type, and does not demonstrate a link, direct or implied, to individual fitness. Investigating habitat selection for specific behaviours (e.g., denning, resting) generally improves the ability of investigators to demonstrate a link to fitness. Habitat selection and preference are often used synonymously; we use only the term "selection" throughout this chapter. 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 statistically greater (selection) or less (avoidance) than expected based on its availability. We have tried to include all information on fisher habitat ecology from studies conducted in the Assessment Area and adjacent regions that was available in the scientific literature or other documents (i.e., progress or final report, thesis, dissertation, peer-reviewed paper, etc.) produced prior to 1 July 2008. New information available since this date has not been included in this review. Our objectives for synthesizing available information on fisher habitat ecology were to 1) identify consistent patterns in habitat associations among fisher populations in the Assessment Area and adjacent regions, 2) relate patterns in fisher habitat associations to life history requisites, and 3) identify important implications for fisher conservation.

Fishers use landscapes at different spatial scales for different behaviors and activities (Powell 1994b, 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 1994b, Powell and Zielinski 1994, Weir and Harestad 2003). There is no universally appropriate spatial scale for investigating fisher habitat associations. Thus, studies of fisher habitat ecology have been conducted at various spatial scales because scale must be consistent with research objectives and questions (Buskirk and Powell 1994, Powell and Zielinski 1994). 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). Recognizing this, we have synthesized fisher habitat associations in a scale-dependent manner starting with the landscape scale (Fig. 7.2). This is the broadest scale (regional extents at which the population of interest and associated population-level processes occur) and, for our purposes, included everything larger than the fisher home range scale. We worked progressively to finer scales of resolution through home range, stand (a distinct area composed of relatively homogenous vegetative characteristics), site (the immediate vicinity surrounding specific locations used by fishers for resting, denning, etc.), and structure (i.e., trees, logs, and other structures used by fishers for resting and denning and the associated microstructures such as mistletoe brooms, cavities, etc.). These scales are



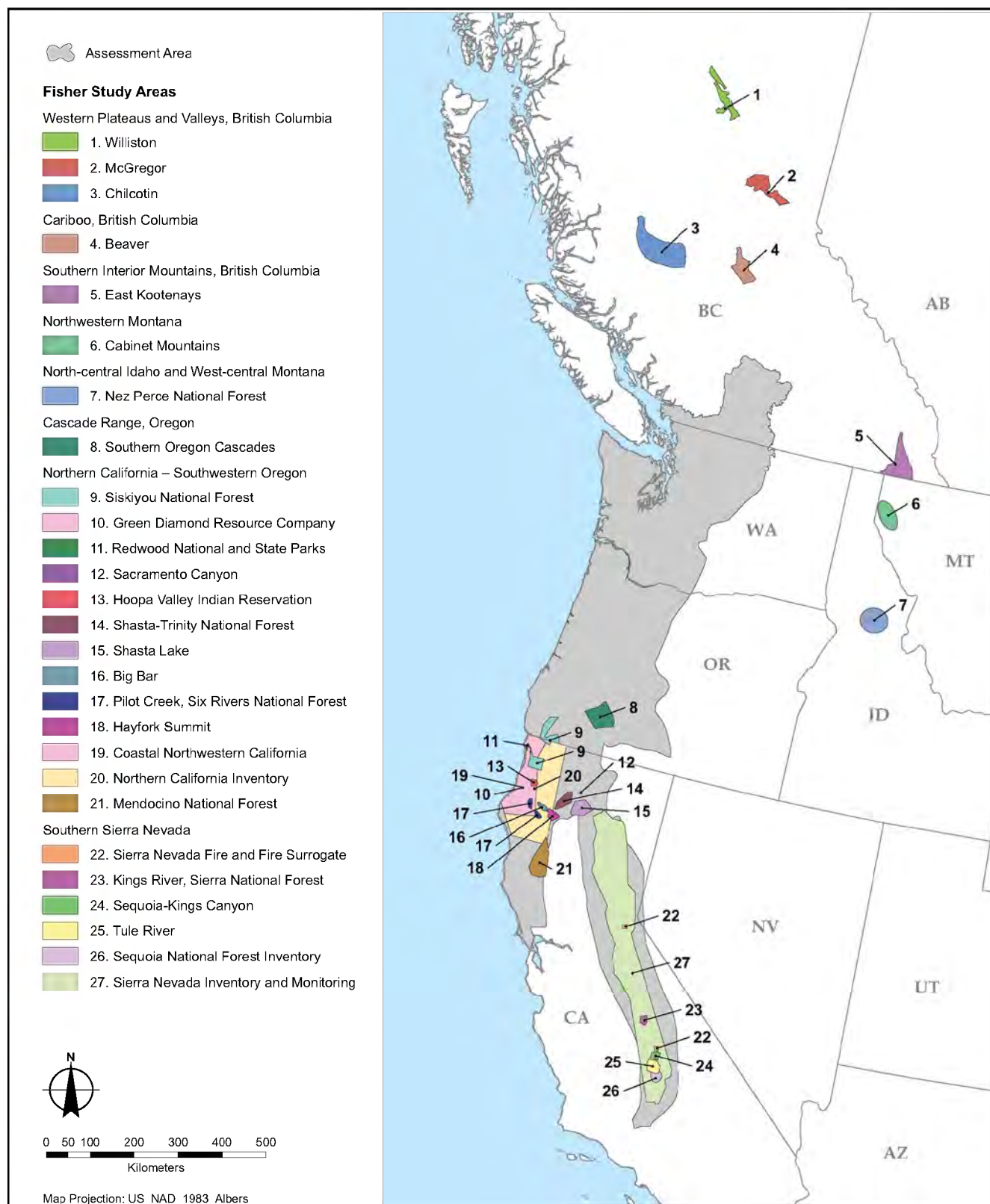


Figure 7.1. Fisher habitat study areas within the Assessment Area and adjacent regions in western North America.

Table 7.1. 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).

Fisher population and study area number	Study year	Spatial scale				
		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; 2000–2001				x	
10. Green Diamond Resource Company	1994–1997; 2002–2003	x		x	x	x
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
	2004–2006					
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	1995–2001	x	x		x	x
24. Sequoia-Kings Canyon	2002–2004	x			x	
25. Tule River	1994–1996		x		x	x
26. Sequoia National Forest Inventory	1991–1992	x			x	
27. Sierra Nevada Inventory and Monitoring	1996–present	x			x	

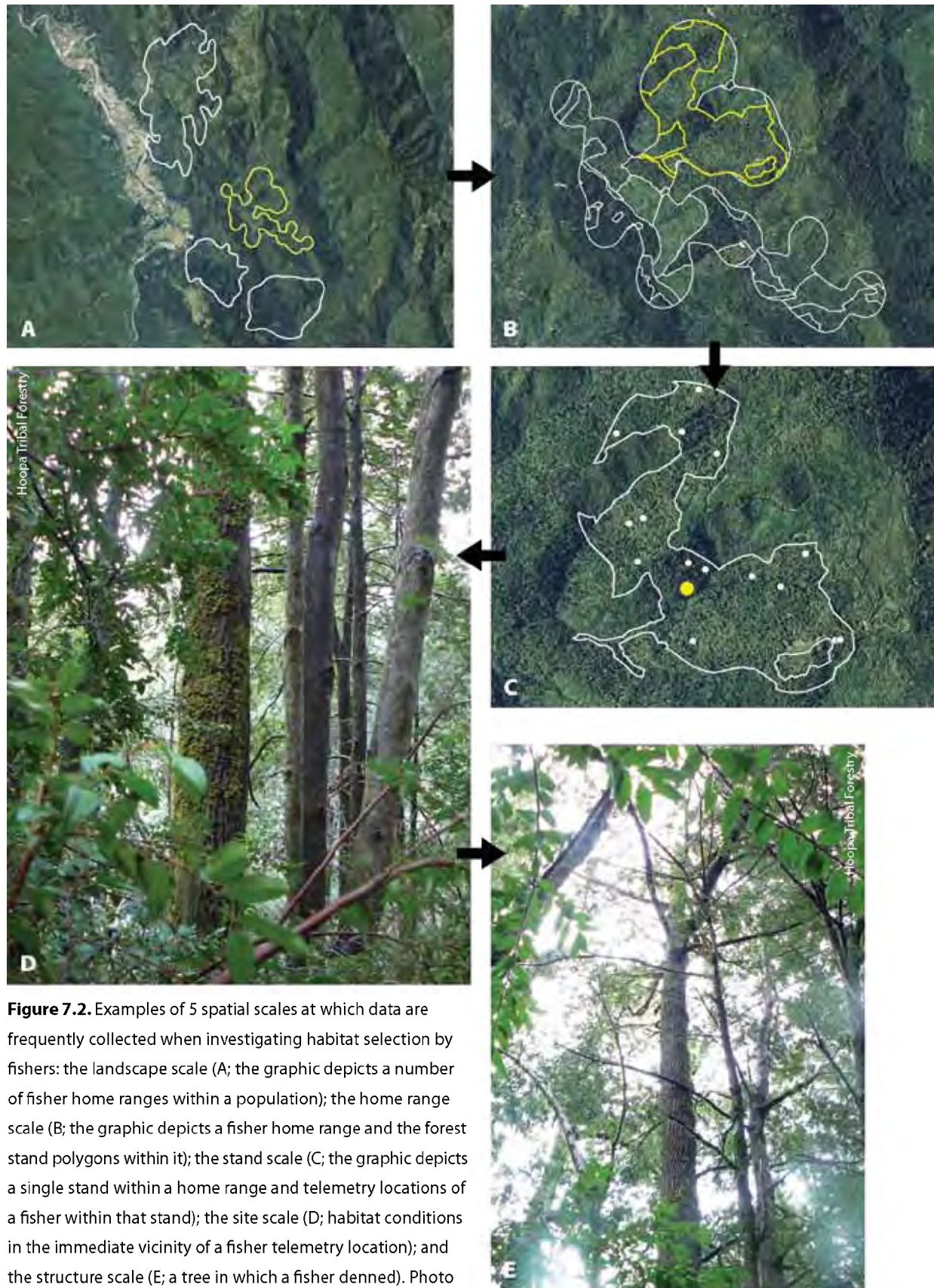


Figure 7.2. Examples of 5 spatial scales at which data are frequently collected when investigating habitat selection by fishers: the landscape scale (A; the graphic depicts a number of fisher home ranges within a population); the home range scale (B; the graphic depicts a fisher home range and the forest 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.

discussed in further detail in Section 1.1 of Volume II (Key Findings From Fisher Habitat Studies in British Columbia, Montana, Idaho, Oregon, and California).

Because of the complexity of available habitat data at various spatial scales, and the availability of new data from several studies that have not been synthesized previously, we developed key research findings (Volume II) for each study area in the Assessment Area and adjacent regions. The key findings provide 1) a consistent format for organizing and summarizing available data on habitat relationships by study area and spatial scale, 2) documentation of data that may be useful in developing a conservation strategy for fisher populations in the Assessment Area, and 3) a reference tool that can be used by biologists and resources managers to better understand fisher ecology in their area of interest.

In the following sections, we present our interpretation of fisher habitat association patterns throughout the Assessment Area and adjacent regions that were best supported by empirical information summarized in Volume II. The section headings highlight important habitat associations and are linked to various spatial scales, fisher distribution, or fisher behavior. In each section, we provide supporting evidence and reference each study area by number (Table 7.1) that corroborates that evidence. We have done this to avoid unwieldy, extensive references to individual reports and publications (Table 7.2; references are also listed by study area in Volume II). When referencing general concepts regarding fisher habitat associations or information not specific to any given study area, we provide citations to specific literature.

Three study areas report findings based entirely (East Kootenays, Cabinet Mountains) or partially (Beaver Valley) on recently translocated fishers.

Because recently translocated individuals make extensive movements in search of suitable conditions for establishing a home range (Section 6.2.5), we have only included reference to these studies when patterns of habitat associations were consistent with those identified for resident fisher populations (i.e., native or populations that resulted from translocations but have been established for many fisher generations). We posited that if translocated fishers naïve to their landscape exhibited patterns common to those observed in resident fishers, the observed patterns were likely important.

7.2. Synthesis of Fisher Habitat Associations

7.2.1. Fishers Occur in a Variety of Low and Mid-Elevation Forested Plant Communities

At regional (i.e., landscape) scales, fisher occurrence in western North America has been consistently associated with low- to mid-elevation forested environments (Grinnell et al. 1937, Hagmeier 1956, Banci 1989, Aubry and Houston 1992, Buskirk and Zielinski 2003, and others). In the Assessment Area and adjacent regions, fisher distribution was primarily associated with plateau and foothill landscapes east of the Coast Ranges in British Columbia (Weir 2003, Lofroth 2004, Hatler et al. 2008) and low to mid-elevation coastal and montane environments in Washington and Oregon (Bailey 1936, Aubry and Houston 1992, Aubry and Lewis 2003). There are currently no established fisher populations in Washington² and, in Oregon, fishers are restricted to the Klamath Mountains and the southern portion of the Cascade Range. Fisher distribution becomes more peninsular and more strongly associated with montane environments in California (Grinnell et al. 1937, Golightly 1997, Zielinski et al. 2005).

Fishers were associated with a narrower range of elevations in most British Columbia study areas than elsewhere in the Assessment Area and adjacent

² A fisher reintroduction program is in progress in Washington State (Chapter 5).

Table 7.2. Publications and reports containing fisher habitat data from the Assessment Area (Study Areas 8–27) and adjacent regions (Study Areas 1–7) in western North America.

Fisher population and study area number	Source publications and reports
Western Plateaus and Valleys, British Columbia	
1. Williston	Weir and Corbould 2000, 2006, 2007, 2008; Weir et al. 2004
2. McGregor	Proulx 2006
3. Chilcotin	Davis 2003, 2006 <i>a, b</i> , 2007, 2008 <i>a, b</i>
Cariboo, British Columbia	
4. Beaver	Weir 1995; Weir and Harestad 1997, 2003; Weir et al. 2004
Southern Interior Mountains, British Columbia	
5. East Kootenays	Apps 1995, Fontana et al. 1999, Fontana and Teske 2000
Northwestern Montana	
6. Cabinet Mountains	Heinemeyer 1993, Roy 1991, Vinkey 2003
North-central Idaho and West-central Montana	
7. Nez Perce National Forest	Jones 1991, Jones and Garton 1994
Cascade Range, Oregon	
8. Southern Oregon Cascades	Aubry and Raley 2002 <i>a, b</i> ; 2006
Northern California-Southwestern Oregon	
9. Siskiyou National Forest	Slauson and Zielinski 2001, Zielinski et al. 2000
10. Green Diamond Resource Company	Hamm et al. 2003, Klug 1997, Simpson Resource Company 2003, Thompson et al. 2007
11. Redwood National and State Parks	Slauson and Zielinski 2003
12. Sacramento Canyon	Reno et al. 2007, 2008; Self and Callas 2006; Self and Kerns 1992, 2001
13. Hoopa Valley Indian Reservation	Higley et al. 1998, Higley and Matthews 2006, Matthews et al. 2008, Yaeger 2005
14. Shasta-Trinity National Forest	Dark 1997, Seglund 1995, Truex et al. 1998, Yaeger 2005
15. Shasta Lake	Lindstrand 2006
16. Big Bar	Buck 1982; Buck et al. 1979, 1983, 1994; Mullis 1985
17. Pilot Creek, Six Rivers National Forest	Truex et al. 1998; Zielinski et al. 1994 <i>b</i> , 1995 <i>d</i> , 2004 <i>a, b</i>
18. Hayfork Summit	Reno et al. 2008, Self and Callas 2006
19. Coastal Northwestern California	Beyer and Golightly 1996
20. Northern California Inventory	Carroll 1997, 2005; Carroll et al. 1999; Davis et al. 2007; Zielinski et al. 1997 <i>b</i> , 2000, 2005, 2006 <i>a</i>
21. Mendocino National Forest	Slauson and Zielinski 2007
Southern Sierra Nevada, California	
22. Sierra Nevada Fire and Fire Surrogate	Truex and Zielinski 2005
23. Kings River, Sierra National Forest	Boroski et al. 2002; Jordan et al. 2005, 2007; Jordan 2007; Mazzoni 2002; Zielinski et al. 2006 <i>b</i>
24. Sequoia-Kings Canyon	Green 2007
25. Tule River	Truex et al. 1998; Zielinski et al. 1994 <i>a</i> , 1995 <i>a, b</i> , 1997 <i>a</i> , 2004 <i>a, b</i> , 2006 <i>b</i>
26. Sequoia National Forest Inventory	Laymon et al. 1991
27. Sierra Nevada Inventory and Monitoring	Campbell 2004; Davis et al. 2007; Spencer et al. 2008; Zielinski et al. 1997 <i>b</i> , 2000, 2005

regions (Table 7.3). Elevations at fisher telemetry locations or detection sites were higher on average in the most southern and eastern studies than elsewhere in the Assessment Area and adjacent regions (Table 7.3; Study Area 27; Aubry and Houston 1992). Upper elevation bounds to fisher distribution were highest in eastern and southern studies (Table 7.3; Study Areas 5, 6, 26) (Luque 1983, 1984; Aubry and Houston 1992). In northern California, elevation and latitude appeared to influence fisher distribution and those influences differed between interior and coastal environments; elevation and precipitation were negatively associated with fisher distribution in interior environments and positively associated with fisher distribution in coastal environments (Study Area 20).

In British Columbia, fisher occurrences were rare in coastal environments and may have represented extra-limital records (Banci 1989, Hatler et al. 2008). Moist climate and associated deep snow packs are cited as primary reasons for this (MacLeod 1950, Banci 1989). However, historical and current fisher distribution in Washington, Oregon, and California included coastal environments (Bailey 1936, Aubry and Houston 1992, Aubry and Lewis 2003, Zielinski et al. 2005). Snow has been posited as limiting suitable fisher habitat and fisher distribution at higher elevations (Aubry and Houston 1992, Powell and Zielinski 1994, Weir et al. 2003). This is consistent with fisher studies elsewhere in North America that indicated that some snow conditions may limit fishers because they are not efficient at traveling and hunting in terrain covered by soft deep snow (Plate 7.1; Leonard 1980, Raine 1983, Krohn et al. 2004, Carr et al. 2007). However other factors associated with increasing elevation (e.g., lower forest productivity, changes in forest structure; Franklin and Dyrness 1988, Meidinger and Pojar 1991, McNab and Avers 1994) may also limit fisher distribution through their influence on the abundance of structures critical for denning and resting, and abundance and availability of prey.

Within the Assessment Area and adjacent regions, fishers were not consistently associated with any specific forested plant community. Rather, fisher populations occupied a diverse range of conifer, mixed conifer, and mixed conifer-hardwood forests (Table 7.4; Plate 7.2). Southern fisher populations occurred in a wider diversity of forest types than did northern populations (Table 7.4). Fishers were not found in high-elevation subalpine and alpine habitats or in dry, warm, open forest and grassland environments (Study Area 6; Cowan and Guiguet 1956, Aubry and Houston 1992, Aubry and Lewis 2003, Zielinski et al. 2005).

7.2.2. Fishers Are Associated With Moderate to Dense Forest Canopy

Within low and mid-elevation forests, the most consistent predictor of fisher occurrence at large spatial scales was moderate to high amounts of contiguous canopy cover rather than any particular forest plant community (Study Areas 1, 2, 5, 9, 14, 20, 21, 24, 25, 27; Plate 7.3). Within the Assessment Area and adjacent regions, empirical evidence suggests that fishers generally have a positive association with increasing canopy cover at all spatial scales investigated (Study Areas 1, 4, 5, 9, 13, 14, 20, 24, 25, 27).

These generalizations are supported by data from 3 types of studies: radiotelemetry studies that explicitly evaluated fisher selection at the landscape scale (Study Areas 1, 4, 13, 25), radiotelemetry studies that reported selection of forest cover by the study population across an entire study area but not selection of home ranges at the landscape scale per se (Study Areas 5, 6, 7, 12, 16, 17), and detection studies that evaluated relationships between verified fisher occurrences at large sampling scales and associated habitat attributes (Study Areas 2, 3, 9, 10, 11, 14, 15, 20, 21, 24, 27). Because of these differences in study designs and objectives, the methods used to derive measures of canopy cover

Table 7.3. Elevation (m) reported for fisher detection surveys (D) and telemetry studies (T) in the Assessment Area (Study Areas 8–27) and adjacent regions (Study Areas 1–7) in western North America.

Fisher population and study area number	Study type	Study area elevation	Elevation used by fishers ^a
Western Plateaus and Valleys, British Columbia			
1. Williston	T	670–1100	Not reported ^b
2. McGregor	T	<900	Not reported
3. Chilcotin	D, T	1000–1500	Not reported ^c
Cariboo, British Columbia			
4. Beaver	T	750–1300	Not reported ^c
Southern Interior Mountains, British Columbia			
5. East Kootenays	T	1067–1981	823–>2200
Northwestern Montana			
6. Cabinet Mountains	T	1000–2680	600–1600 ^d
North-central Idaho and West-central Montana			
7. Nez Perce National Forest	T	1006–2165	1374 (SD = 132)
Cascade Range, Oregon			
8. Southern Oregon Cascade Range	T	610–2134	610–1525
Northern California-Southwestern Oregon			
9. Siskiyou National Forest	D	600–2900	880 (SD = 341)
10. Green Diamond Resource Company	D, T	5–1400	619 (SE = 6.5) ^e 663 (SE = 37) ^e
11. Redwood National and State Parks	D	0–945	39–617
12. Sacramento Canyon	T	615–2154	Not reported
13. Hoopa Valley Indian Reservation	T	75–1170	195–701 ^f
14. Shasta-Trinity National Forest	D, T	325–1500	Not reported
15. Shasta Lake	D	326–366	Not reported
16. Big Bar	T	730–1912	473–1494
17. Pilot Creek, Six Rivers National Forest	T	600–1800	Not reported
18. Hayfork Summit	T	500–1600	Not reported
19. Coastal Northwestern California	D	Not reported	466 (SE = 6.8)
20. Northern California Inventory	D	0–2700	998 (SD = 409)
21. Mendocino National Forest	D	230–2500	1499 (SE = 66.8)
Southern Sierra Nevada, California			
22. Sierra Nevada Fire and Fire Surrogate	D, T	1200–1500 1900–2150	Not reported
23. Kings River, Sierra National Forest	D, T	294–2592	1067–2438
24. Sequoia-Kings Canyon	D	500–4400	1000–2780
25. Tule River	T	1300–2300	Not reported
26. Sequoia National Forest Inventory	D	1170–2460	1512–2194
27. Sierra Nevada Inventory and Monitoring	D	760–2500	Not reported

^a Elevation ranges are for fisher locations or detections. Single estimates represent the mean elevation of fisher locations or detections followed by the reported error measurement.

^b 93% of fisher home ranges were within the study area boundaries and elevation range.

^c All fisher home ranges were within the elevation range of the study area.

^d 98.5% of locations occurred in this elevation range.

^e Elevation used by fishers reported separately for each of 2 study years (1994, 1995).

^f Elevation of den locations.



Plate 7.1. Some snow conditions may limit the distribution of fishers as deep, soft snow has been reported to restrict their movements.



Plate 7.2. Fishers occupy a diverse range of forested plant communities including but not limited to sub-boreal and boreal mixed conifer forests comprised of white spruce, lodgepole pine, subalpine fir, black cottonwood, and trembling aspen (A: Study Area 1, British Columbia); mixed conifer with Douglas-fir, true fir, sugar and ponderosa pines, incense cedar, and western hemlock (B: Study Area 8, Oregon); Klamath mixed evergreen with Douglas-fir, tanoak, and madrone (C: Study Area 13, northern California); and Sierra mixed conifer comprised of ponderosa pine, white fir, incense cedar, and Jeffrey pine (D: Study Area 27, southern Sierra Nevada, California).

Table 7.4. Ecological regions and forest plant communities (based on potential natural vegetation) occupied by extant fisher populations in the Assessment Area and adjacent regions in western North America.

Fisher population	Ecological region^a	Forest plant community^b
Western Plateaus and Valleys, British Columbia	Chilcotin Plateau Ecoregion	Sub-boreal Pine Spruce
	Parsnip Trench Ecoregion	Montane Spruce
		Interior Douglas-fir
		Sub-boreal Spruce
Cariboo, British Columbia	Cariboo Plateau Ecoregion	Sub-boreal Spruce
Northwestern Montana	Flathead Valley Section	Spruce–Fir
		Douglas-fir
		Cedar–Hemlock–Douglas-fir
		Pine–Douglas-fir
North-central Idaho and West-central Montana	Bitterroot Mountains Section	Cedar–Hemlock–Douglas-fir
	Idaho Batholith Section	Douglas-fir
		Spruce–Fir
		Grand fir–Douglas-fir
		Pine–Douglas-fir
Cascade Range, Oregon	Western Cascades Section	Silver fir–Douglas-fir
	Eastern Cascades Section	Cedar–Hemlock–Douglas fir
	Southern Cascades Section	Fir–Hemlock
		Ponderosa Shrub
		Mixed Conifer
Northern California–Southwestern Oregon	Klamath Mountains Section	Douglas-fir
	Northern California Coast Ranges Section	Douglas-fir–Ponderosa Pine
	Northern California Coast Section	Douglas-fir–Tanoak
		Jeffrey Pine
		Mixed Conifer
		White Fir
		Redwood
Southern Sierra Nevada, California	Sierra Nevada Section	Mixed Conifer
	Sierra Nevada Foothills Section	Ponderosa Pine
		Jeffrey Pine
		White Fir
		Red Fir
		Lodgepole Pine
		Giant Sequoia

^a For the fisher populations in British Columbia, these are based on Ecoregions (Demarchi 1996); for all the remaining populations, these are based on Ecological Subregion Sections (McNab and Avers 1994).

^b For the fisher populations in British Columbia, these are based on Biogeoclimatic Zones (Meidinger and Pojar 1991); for the Southern Oregon Cascades population, these are based on Kuchler’s Potential Natural Vegetation groups (Kuchler 1964, Schmidt et al. 2002); for all the remaining populations, these are based on Miles and Goudy (1997) section descriptions, which rely on potential natural community series described by Sawyer and Keeler-Wolf (1995).

were varied and descriptors reported by investigators (e.g., low, moderate, dense) are relative to conditions and forest community types available in any given study area. Where possible, we have included relevant measures of canopy cover as reported in the literature.

In telemetry studies, landscape-level selection for forest cover has been demonstrated where investigated (Study Areas 1, 4, 13, 25). The 95% confidence set of models explaining selection of home ranges by fishers in British Columbia (Study Area 1) included avoidance of areas lacking forested cover, avoidance of nonforested ecosystems (e.g., wetlands), selection of forested ecosystems, and selection of forests with $\geq 30\%$ canopy cover. This model suggested that if 5% of a potential fisher home range comprised open areas (i.e., no forest cover), the mean relative probability of occupancy by fishers was reduced by 50%; if 25% of a potential fisher home range comprised open areas, the mean relative probability of occupancy was reduced to 0. Fishers in British Columbia avoided a variety of open, nonforested environments including cultivated fields and herb-shrub successional stages (Study Area 4). In northern California, fishers selected older closed-canopy forest, sapling-brushy pole, and seedling stands, but did not avoid any types (Study Area 13). In the southern Sierra Nevada, selection of home ranges was influenced by the forested vegetation type, tree size-class, and canopy cover, with home ranges dominated by mixed conifer, ponderosa pine, and montane hardwood forest types (Study Area 25). Female home ranges included more lower elevation forest types (e.g., ponderosa pine) whereas male home ranges included more higher elevation forest types (e.g., red fir; Study Area 25). On average, 66% of the area within fisher home ranges in the southern Sierra Nevada was composed of forests with 60–100% canopy cover and an additional 22% had canopy cover of 40–59% (Study Area 25). Female home ranges had more forest with 60–100% canopy cover than did male home ranges (71.7% vs. 55.6%; Study Area 25).

In telemetry studies where fisher habitat selection was reported for the entire study population over the entire study area (as opposed to selection of individual home ranges), fishers also demonstrated landscape-scale habitat selection. In the East Kootenays of British Columbia, fishers selected forested habitats with $>45\%$ canopy closure and avoided open habitats in all seasons (Study Area 5). In the Cabinet Mountains, fishers selected mixed conifer and cedar–hemlock stands and avoided using newly regenerating clearcuts and alpine areas (Study Area 6). Most fisher locations were in dense forest stands with $>76\%$ canopy cover; stands with $<50\%$ canopy cover were avoided (Study Area 6). In Idaho, $<1\%$ of fisher locations occurred in nonforested cover types (Study Area 7). Fishers did not use nonforested or pole sapling stands during winter, and 90% of summer locations were in mature and late-successional forests (Study Area 7). In northern California, fishers selected closed-canopy conifer types and avoided open areas (Study Area 16). Mid to late-successional stands were the dominant component of fisher home ranges, whereas nonforested areas composed only 1.5% of home ranges (Study Area 17). In northern California, male fishers were reported as being positively associated with dense canopy classes. They were also, however, reported to select areas of low to moderate canopy cover (25–40%), but these areas typically included a heavy understory component (Study Area 12).

In British Columbia, fisher detections were negatively associated with plant communities lacking forest canopy (e.g., sedge wetlands; Study Area 3) and positively associated with coniferous and mixed coniferous-deciduous stands (Study Area 2). Eighty percent of fisher detections ($n = 89$ total detections) were in forest stands with 30–60% canopy cover whereas only 1 detection was in a nonforested site (Study Area 2). In northern California, all fisher detections were in forested environments (Study Areas 9, 10, 11, 14, 15) or were negatively associated with barren areas (Study Area 14). Fisher detections

Plate 7.3. Fishers occur in landscapes with moderate to high amounts of contiguous canopy cover. In these examples, fishers do not occur everywhere on the landscape shown, but the image is centered on areas known to be occupied by fishers. This page: Study Area 1 in British Columbia (A) and Study Area 8 in Oregon (B). Following page: Study Area 13 in northern California (C) and Study Area 27 in the southern Sierra Nevada (D).





were positively associated with Douglas-fir plant associations in many areas (Study Areas 9, 10, 14). Fishers were detected at sites with 70–95% canopy cover (Study Area 9), most frequently at sites with 51–75% canopy cover (Study Area 14), or at sites with significantly higher tree canopy cover (\bar{x} = 78%) than random sites (Study Area 21). Canopy cover was the best predictor of fisher occurrence at landscape scales, and investigators have suggested that inadequate canopy cover limits fisher distribution across forest types and ecoregions (Study Area 20). In the southern Sierra Nevada, all fisher detections were in forested sites and in a variety of conifer, mixed conifer, and hardwood plant associations (Study Areas 24, 27). Fishers occurred at sites with $\geq 40\%$ canopy cover (Study Area 24) or were closely associated with dense-canopied forests (Study Areas 26, 27). Canopy cover was a significant predictor in multivariate models of fisher occurrence in the southern Sierra Nevada (Study Area 27).

Various researchers have reported other factors associated with fisher distribution, but the patterns were not consistent among studies. Proximity to water, including permanent or ephemeral streams, was a factor associated with fisher habitat selection or distribution at large spatial scales in several studies (Study Areas 6, 12, 26). Other abiotic variables including terrain ruggedness, percent slope, elevation, and road density have been reported as useful contributing predictors or correlates of fisher distribution in several studies (Study Areas 6, 10, 20, 27).

7.2.3. Fisher Home Ranges Typically Include a Diversity of Forest Successional Stages and Plant Communities

Composition of individual fisher home ranges generally included a mosaic of forested environments ranging from pure hardwood (Study Areas 17, 25) and mixed conifer-hardwood (Study Areas 12, 17) to pure conifer stands (Study Areas 1, 4, 6, 7, 16, 17, 25). For the most part, fisher home range composition tended to reflect the forested plant

communities found in the study areas (Chapter 3). Although fisher home ranges were generally dominated by coniferous forests, the amount and diversity of conifer types varied from north to south. Fisher home ranges in northern study areas were predominantly coniferous (e.g., spruce, lodgepole pine, true firs, western redcedar, and hemlock; Study Areas 1, 4, 6, 7). Fisher home ranges farther to the south included a more diverse mix of conifer types and tree species (e.g., Klamath mixed conifer, Douglas-fir, true firs, mixed oak-pine, Sierran mixed conifer, ponderosa pine; Study Areas 12, 13, 16, 17, 25) and also included mixed conifer-hardwood and pure hardwood plant communities (e.g., mixed oak pine, montane hardwood conifer, white oak [*Quercus alba*] hardwood, montane hardwood; Study Areas 17, 25). In several studies, fishers selected riparian forests or forested environments relatively close to water (Study Areas 1, 6, 25). In some study areas where hardwood plant communities were relatively rare, fishers selected these communities because they contained important habitat attributes not found elsewhere (e.g., den sites; Study Areas 1, 4) whereas, in other areas, fishers avoided using some or all hardwood types (Study Areas 6, 16). Hardwood components were more common in fisher home ranges in California than elsewhere (Study Areas 12, 13, 17, 25). In the southern Sierra Nevada, pure hardwood stands (e.g., canyon live oak [*Quercus chrysolepis*]) were used by fishers for resting and may provide important habitat for certain prey species (Study Area 25). The smallest home ranges reported for fishers in the Assessment Area and adjacent regions (Chapter 6) were from study areas where mast-producing hardwoods are a major component of the forest (Study Areas 10, 13, 23, 25), presumably resulting in abundant prey.

Fisher home ranges were composed of a mosaic of successional stages that often included high proportions of mid- to late-successional forests (Table 7.5; Study Areas 13, 17, 25). Nevertheless, in some studies, fisher home ranges included or

Table 7.5. Successional stage composition of fisher home ranges in the Assessment Area (Study Areas 12–25) and adjacent regions (Study Areas 1–7) in western North America. Included in home ranges (I); selected for inclusion in home ranges (+); selected against inclusion in home ranges (–).

Fisher population and study area number	Non-vegetated	Herb and shrub	Pole sapling and young forest	Mid-successional forest	Late-successional forest
Western Plateaus and Valleys, British Columbia					
1. Williston	I –	I –	I	I +	I +
Cariboo, British Columbia					
4. Beaver	–	I –	I +	I	I
Northwestern Montana					
6. Cabinet Mountains			I	I	I
North-central Idaho and West-central Montana					
7. Nez Perce	–	–	I – (summer) I + (winter)	I +	I +
Northern California-Southwestern Oregon					
12. Sacramento Canyon		I	I +, –	I +	I +
13. Hoopa Valley Indian Reservation		I +	I +		I +
16. Big Bar	I –	I –			I +
17. Pilot Creek, Six Rivers National Forest		I	I	I	I
Southern Sierra Nevada, California					
25. Tule River		I	I	I	I

were positively associated with younger successional stages, likely because of prey resources associated with those environments (e.g., snowshoe hare, woodrats; Study Areas 4, 7, 12, 13). When investigated, fishers avoided inclusion or use of the youngest successional stages in their home ranges (nonforested and herb-shrub; Table 7.5), except in Hoopa Valley where fishers selected dense shrub environments in addition to other successional stages (Study Area 13). Nonvegetated sites were typically avoided by fishers when establishing or using areas within their home ranges (Study Areas 4, 6, 7, 16).

7.2.4. Active Fishers Are Frequently Associated With Complex Forest Structure

On a daily basis, fishers need to locate and capture prey, locate resting sites, and defend their territory. Seasonally, fishers may need to travel farther or more frequently to find enough food to raise young or locate mates (Sections 6.2, 6.3). To meet these needs,

fishers probably make decisions based on location and abundance of potential prey, environments in which they can hunt effectively, and environments that provide escape cover from potential predators.

Several studies have investigated forest characteristics in the immediate vicinity (i.e., site scale) of active (i.e., mobile) locations of radio-marked fishers (Study Areas 1, 4, 7, 8, 13) or snow-tracks of active fishers (Study Area 3). In all studies, fishers appeared to be more flexible in their use of various forest successional stages when active than when resting or denning (Study Areas 1, 4, 7, 8, 13; Plate 7.4). When active, male fishers in Oregon appeared to use a wider array of habitat conditions than females (Study Area 8). Nevertheless, active fishers typically avoided nonforested environments (Study Areas 3, 7, 8) and early-successional forest stands that lacked canopy cover (Study Area 4). These results may reflect the need for fishers to hunt for a variety of



Plate 7.4. At the site scale, fishers used a variety of forest conditions when travelling or foraging (A: Study Area 8, Oregon; B: Study Area 13, northern California; C: Study Area 27; Southern Sierra Nevada). These examples do not represent the entire range of forest conditions used by fishers.

prey species that occupy various forest conditions, including younger successional stages or ecotones (e.g., Study Area 3), while also needing security cover from potential predators when hunting or traveling. Active fishers may also select habitat at smaller spatial scales. In British Columbia, when using stands with low amounts of forest structure, active fishers selected patches with high volumes of coarse down wood and moderate cover of shrubs (Study Area 4). This structural complexity most likely provided overhead cover for fishers and cover for snowshoe hares, a primary prey of fishers in that region, and other small mammals (Study Area 4). In contrast, stands with dense shrub cover (61–80% low shrubs, 41–60% high shrubs) may have hampered hunting success and, in these stands, fishers selected patches that had less structure than was typical (Study Area 4). Systematic snow-tracking surveys revealed that

fishers typically investigated any coarse down wood they encountered, presumably for potential prey. Compared to random transects, fishers were more active in areas with higher volumes of coarse down wood and greater numbers of snowshoe hares and red squirrels (*Tamiasciurus hudsonicus*; Study Area 3).

Vegetative data collected at track-plate or remote-camera survey stations have frequently been used to compare forest conditions at sites where fishers were detected with those at sites where fishers were not detected. Although some studies used bait or lure, or stations were located in specific forest types or successional stages, investigators have generally assumed that forest conditions associated with fisher detections represent foraging or, at least, travel habitat (e.g., Study Areas 10, 11). Results from systematic surveys in northern California suggested

that sites where fishers were detected were more structurally complex than those where fishers were not detected (Study Areas 9, 10, 11, 20, 21). Fishers were more likely to visit sites that had greater log volume (Study Area 10), greater densities of medium and large dead woody structures (snags [dead trees], stumps, coarse down wood; Study Area 11), greater overstory tree or shrub cover (Study Areas 11, 21), and large or greater basal area of hardwood trees (Study Areas 10, 20, 21). During systematic surveys in the southern Sierra Nevada, fishers were also detected at sites that were more structurally complex than nondetection sites (Study Areas 24, 26, 27). Fishers visited sites that had greater than expected canopy cover (>40%), and most (67–78%) sites had the largest tree classes (>60 cm dbh [diameter at breast height]), a hardwood component, and were next to a stream (Study Area 24). Although sample sizes were small, fisher detection sites on the Sequoia National Forest had significantly larger trees than nondetection sites and were frequently closer to streams, farther from openings, had greater densities of snags, and greater canopy cover (Study Area 26). Although slope was the best predictor of where fishers were detected in the southern Sierra Nevada, steeper slopes were typically associated with sites that had greater amounts of shrub cover, hardwood basal area, and canopy cover (Study Area 27).

Several investigators have speculated that greater vertical structure (large-diameter conifer and hardwood trees and snags, canopy cover; e.g., Study Areas 2, 20), mast production by hardwoods (e.g., Study Area 20), and structural complexity on or near the forest floor (shrubs cover and coarse down wood; e.g., Study Areas 1, 4) support a greater diversity and abundance of prey species and, consequently, are likely important components of fisher foraging habitat (Powell and Zielinski 1994). Habitat associations for many of the small and medium-sized mammals consumed by fishers in the Assessment Area and adjacent regions provide supporting evidence. For example, multilayered forests with

large old trees and a diversity of conifers that provide perennial seed sources are important habitat elements for tree squirrels and other arboreal rodents (Smith 1981, Vahle and Patton 1983, Buchanan et al. 1990, Carey 1995, Aubry et al. 2003). Understory cover (1–3 m in height) and vegetation density are key habitat components for snowshoe hares (e.g., Litvaitis et al. 1985; Sievert and Keith 1985; Hodges 2000). Brush rabbits (*Sylvilagus bachmani*; Chapman 1974), ground squirrels (e.g., California ground squirrel [*Spermophilus beecheyi*]; Zeiner et al. 1990), dusky-footed woodrats (*Neotoma fuscipes*; Carey et al. 1999), and chipmunks (*Tamias* spp.; Ingles 1965) are typically associated with brushy understory conditions. Mast-producing hardwoods provide substantial food resources for birds and mammals and may increase the abundance of mast-eating rodents (Wolff 1996). Deteriorating live hardwoods and conifers, snags, and coarse down wood also provide habitat for many fisher prey species such as the northern flying squirrel (*Glaucomys sabrinus*), western gray squirrel (*Sciurus griseus*), Douglas' squirrel (*Tamiasciurus douglasii*), red squirrel, western red-backed vole (*Myodes californicus*), and bushy-tailed woodrat (*Neotoma cinerea*; e.g., Ingles 1947, Maser et al. 1981, Tallmon and Mills 1994, Carey 1991, Carey et al. 1999).

Although results from studies involving radio-telemetry, snow-tracking, and detection surveys suggest that complex vegetative structure is important to active fishers, the lack of strong consistent patterns of selection may be related to several factors. Active fishers are likely engaged in several behaviors, each of which may be linked to different environmental conditions including foraging for different types of prey (e.g., ground-dwelling vs. arboreal mammals; Study Area 1), traveling between kill and rest sites, territory defense, and various social interactions. Fisher prey species vary regionally and probably seasonally; thus fine-scale forest conditions associated with active locations may also vary among studies and seasons. Finally, sample sizes in some studies may be too small to detect selection.

Investigating foraging habitat preferences of a secretive and vagile carnivore is challenging. In general, foraging habitat preferences of fishers will typically reflect those of their primary prey (Powell 1993, Buskirk and Powell 1994, Powell and Zielinski 1994). The diet of fishers in the Assessment Area and adjacent regions appears to be quite variable and additional work is needed to identify key prey species and seasonal foraging patterns (Section 6.3). Fishers probably do not forage everywhere their prey occur, rather they choose conditions where they are most effective at locating and capturing prey (Buskirk and Powell 1994). Forest environments with high prey densities may not have high numbers of available prey as prey size, palatability, and behavior most likely influence where fishers hunt and what they can capture (Buskirk and Powell 1994). Although this has not been investigated for fishers, recent work on American martens provides empirical support for these hypotheses. Prey densities in Ontario were similar among forest types, but greater predation efficiency by martens on red-backed voles in older uncut stands was linked to higher abundances of coarse down wood (Andruskiw et al. 2008). The authors hypothesized that down wood provided sensory cues to martens (increasing their hunting success) and decreased the wariness of voles in that environment (Andruskiw et al. 2008).

7.2.5. Fisher Rest Sites Are Strongly Associated With Moderate to Dense Forest Canopy and Elements of Late-Successional Forests

Rest sites (i.e., the forest environment in the immediate vicinity surrounding a rest structure) are presumably selected to provide 1 or more advantages to fishers (e.g., thermal, security, proximity to prey). Because fishers likely base their use of rest sites on these multiple needs, they may also select for many forest attributes at these sites (Plates 7.5, 7.6). In the Assessment Area and adjacent regions, fishers selected for a suite of characteristics, either by selecting sites in stands that had an abundance of preferred

characteristics or by selecting sites with atypically high levels of preferred characteristics for a particular stand type. Most studies report data on the use of rest sites. However, investigators in Idaho combined all types of sites used by fishers in their analyses and reported that 82% of summer use sites and 67% of winter use sites were rest sites (Study Area 7). Consequently, references to rest sites in this study area include some sites (18% in summer, 33% in winter) that were used for activities other than resting.

In most studies, fishers selected rest sites with dense canopy cover (Table 7.6). When resting in stands where the average value of canopy cover was low, fishers compensated by using sites with values higher than expected for that stand type (Study Areas 4, 12). However, in British Columbia, fishers selected sites with moderate canopy cover (<60%) when in stands with high mean canopy cover (Study Area 4). In Idaho, fisher summer use sites were associated with greater canopy cover than typical for the stand (Study Area 7). The average canopy cover at resting sites in Oregon was 84% for females and 82% for males compared to 67% at random sites (Study Area 8). In northern California, 90% of fisher rest sites had canopy cover >40% (Study Area 12), canopy cover >93% (Study Area 17), or canopy cover higher than random sites (\bar{x} > 85%; Study Area 14). In Hoopa Valley (Study Area 13), >50% canopy cover was an effective predictor of rest sites and most rest sites were in stands with 25–76% canopy cover. Sites used by fishers for resting in the southern Sierra Nevada had very dense canopies (\bar{x} > 92%; Study Area 25), canopy cover and crown volume higher than random sites (Study Area 23), or canopy cover that was less variable than at random sites (Study Area 22). Females in both northern California and the southern Sierra Nevada tended to select sites with higher canopy cover than did males, which used a wider range of canopy conditions (Study Areas 17, 25).

Fisher rest sites had larger trees and a greater abundance of large trees than were typically available



Plate 7.5. Forest conditions at sites used by fishers for resting were variable but frequently had moderate to dense forest canopy (A-B: Study Areas 1 and 3, British Columbia; C: Study Area 8, Oregon; D: Study Area 17, northern California). These examples do not represent the entire range of forest conditions used by fishers for resting.



Plate 7.6. Forest conditions at sites used by fishers for resting in northern California (A–B: Study Area 13) and the southern Sierra Nevada, California (C–D: Study Area 23) often comprised moderate to dense forest canopy. These examples do not represent the entire range of forest conditions used by fishers for resting.

(Table 7.6). Winter and summer use sites in Idaho had greater densities of large trees than random sites (Study Area 7), and female rest sites in Oregon had higher basal area of large and very large trees than male rest sites (Study Area 8). At least 50% of fisher rest sites in northern California had 1 tree >75 cm dbh and 40% had at least 1 tree >100 cm dbh (Study Area 12). In other areas of northern California, rest sites were positively associated with large-diameter

trees (Study Areas 14, 17), had larger diameter trees than random sites (\bar{x} dbh of the 5 largest trees at rest sites = 118 cm; Study Area 17), or were associated with stands with large-diameter conifer and hardwood trees (Study Area 13). In the southern Sierra Nevada, rest sites had larger trees than random sites (Study Areas 22, 25), and the mean dbh of the 5 largest trees at rest sites was 90 cm (Study Area 25).

Table 7.6. Association among forest attributes and fisher rest sites in the Assessment Area (Study Areas 8–25) and adjacent regions (Study Areas 1–7) in western North America. A symbol indicates a reported measure of selection (+) or avoidance (–), or a reported predominance of that characteristic at fisher rest sites (i.e. no selection analyses but characteristics of rest sites reported).

Fisher population and study area number	Higher canopy closure	Large tree size	Large tree density	Trees with rust brooms or other pathogens	Hardwoods	Large snag size and abundance	Coarse down wood	Mature or late-successional forest
Western Plateaus and Valleys, British Columbia								
1. Williston				+			+	
Cariboo, British Columbia								
4. Beaver ^a		+	+	+			+	
North-central Idaho and West-central Montana								
7. Nez Perce	+	+	+			+	+	+
Cascade Range, Oregon								
8. Southern Oregon	+		+			+	+	
Cascades								
Northern California-Southwestern Oregon								
10. Green Diamond				+				
12. Sacramento Canyon	+	+						+
13. Hoopa Valley Indian Reservation	+	+			+			
14. Shasta-Trinity National Forest	+	+	+		+	+	+, –	
16. Big Bar								+
17. Pilot Creek, Six Rivers National Forest	+	+	+			+		
Southern Sierra Nevada, California								
22. Sierra Nevada Fire Surrogate	+	+			+			
23. Kings River, Sierra National Forest	+	+	+			+	+	
25. Tule River	+	+			+	+		

^a Includes maternal dens.

In several studies, fisher rest sites were positively associated with the abundance of trees that had rust brooms and mistletoe (Table 7.6), which are structural features that provide rest platforms for fishers. In British Columbia, fishers selected rest sites that had more trees with rust brooms than available sites (Study Areas 1, 4) and the density of trees with rust brooms was a key variable in rest-site selection models (Study Area 1). Rest sites in northern California were typically in hemlock stands with dwarf mistletoe (Study Area 10).

In most of the California study areas, particularly those in the southern Sierra Nevada, fisher rest sites were associated with the presence or abundance of hardwood trees (Table 7.6). In northern California, selection models predicted rest sites in both conifer and hardwood stands (Study Area 13), or rest sites had more species of hardwoods and fewer species of conifers (Study Area 14). In the southern Sierra Nevada, pure hardwood stands (e.g., canyon live oak) were used by fishers for resting (Study Area 25), presumably because these sites offered more potential rest structures (Section 7.2.6). Hardwood trees at rest sites were typically larger than those at random sites (Study Areas 22, 23, 25).

Fisher use of cavities for resting was common in many study areas (Section 7.2.6), and rest sites were frequently positively associated with snag size and abundance (Table 7.6). In Idaho, winter and summer use sites were positively associated with greater densities of large snags whereas random sites were not (Study Area 7). In Oregon, female rest sites had higher densities of snags than male rest sites (Study Area 8). In northern California and the southern Sierra Nevada, rest sites had greater densities of large snags than random sites (Study Areas 14, 17, 23, 25).

Fisher rest sites were positively associated with various attributes of coarse down wood (volume, size, cover; Table 7.6). The positive association with downed wood was pronounced in British Columbia (Study

Areas 1, 3, 4), Oregon (Study Area 8), and northern California (Study Area 14), but not as evident in more southern fisher populations. This may be related to thermal constraints as fishers select for subnivean resting sites and structures during periods of extreme cold (Study Areas 1, 4; see section 7.2.6). In British Columbia, fishers selected rest sites that had greater amounts of sound, large, coarse down wood than was typical for the stand (Study Areas 1, 4). In Idaho, winter use sites were associated with greater volumes of large coarse down wood than were random sites (Study Area 7), and female rest sites in Oregon had higher densities of coarse down wood than male rest sites (Study Area 8). Fisher rest sites in northern California and the southern Sierra Nevada were associated with greater cover of coarse down wood than were random sites (Study Areas 14, 23), but this cover was provided by fewer logs (i.e., the logs at rest sites were larger; Study Area 14).

Although most studies reported that rest sites were associated with attributes characteristic of late-successional forests, rest sites were not always located in late-successional forest stands (Table 7.6). In Idaho, summer use sites were typically in older successional stages (Study Area 7). In Oregon, 63% of female and 25% of male rest sites were located in patches of unmanaged forests whereas only 1% and 2%, respectively, were in nonforested patches (Study Area 8). In British Columbia, fishers selected Douglas-fir and spruce stands for resting and avoided stands of lodgepole pine (a successional species), early successional forests, and nonforest vegetation (Study Area 4).

In many study areas, fisher rest sites were located close to water. In Idaho, winter and summer use sites were typically closer to water than were random sites (Study Areas 6, 7). In northern California, rest sites tended to be in drainage bottoms (Study Area 13) or were closer to water than random sites (Study Areas 12, 14). In the warm interior forests of northern California, 81% of all rest sites were within 100 m of water (Study Area 14). Fishers in the southern Sierra

Nevada also selected resting sites within 100 m of water (Study Area 25), or selected sites closer to water than randomly located sites (Study Area 23). In southern climates, selection of rest sites by fishers may be related to microclimate, and rest sites near water may provide fishers with thermal relief during hot weather (Zielinski et al. 2004a). Yaeger (2005), however, posited that selection of rest sites close to water may be related to growing conditions and the production of large structures that are amenable to resting.

Other forest characteristics and physiographic variables have been associated with fisher rest sites, but patterns of association were not consistent among studies. Fisher winter use sites in Idaho were positively associated with lower densities of small trees and greater understory cover (Study Area 7). Rest sites used by fishers in Oregon typically had a diverse assemblage of tree species ($\bar{x} = 5$; Study Area 8). Rest sites in northern California were positively associated with the number of vegetation layers, and greater distances to roads and human disturbance (Study Area 14). In contrast, rest sites in Hoopa Valley (Study Area 13) were closer to landscape alterations than random sites. In the southern Sierra Nevada, rest sites had greater canopy layering (Study Area 23), and in both northern California and the southern Sierra Nevada, rest sites were on steeper slopes than were random sites (Study Areas 17, 23, 25).

7.2.6. Fishers Typically Rest in Large, Deformed or Deteriorating Trees and Logs

When fishers are not actively foraging or traveling, they use various structures for resting that most likely provide protection from potential predators, thermal advantages, and secure locations for consuming prey (Plates 7.7, 7.8; see Section 6.2.3). Although the types of structures used for resting were similar across study populations within the Assessment Area and adjacent regions, the relative use of each type differed (Table 7.7). Fishers rested primarily in live trees (64–83% of all rest structures reported by individual studies), and secondarily in snags (7–26%) and

coarse down wood (2–20%). Use of other ground structures (e.g., logging debris piles, rock crevices, etc.) by fishers was infrequent and varied among studies (0–9% of all rest structures identified). Re-use of rest sites by fishers was infrequent (14.0% in Study Area 8, 3.5% in Study Area 17, 13.8% in Study Area 25).

The tree species used by fishers within the Assessment Area and adjacent regions were relatively consistent with the distribution and diversity of conifer and hardwood species present. Conifer forests dominate in northern study areas, but hardwoods are more prevalent and overall species diversity is higher in southern study areas (Burns and Honkala 1990, Hicke et al. 2007). When resting in live trees, fishers were observed using deformities associated with mistletoe and broom rust infections, large branches, interlaced branching structures, platform nests, and cavities (Plate 7.9). In the more northern study areas, fishers primarily rested in live conifer trees with rust brooms (Study Areas 1, 4) or mistletoe brooms and other platforms (Study Areas 7, 8, 10, 12). Engelmann spruce was one of the conifer species most frequently used in Idaho (Study Area 7), and fishers selected live hybrid spruce trees with rust brooms for resting in British Columbia (Table 7.8; Study Area 4). Fishers used a diversity of conifer species for resting in the remaining regions (Table 7.8), but live and dead hardwood trees with cavities were an increasingly important resource in many of the California study areas (Table 7.9; Study Areas 13, 14, 17, 23, 25). Fishers selected black oak (*Quercus kelloggii*) in several studies (Study Areas 13, 14, 23), and used black oak >2 times as frequently for resting in the southern Sierra Nevada than in coastal forests of northern California (37.5% of all resting structures in Study Area 25 and 10.9% of all structures in Study Area 17).

Snags represented $\leq 7\%$ of all rest structures used by fishers in the most northern study areas (Study Areas 1, 4, 7) compared to $\geq 12\%$ elsewhere (Table 7.7; Study Areas 8, 12, 13, 14, 17, 23, 25). When resting in snags, fishers primarily used cavities (e.g.,



Plate 7.7. Fishers used various species and conditions of live trees for resting including but not limited to Douglas-fir with mistletoe infections (A), western hemlock with a dead top and platform branches (B), black oak with cavities (C), and sugar pine with internal decay and a stick nest (D). Typically, live trees used for resting were among the largest diameter classes available in a given area.



Plate 7.8. Fishers used various species of snags and logs for resting including but not limited to white fir (A: snag), Douglas-fir (B: snag), lodgepole pine (C: log), and incense cedar (D: log). Typically, snags and logs used for resting were among the largest diameter classes available in a given area.

Table 7.7. Types of forest structures used for resting by fishers in the Assessment Area (Study Areas 8–25) and adjacent regions (Study Areas 1–7) in western North America. Other types of ground structures included woody debris piles from logging, rock outcrops, woodrat nests, unknown structures under snow, and dense shrubs.

Fisher population and study area number	% trees			% ground structures		n
	All	Live	Dead	Log and coarse down wood	Other	
Western Plateaus and Valleys, British Columbia						
1. Williston	71	64	7	20	9	55
Cariboo, British Columbia						
4. Beaver	81	75	<6 ^a	13	6	32
North-central Idaho and West-central Montana						
7. Nez Perce	86	78	7	14	1	172
Cascade Range, Oregon						
8. Southern Oregon Cascades	79	66	13	16	5	641
Northern California-Southwestern Oregon						
10. Green Diamond Resource Company	90 ^b			7	3	35
12. Sacramento Canyon	94	79	15	2		34
13. Hoopa Valley Indian Reservation	95	83	12	3	2	218
14. Shasta-Trinity National Forest	90	76	14	9	1	296
17. Pilot Creek, Six Rivers National Forest	95	69 ^c	26 ^d	5		191 ^e
Southern Sierra Nevada, California						
23. Kings River, Sierra National Forest	91	76	15	4	5	78
25. Tule River	91	65 ^c	26 ^d	9		360 ^e

^a Only 1 or 2 structures used for resting were dead trees.

^b Number of live vs. dead trees was not available, but use of dead trees was infrequent (<10%).

^c Includes live conifers and all live and dead hardwood trees, thus percentage of live trees used for resting was slightly less.

^d Only includes dead conifers and not dead hardwood, thus percentage of dead trees used for resting was slightly greater.

^e Total did not include number of other types of ground structures used. Other ground structures appeared to make up <5% of all rest structures identified in Pilot Creek and <10% in Tule River.

Study Areas 8, 12, 17, 25; Plate 7.10). Several studies have reported that females used snags more frequently than males (Study Areas 8, 14, 17, 23, 25). In the southern Sierra Nevada and coastal forests of northern California, female fishers used snags significantly more often than males (31.7 vs. 18.0%), whereas males used platforms in trees more frequently than females (16.8 vs. 8.3%; Study Areas 17, 25). Because females are substantially smaller than males, they may be more vulnerable to predation and weather extremes. Thus, compared to males, females may use resting structures that offer greater protection from predators and from extreme temperature and moisture conditions (e.g., cool and

moist in California coastal forests vs. hot and dry in the Sierra Nevada; Study Areas 17, 25).

Fishers used coarse down wood more frequently in regions with colder winter temperatures than in regions with milder temperatures. Coarse down wood composed 13–20% of all fisher rest structures identified in British Columbia, Idaho, and Oregon (Study Areas 1, 4, 7, 8) compared to 3–9% of rest structures in California studies (Table 7.7; Study Areas 10, 12, 13, 14, 17, 23, 25). When resting in woody debris, fishers used hollow portions of logs or spaces created by coarse down wood under the snow (Study Areas 1, 4, 7, 8, 23; Plate 7.10). In Idaho,



Plate 7.9. When resting in live trees, fishers used various microstructures including but not limited to brooms caused by rust fungi (A), dense branching or brooms caused by mistletoe infections (B), natural forming platform branches (C), and rodent nests (D).



Table 7.8. Conifer tree species used by fishers for reproductive dens (D or d), resting structures (R or r), or both in the Assessment Area (Study Areas 8–25) and adjacent regions (Study Areas 1–7) in western North America. Upper case denotes more frequently used species; lower case denotes less frequently used species (typically <10%). Some studies only investigated reproductive dens or resting structures, but not both.

Fisher population and study area number	Coast redwood	Incense cedar ^a	Port Orford cedar	Western redcedar	Douglas-fir	True fir	Western hemlock	Jeffrey pine	Lodgepole pine	Ponderosa pine	Sugar pine ^b	Western white pine ^c	Engelmann spruce	Hybrid spruce ^d	Pacific yew ^e
Western Plateaus and Valleys, British Columbia															
1. Williston						r								R	
3. Chilcotin					D				D						
Cariboo, British Columbia															
4. Beaver					r									R	
North-central Idaho and West-central Montana															
7. Nez Perce					r	R								R	
Cascade Range, Oregon															
8. Southern Oregon Cascades		DR			DR	DR	R		r	r	R	Dr	r		r
Northern California-Southwestern Oregon															
10. Green Diamond Resource Company	Dr			dR	DR		R								
12. Sacramento Canyon		Dr	d		DR	dr				dR	r				
13. Hoopa Valley Indian Reservation			d		DR	r					dr				
14. Shasta-Trinity National Forest		r			R	r		r		dR	R				r
17. Pilot Creek, Six Rivers National Forest		dr			DR	DR					r				
18. Hayfork Summit					D										
Southern Sierra Nevada, California															
23. Kings River, Sierra National Forest		R				R				R	R				
25. Tule River		r				DR				R	R				

^a *Calocedrus decurrens*

^b *Pinus lambertiana*

^c *Pinus monticola*

^d *Picea glauca* x *engelmanni*

^e *Taxus brevifolia*

Table 7.9. Hardwood tree species used by fishers for reproductive dens (D or d), resting structures (R or r), or both in the Assessment Area (Study Areas 8–25) and adjacent regions (Study Areas 1–4) in western North America. Upper case denotes more frequently used species, lower case denotes less frequently used species (typically <10%). Some studies only investigated reproductive dens or resting structures but not both.

Fisher population and study area number	Trembling aspen	Black cottonwood	Pacific madrone	Bigleaf maple	Golden chinquapin	Tanoak	Black oak	Canyon live oak	White oak	California bay laurel
Western Plateaus and Valleys, British Columbia										
1. Williston	r	Dr								
3. Chilcotin	D									
Cariboo, British Columbia										
4. Beaver	r	DR								
Cascade Range, Oregon										
8. Southern Oregon Cascades			r		dr					
Northern California-Southwestern Oregon										
10. Green Diamond Resource Company				r	D	Dr				r
12. Sacramento Canyon							Dr			
13. Hoopa Valley Indian Reservation			dr	r	dr	DR	DR	r	dr	
14. Shasta-Trinity National Forest					r		DR	Dr		
17. Pilot Creek, Six Rivers National Forest					r	r	dR			
18. Hayfork Summit				d			D	D		
Southern Sierra Nevada, California										
23. Kings River, Sierra National Forest							R			
25. Tule River							DR	r		

fishers used coarse down wood for resting >3 times as often in winter as in summer (27 vs. 8%; Study Area 7). In British Columbia, ambient temperatures were significantly colder when fishers used coarse down wood for resting compared to when they used arboreal structures. Fishers exclusively used subnivean sites associated with coarse down wood when ambient temperatures were below -14.2° C (Study Areas 1, 4).

Live and dead trees used for resting were relatively large, but the sizes used ranged widely (\bar{x} dbh ranged from 56 cm to 118 cm; Table 7.10). Some of this variability is likely related to differences in tree condition and growth potential of conifers versus hardwoods (i.e., in this region, conifer species

typically attain larger sizes than do hardwood species). For studies that summarized data by these factors, dead trees used for resting were 1.2–1.6 times the diameter of live trees used, and conifers used were 1.2–1.6 times the diameter of hardwoods used (Table 7.10). Because investigators measured coarse down wood in various ways (i.e., small-end diameter, mean diameter, large-end diameter), it is difficult to compare the size of coarse down wood used by fishers for resting among studies. Nevertheless, coarse down wood used for resting was also relatively large (\bar{x} diameter ranged from 41–132 cm; Table 7.10).

In all but 1 of 7 studies that investigated selection of rest structures, fishers selected structures that



Plate 7.10. When resting in snags and logs, fishers used various microstructures including but not limited to cavities in the bole of a snag (A–B), platforms created when the top of a snag breaks off (C), and hollows in logs (D).

were 1.4–3.2 times larger than the diameter of those available (Study Areas 4, 13, 14, 17, 23, 25). In British Columbia, the mean diameter of rest trees was about 1.9 times that of available trees, and fishers

selected coarse down wood that was almost twice the diameter of randomly sampled coarse down wood (Study Area 4). In the southern Sierra Nevada and coastal forests of northern California, trees used

Table 7.10. Size (cm) of forest structures used for resting by fishers in the Assessment Area (Study Areas 8–25) and adjacent regions (Study Areas 1–7) in western North America. dbh = diameter at breast height.

Fisher population and study area number	\bar{x}	Variability	<i>n</i>
Western Plateaus and Valleys, British Columbia			
1. Williston			
Tree dbh	57	24 ^a	39
Log diameter	41	25 ^a	12
Cariboo, British Columbia			
4. Beaver			
Tree dbh	87	46–103 ^b	25
Log diameter	80	12 ^c	4
North-central Idaho and West-central Montana			
7. Nez Perce			
Live tree dbh	56	53–59 ^d	134
Dead tree dbh	86	74–97 ^d	13
Log small-end diameter	53	46–61 ^d	24
Cascade Range, Oregon			
8. Southern Oregon Cascades			
Live tree dbh	76	18–201 ^b	259
Dead tree dbh	118	29–196 ^b	54
Log large-end diameter	107	48–182 ^b	75
Northern California-Southwestern Oregon			
12. Sacramento Canyon			
Live tree dbh	76	30 ^a	27
Dead tree dbh	107	91–122 ^b	5
Log large-end diameter	97	48–147 ^b	2
13. Hoopa Valley Indian Reservation			
Tree dbh	87	3 ^c	129
14. Shasta-Trinity National Forest			
Tree dbh	104	4–8 ^e	147
17. Pilot Creek, Six Rivers National Forest			
Conifer tree dbh	104	30–38 ^f	149
Hardwood tree dbh	88	30 ^a	32
Log maximum diameter	95	44 ^a	10
Southern Sierra Nevada, California			
23. Kings River, Sierra National Forest			
Live tree dbh	95	28 ^a	53
Dead tree dbh	117	47 ^a	12
25. Tule River			
Conifer tree dbh	102	31–51 ^f	181
Hardwood tree dbh	65	21 ^a	146
Log maximum diameter	132	92 ^a	33

^a Standard deviation.

^d 95% confidence interval.

^b Range.

^e Range of standard error values calculated for 3 sampling periods.

^c Standard error.

^f Range of standard deviation values calculated for 3 functional groups of trees used.

by fishers were 1.5 and 1.7 times the diameter of available trees within the immediate vicinity of the rest structure or in random plots, respectively (Study Areas 17, 25). Although trees used by fishers for resting in British Columbia were about 1.3 times the diameter of available trees (57 vs. 44 cm), the presence of rust brooms was a stronger predictor of which trees fishers were most likely to use (Study Area 1).

Results from these studies suggest that fishers are somewhat flexible in the tree species they use for resting, and probably select live trees and snags based on other structural characteristics including the presence of platform structures and cavities (e.g., Study Areas 1, 17, 25). Within each locality, the species of live trees and snags that are most likely to develop rust brooms, mistletoe brooms, platforms, or cavities appear to be more important to fishers than those that do not (e.g., Study Areas 1, 17, 25). The relatively large size of structures used for resting is most likely related to several factors including tree age and the time required to develop various microstructures (Chapter 8). Only 2 studies have estimated the age of trees used for resting. In British Columbia, where fishers demonstrated selection for hybrid spruce with rust brooms, rest trees were among the oldest trees available (\bar{x} = 129 yr; Study Area 1). Available trees were smaller and had significantly fewer rust brooms than those used for resting (Study Area 4). Although rust brooms develop on spruce trees of various ages, they occur primarily in older, larger diameter trees (Weir and Harestad 2003). In northern California, the average age of conifer trees used for resting was 100 years and possibly 160 years (the age of 6 trees could not be determined but were assigned a maximum age of 350 yr), whereas, the average age of available conifer trees was only 47 years (Study Area 12).

7.2.7. Cavities in Large Trees Are a Critical Resource for Reproduction

The strongest and most consistent habitat association observed across all fisher studies in the Assessment Area and adjacent regions was the use of cavities in live and dead trees by reproductive females with kits

(Study Areas 1, 3, 4, 8, 10, 12, 13, 14, 17, 18, 25; Plates 7.11, 7.12). Fisher kits are born during late winter-early spring when weather conditions are still cold and wet (snow or rain; see Section 6.1.1) and are completely vulnerable until weaned at about 10 weeks of age. Tree cavities provide both thermal insulation and security from potential predators. Kits are still vulnerable after weaning and dependent on their mother until they can hunt on their own (Section 6.1.1). During these developmental stages, tree cavities as well as other forest conditions that provide security cover are probably important for survival.

In most cases, cavities used by reproductive females for birthing (natal) and nursing (pre-weaning) were created by heartwood decay (Study Areas 1, 3, 4, 8, 12, 13, 14, 18, 25). Females generally accessed internal cavities through relatively small or narrow openings created by branches breaking away from the bole, cracks in the bole, fire scars, and pileated woodpeckers (*Dryocopus pileatus*; Table 7.11; Plate 7.13). In British Columbia, entrances to 7 natal dens averaged about 8 cm wide by 10 cm vertical length (Study Area 1). Tree cavities used later in the kit-rearing period also had relatively small or narrow openings (\bar{x} width = 11 cm, \bar{x} length = 28 cm, n = 4; Study Area 1). In Oregon, video footage of female fishers accessing natal dens through openings excavated by pileated woodpeckers (about 9 cm wide by 12 cm long) revealed that larger animals, including male fishers, would probably be excluded (Study Area 8). The average height of natal den entrances above ground level was 15 m (range = 3–26, n = 7; Study Area 1) and 16 m (range = 4–47, n = 10; Study Area 8). Both the size and height of cavity entrances may be important for excluding potential predators. In contrast to the size of the cavity entrance, the interior chamber needs to be large enough to accommodate an adult female and 1–4 growing kits (Plate 7.14). The average interior dimensions of 5 natal den cavities were about 24 cm in diameter by 280 cm in vertical length; tree cavities used later in the kit-rearing period were also relatively large (\bar{x} diameter = 25 cm, \bar{x} vertical length = 119 cm, n = 4; Study Area 1).



Plate 7.11.

Reproductive female fishers used various species of live and dead trees with cavities for natal and pre-weaning dens including but not limited to black cottonwood (A), trembling aspen (B), lodgepole pine (C), and white pine (D). Typically, den trees were among the largest diameter classes available in a given area.



Plate 7.12. Reproductive female fishers used various species of live and dead trees with cavities for natal and pre-weaning dens including but not limited to incense cedar (A), Douglas-fir (B), ponderosa pine (C), and black oak (D–E). Typically, den trees were among the largest diameter classes available in a given area.

Adult female fishers used a variety of conifer and hardwood species for reproductive dens. In regions where both hardwoods and conifers occurred, hardwoods were used for denning more frequently than conifers, even in areas where they were a minor component of the forest (Table 7.11; Study Areas 1, 4, 14). In 2 of 3 study areas in British Columbia,

reproductive females used black cottonwood trees exclusively for denning (Table 7.9; Study Areas 1, 4). Compared to other available trees species in these study areas, black cottonwoods had a high incidence of heartwood decay and cavities (Study Area 1). In contrast, denning females in the Chilcotin area of British Columbia primarily used cavities in Douglas-

Table 7.11. Mean diameter breast height (dbh) of den trees used by reproductive female fishers in the Assessment Area (Study Areas 8–25) and adjacent regions (Study Areas 1–4) in western North America. We categorized dens by the developmental stage of kits: natal, pre-weaning, post-weaning, or reproductive when developmental stage was unknown. Cavity openings were created by broken-off branches (B), cracks in the bole or other deformities (C), fire scars (F), pileated woodpeckers (P), or unknown (Unk).

Fisher population and study area number	Den type	No. conifer		No. hardwood		dbh (cm)	Range or variability	Cavity opening
		live	dead	live	dead			
Western Plateaus and Valleys, British Columbia								
1. Williston	natal			7	1	103	88–132	B
	pre-, post-			3	2	120	80–154	
3. Chilcotin	natal	5	1	4		46	34–78	B, C, P
	pre-, post-	7 ^a		1 ^a		49	37–73	
Cariboo, British Columbia								
4. Beaver	reproductive			5		103	12.9 ^b	B
Cascade Range, Oregon								
8. Southern Oregon Cascades	natal, pre-	6	5	1	1	91	61–138	B, C, P
	post-	8	5			115	35–250	
Northern California-Southwestern Oregon								
10. Green Diamond Resource Company	natal		1	3		77	63–95	F, P
	pre-, post-reproductive		3	2		112	63–184	
		3		4		186	74–295	
12. Sacramento Canyon	natal	1	1			67	66–68	B, C, P
	pre-, post-	1	7	2	3	79	45–113 ^c	
13. Hoopa Valley Indian Reservation	natal	2	3	21		88	37–192	B, C, F, P
	pre-	6	7	26	4	92	35–205	
	post-		1	1		110	72–147	
	reproductive		1	10	1	66	44–96	
14. Shasta-Trinity National Forest	reproductive		1	5		74	41–126	Unk
17. Pilot Creek, Six Rivers National Forest	pre-, post-	3	1	1		104	53–138	Unk
18. Hayfork Summit	reproductive	3	6	34	2	74	31–130 ^b	B, C, P
Southern Sierra Nevada, California								
25. Tule River	natal	1	2	2		103	76–148	Unk
	pre-, post-	1		2		79	40–146	

^a Detailed information on tree condition was not available; this number may include live or dead trees.

^b Standard error.

^c Range of mean values calculated for each tree species used.



Plate 7.13. Typically, cavities used by female fishers for denning were created by heartwood decay, and females accessed these internal cavities through relatively small openings including but not limited to frost cracks (A), branches that have broken away from the bole (B), and pileated woodpecker excavations (C–D).

fir, trembling aspen, and lodgepole pine (Tables 7.8, 7.9; Study Area 3). Reproductive females primarily used conifers for denning in Oregon (Table 7.8; Study Area 8). Hardwood species, especially black oak, appeared to be particularly important for denning in many of the California study areas (Tables 7.9). Fishers used live and dead conifers about equally for denning, but 91% of all dens in hardwoods were in live trees (Table 7.11).

Trees used by reproductive females for denning were large (\bar{x} dbh across all studies was 92 cm, range of means = 46–186; Table 7.11). Some of the variability in sizes of trees used for denning within and among studies is likely related to the greater growth potential of conifers compared to hardwoods and, in some localities, site productivity. In studies where both were used, conifer den trees were on average 1.7–2.3 times larger than the diameter of hardwood den trees (e.g., Study Areas 12, 13, 18, 25). In all studies that analyzed den tree selection, den trees were on average 1.7–2.8 times the diameter of other available trees within the vicinity of the den (Study Areas 1, 3, 4, 12, 18). The mean dbh of trees used for denning in the Chilcotin study area was smaller than in other studies (Table 7.11), but fishers selected the largest trees available (den trees were about 2 times the diameter of available trees; Study Area 3). Den trees were also much older than available trees. The average estimated age of trees used for denning was 372 years for Douglas-fir, 177 years for lodgepole pine, and 96 years for trembling aspen; whereas only 20% of the available trees sampled were >100 years (12/56) and only 1 was >150 years (Study Area 3). The relatively large size of trees and snags used for denning is most likely related to tree age and the time required for heartwood decay to develop and form cavities, and the size of cavities needed to accommodate an adult female and kits.

All documented natal and pre-weaning dens were cavities in standing live or dead trees, and most post-weaning dens were also tree cavities. Nevertheless, females with older kits occasionally used other types

of forest structures during the post-weaning period including hollow logs or other coarse down wood (Study Areas 8, 17, 18) and platform structures in live trees (mistletoe broom, rodent nest; Study Area 8). Although data are available for only 5 dens in hollow logs, these structures were also relatively large (\bar{x} diameter at the wide end = 105 cm, range = 56–166; length = 15 m, range = 5–27; Study Area 8).

Although there is strong evidence that adult females select specific structural characteristics for denning (i.e., large live and dead trees with cavities), there is little information available to determine whether forest characteristics of the surrounding site also influence selection. Regardless, many studies have demonstrated that fishers select specific site-level forest characteristics for resting (section 7.2.5); thus, forest conditions around den structures are also likely important to reproductive females (Plate 7.15). Investigators in British Columbia speculated that selection of riparian forest stands by fishers was related to the abundance of suitable reproductive den trees (i.e., black cottonwoods in that locality) and greater diversity and abundance of prey populations (Study Area 1). Yet, at smaller spatial scales, no factor other than tree species appeared to influence selection of reproductive den sites (Study Area 1). In the Chilcotin area of British Columbia, den trees were never located on cold aspects and were frequently on the toe of slopes close to wetlands and watercourses (Study Area 3). Investigators speculated that, in the dry climate of this region, these sites were some of the most productive, were more likely to have large trees capable of developing a suitable cavity, and may have supported more abundant prey (Study Area 3). Several studies reported that females used sites for denning that had relatively high amounts of overhead canopy cover (70–100%; Study Areas 8, 14, 17, 25; Plate 7.15). In general, overhead vegetation cover is believed to provide fishers with security cover from potential predators (e.g., Buskirk and Powell 1994) and favorable microclimates (e.g., Zielinski et al. 2004a).



Plate 7.14. Den cavities provide fisher kits with thermal insulation and security from potential predators (A: at least 3 kits are visible in the bottom of this natal den cavity). The interior chamber needs to be large enough to accommodate an adult female with kits (B: this hollow, created by heartwood decay in a live golden chinquapin, was used as a natal den by a female fisher with 3 kits).



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7.3. Implications for Conservation

1. Fishers are obligate users of tree cavities for reproductive dens throughout the Assessment Area and elsewhere in North America (Powell and Zielinski 1994). Because reproduction is essential for conserving and expanding fisher populations, conservation measures must emphasize the maintenance and development of critical denning structures.
2. Structures used for reproductive dens and resting are typically among the largest available trees, snags, and logs. These structures are also typically associated with trees that are among the oldest available in the resting or denning site. Large structures with the types of microstructures (e.g., cavities, mistletoe or rust brooms) used by fishers for denning and resting are relatively rare in forested landscapes. To effectively provide critical life requisites, conservation measures for fishers must ensure that these important large, old structures are maintained where they exist and are promoted where they are scarce or lacking.
3. In any given locality, the species of live trees and snags most likely to have heartwood decay and large cavities are more important to fishers than those that do not. Trees that have the types of cavities used by fishers for denning and resting may be relatively uncommon in some forested landscapes. Conservation strategies must ensure that, regionally, preferred species of cavity-prone trees are maintained and promoted.
4. Fishers rest every day, but reuse of rest sites is infrequent. Use of rest sites and structures may be dictated by weather conditions, proximity to available prey, and other factors that change daily and seasonally. Therefore, each fisher requires an abundance of suitable rest structures within its home range. To maintain and grow fisher populations, conservation measures must ensure that appropriate rest structures are abundant and well distributed over the landscape.
5. Hardwoods are an important component of fisher habitat in many regions within the Assessment Area that provide denning and resting structures and may support a high diversity and abundance of prey populations. However, their importance should not be overemphasized relative to conifers (Zielinski et al. 2004a), because conifers were also used extensively by fishers for denning and resting and contributed important elements of forest structure (e.g., canopy cover, coarse down wood) throughout the Assessment Area. Where hardwoods are a significant component of fisher habitat, conservation measures should seek opportunities to maintain and promote them.
6. Canopy cover is critical to fishers; the most consistent predictor of fisher occurrence at large spatial scales was moderate to high amounts of contiguous canopy cover. Fishers typically occur where canopy cover is greatest. To facilitate recovery of fisher populations in the Assessment Area, conservation measures must ensure that moderate to high levels of canopy cover (relative to the inherent potential for any given forest plant community) are maintained and promoted across forested landscapes and within potential fisher home ranges.
7. In some parts of the Assessment Area, proximity to natural water courses appears to be an important influence on fisher distribution and habitat selection. The reasons for this vary regionally (e.g., thermal effects, prey abundance and availability, and more productive ecosystems capable of producing greater abundances of favoured habitat features). Where proximity to water is an important factor, conservation strategies should include this feature when identifying areas that are potentially important to fishers.
8. Fisher distribution may be limited by a number of potentially inter-correlated environmental conditions, including high elevations, lack of forested cover, deep or unsuitable snow



Plate 7.15. Forest conditions at sites used by female fishers for denning (natal or pre-weaning den sites) in British Columbia (A: Study Area 1), Oregon (B: Study Area 8), northern California (C: Study Area 13), and southern Sierra Nevada, California (D: Study Area 23). These examples do not represent the entire range of forest conditions used by fishers for denning.

conditions, and forest environments that lack critical structural features. To successfully maintain and expand fisher populations in the Assessment Area, a conservation strategy must: 1) recognize this inherent distributional niche (low to moderate elevations, moderate to high forest cover, suitable snow conditions, and large forest structures), 2) be implemented at appropriately large regional scales, and 3) plan for potential shifts in fisher distribution over time resulting from habitat changes associated with climate change and changes in human development and landscape-use patterns.

9. Fishers are associated with complex forest structure (e.g., dense and layered canopy, snags, large trees, structures associated with forest pathogens, large logs) when active, resting, and denning. Although fishers are not obligates of late-successional forest, many of the elements they need typically only develop in late-successional forests and require many years (tens of fisher generations) to form. To conserve fishers in the Assessment Area, it will be critical to maintain these forest elements as important legacies in younger forests regenerating following timber harvest. Their loss would likely result in local extirpations.
10. Fishers are more discerning in their habitat needs for resting and denning than for foraging. Female fishers are also more selective in their use of various forest conditions than males. Entire landscapes likely do not need to be composed solely of denning and resting habitat, however their interspersions with habitats that also support abundant and available prey and other active behaviours (e.g., dispersal, breeding season movements) will likely maximize occupancy probabilities and improve demographics. Conservation efforts should be focused on the most productive areas to maximize habitat quality for reproductive females, as long as other areas have adequate resources to support males.

11. Within their distributional niche, fishers are relatively flexible in their use of the forested plant communities and successional stages that occur in the Assessment Area. This may benefit fishers in significant ways by providing greater access to seasonal prey abundance, diversity, and availability, and a wider diversity of resting opportunities. Nevertheless, fisher populations may not occur or persist in areas where the forest environment does not provide the resources necessary to meet their life requisites. What appears to be important are the site productivity and ecological processes that promote development of complex forest structure that provides the security cover, adequate prey, coarse down wood, and trees and snags with cavities and platforms for needed reproductive dens and rest sites. Although fishers are not necessarily incompatible with forest management, forested landscapes with a history of intensive management (e.g., repeated clearcut logging, hygienic forestry practices, removal of coarse down wood) may no longer provide these attributes. To be successful, conservation measures must recognize differences in the potential for current forest ecosystems to provide these needs, and how landscape patterns, including those from past and current timber management, may affect the size of areas needed to support not only individuals but populations.



CHAPTER 8. ECOLOGICAL PROCESSES THAT INFLUENCE FISHER HABITAT

8.1. Processes That Create Forest Structure

Forest structure, including tree size and age, canopy cover, understory vegetation cover, and standing and down dead wood are important for many aspects of fisher ecology including reproduction, resting, and foraging (Chapter 7). Thus, understanding the role of ecological processes in creating and maintaining components of forest structure important to fishers and their prey populations is essential for the development of effective conservation strategies.

Natural processes and disturbance events that shape landscape patterns, vegetation communities, and forest structure within the Assessment Area include fire, wind, insect and disease outbreaks, landslides, and volcanic activity (McNab and Avers 1994, Wong et al. 2003; see Chapter 3). The magnitude and intensity of these disturbances vary throughout the Assessment Area (Chapter 3) and, thus, so will their influence on fisher habitat. In this section, we present an overview of the ecological processes that create and maintain components of forest structure that are important for fishers. Forest structure can be described in various ways; however, 4 particularly important components are the distributions of tree sizes and ages, vertical foliage distribution (understory and overstory vegetation layers), horizontal canopy distribution (continuity in canopy cover, canopy gaps), and dead wood (Spies 1998). In turn, these components are linked to other structural features in a forest ecosystem. The size distribution of live trees is linked to foliage distribution and crown attributes, and the potential of a forest to produce other features, such as large deteriorating live trees, snags, and down wood of various sizes (Spies 1998).

Historically in the Assessment Area, fire was a major influence on forest ecosystems at various spatial scales and, although fire regimes have shifted during contemporary times (Chapters 3, 4), fire continues to influence forest composition and structure. At large spatial scales, frequent (<50-yr return interval) low-intensity fires typically create multilayered forests composed of a mosaic of different age classes of fire-resistant tree species, including large old trees (Agee 1993). Fire is believed to be one of many natural processes that created and maintained different successional stages in ponderosa pine and Douglas-fir forests of the inland west prior to European settlement (Everett et al. 2000). Forest ecosystems that experience infrequent stand-replacing fires tend to have larger expanses of single-aged stands and more fire-intolerant tree species reaching mature and late-successional forms (Agee 1991). Nevertheless, scattered patches of residual trees in protected areas, and partial mortality patterns resulting from moderate-severity fires, typically creates heterogeneity in stand structure and regeneration (Agee 1993).

Small-scale disturbances that create gaps by killing 1 or a small patch of canopy trees are also a key ecological process in the development and maintenance of forest structure (Spies et al. 1990, Lertzman et al. 1996). The role of small-scale disturbances may be particularly important in forests where stand-replacing events occur infrequently (Lertzman et al. 1996). Small-scale disturbances include, but are not limited to, localized fires, windthrow, disease, and insect outbreaks. In Douglas-fir dominated forests of western Washington and Oregon, tree mortality from small-scale disturbances creates structural complexity by opening gaps in the



canopy that, depending on gap size and seed sources, allow regeneration of both shade-tolerant and intolerant tree species and the eventual development of stands containing multiple age and size classes and canopy layers (Spies et al. 1990, Gray and Spies 1996). Although gaps may not be necessary for the regeneration of shade-tolerant species in these forests, evidence suggests that development of secondary canopy layers may be more rapid where gaps occur (Gray and Spies 1996).

Another key ecological role of both large- and small-scale disturbances is the creation of standing and coarse down wood (Spies et al. 1988). The abundance and distribution of coarse down wood is strongly controlled by disturbance regimes (Spies et al. 1988). Fire, wind, disease and insect outbreaks, and landslides are the primary mechanisms for damaging live trees and creating snags and logs in forest ecosystems (Spies et al. 1988, Campbell and Liegel 1996, Lertzman et al. 1996). Under natural disturbance regimes, amounts of coarse down wood in Douglas-fir-dominated forests in western Washington and Oregon have been quite high (Spies et al. 1988). However, increasingly, forest management has reduced amounts of coarse down wood by removing existing large snags and logs, and reducing the potential of stands to produce future inputs of dead wood (Spies et al. 1988, Spies and Cline 1988).

Synergistic effects among fire, insect and disease outbreaks, and other events can alter natural disturbance cycles and affect forest structure. For example, frequent low-intensity fires may help keep bark beetle outbreaks at low levels by reducing stem densities, which can reduce competitive stress on residual trees. Other environmental conditions may increase bark beetle attacks on fire-scarred trees (Agee 1994). Insect outbreaks may, in turn, alter fire severity, extent, and return intervals (Taylor and Carroll 2003, Carroll et al. 2003). Although fire, insects, and disease have historically been key agents causing tree mortality in unmanaged forests in

western North America (Campbell and Liegel 1996), forest management practices can alter ecological processes and forest structure important for fishers, including the abundance of dying and dead wood in forest ecosystems.

8.2. Processes That Create Cavities for Fishers

8.2.1. Wood Decay

Cavities or hollows in the bole or large branches of live trees, snags, and logs are important microstructures used by fishers for reproductive dens and resting (Chapter 7). Although various types of disturbances create logs, snags, and deteriorating live trees, not all such structures provide potential habitat for fishers. Cavities can be created by wood decay or by primary excavators such as the pileated woodpecker (Bull et al. 1997). This section focuses on cavities and hollows that are created by wood decay. In general, wood decay processes can be divided into 2 major categories: 1) decay of live trees and 2) decay of snags and logs (Manion 1991, Bull et al. 1997). Decay processes that create the cavities and hollows in live trees, snags, and logs that fishers use can only occur when trees are alive (Bull et al. 1997). Understanding the difference between these 2 decay processes is essential to understanding fisher habitat and, ultimately, informing an effective conservation strategy.

Decay of heartwood in live conifers and hardwoods is caused by heart-rot fungi (Manion 1991, Bull et al. 1997; Plate 8.1). These are specialized fungi that are able to tolerate the chemical and morphological defense mechanisms of live trees, and typically infect trees through wounds in the sapwood (Manion 1991, Bull et al. 1997). There are relatively few fungi that cause heartwood decay in live trees, but every tree species is susceptible to at least 1 species of heart-rot fungi (Bull et al. 1997). The defense mechanisms of live trees typically restrict decay to the column of heartwood (Manion 1991). The progression



Plate 8.1. Examples of heartwood decay fungi that infect various conifer species in the Assessment Area including Indian paint fungus (*Echinodontium tinctorium*; A–B), brown trunk rot (*Fomitopsis officinalis*; C), and red ring rot (*Phellinus pini*; D). Aspen trunk rot (*Phellinus tremulae*; E) is only found in trembling aspen.

of heartwood decay in live trees is variable and depends on many factors including the species of heart-rot fungi, tree species and condition, and site conditions (Bull et al. 1997). However, over the years (sometimes decades) the column of decay enlarges and the heartwood may become so deteriorated that it disintegrates, forming a cavity or hollow chamber that is surrounded by sound, live sapwood (Manion 1991, Bull et al. 1997). Heart-rot fungi that affect the bole (and not the roots) of live trees typically do not kill trees, thus such trees may continue to live and grow for many decades (Manion 1991, Bull et al. 1997). When live trees with heartwood decay eventually die, and become snags or logs, the heart-rot fungi either do not persist very long or become relatively inactive (Manion 1991, Bull et al. 1997). Thus, in order for snags or logs to have a cavity or hollow, the original live tree had to be infected with heart-rot fungi and then remain living long enough for a cavity or decay column to develop (Bull et al. 1997).

Once a tree dies, whether it remains standing as a snag or becomes a log, it is invaded relatively rapidly by saprophytic fungi (Manion 1991, Bull et al. 1997). There are many species of saprophytic fungi and, unlike heart-rot fungi, these fungi are generalists (Manion 1991, Bull et al. 1997). Saprophytic fungi only invade dead wood, and decay progresses from the outer sapwood to the core of heartwood (Manion 1991). Although heartwood is more resistant to decay than dead sapwood, saprophytic fungi will eventually decompose the heartwood of snags and logs (Manion 1991). If cavities or hollows were already present at the time of tree death, these microstructures may still provide potential fisher denning or resting habitat until saprophytic decay processes and other wood-destroying organisms break down the cavity walls or weaken the structural integrity of the tree.

Not all live trees become infected with heart-rot decay fungi. Even within stands of the same age and species, some individuals will become infected and others will not (Wagener and Davidson 1954, Boyce

1961). Thus, not all snags and logs will have cavities or hollows. Infection of live conifers and hardwoods by heart-rot fungi, and the subsequent development of cavities or hollows, typically begins with damage to the bole or limbs and the protective layer of bark. Sources of damage include fire, wind, ice and snow breakage, cracks from freezing, lightning, mechanical damage, and potentially woodpeckers and other animals (Wagener and Davidson 1954, Manion 1991, Bull et al. 1997). However, chemical and morphological defense mechanisms of rapidly growing, healthy trees (i.e., younger or nonstressed trees) are typically capable of healing wounds and protecting the tree from infection (Wagener and Davidson 1954, Manion 1991). In contrast, the defense mechanisms of older, suppressed, or unhealthy trees are less capable of responding to injuries and invasion by heart-rot fungi (Wagener and Davidson 1954, Manion 1991). Thus, tree age, in conjunction with environmental stressors such as competition, drought, insects, or pathogens, are important factors contributing to the susceptibility of live trees to infection by heart-rot fungi (Wagener and Davidson 1954, Manion 1991, Schmitt and Filip 2005). These factors are also consistent with observations that heart-rot fungal spores are abundant in all ages of forest, but older stands have a much higher incidence of heart-rot decay (Wagener and Davidson 1954, Manion 1991).

Compared to conifers, hardwoods typically have thinner bark and their open-growth form make them more susceptible to breakage (Gumtow-Farrior 1991, Bunnell et al. 2002). Thus, hardwoods may incur more injuries that result in infection by heart-rot decay fungi at younger ages than do conifers. Bunnell et al. (2002) speculated that, in general, hardwood species in western forests may be more susceptible to heartwood decay than conifers because they produce smaller amounts of resins and toxic extracts. Regardless, for any tree species to provide cavities that are large enough for a fisher to use, sufficient time is necessary for trees to attain large diameters, for

damage or other stress factors to weaken their vigor, and for heart-rot decay to reach an advanced stage and develop cavities. This time frame is dependent, to some extent, on local ecological conditions and may be many decades.

8.2.2. Primary Excavators

Excavation by woodpeckers is a key process in the creation of tree cavities for secondary users. Fishers have been documented using old pileated woodpecker cavities for reproductive dens in British Columbia, Oregon, and California (Table 7.11; Plate 8.2). In coniferous forests of Washington and Oregon, pileated woodpeckers excavate nest cavities in both live and dead trees softened by heartwood decay (Aubry and Raley 2002*c*), or in relatively sound snags (Bull 1987). For roosting, pileated woodpeckers excavate openings that provide access to hollows in live and dead trees that otherwise would

not have been accessible to secondary cavity users (Bull et al. 1992, Aubry and Raley 2002*c*). Thus, in many areas, pileated woodpeckers rely on structures decayed by heart-rot fungi and, through their excavations, provide potential microstructures for fisher reproductive dens and resting (Aubry and Raley 2002*d*). Cavities created by pileated woodpeckers also provide habitat for a variety of other wildlife species, including some fisher prey species (e.g., Douglas', red, and northern flying squirrels, and woodrats; Aubry and Raley 2002*d*). It is unknown whether female fishers can use nest or roost cavities excavated by smaller woodpecker species, most of which create much smaller openings and nest chambers (Aubry and Raley 2002*d*). Nonetheless, cavities created by smaller woodpeckers provide habitat for smaller secondary cavity users (Bull et al. 1997) and, thus, may help support various fisher prey species.

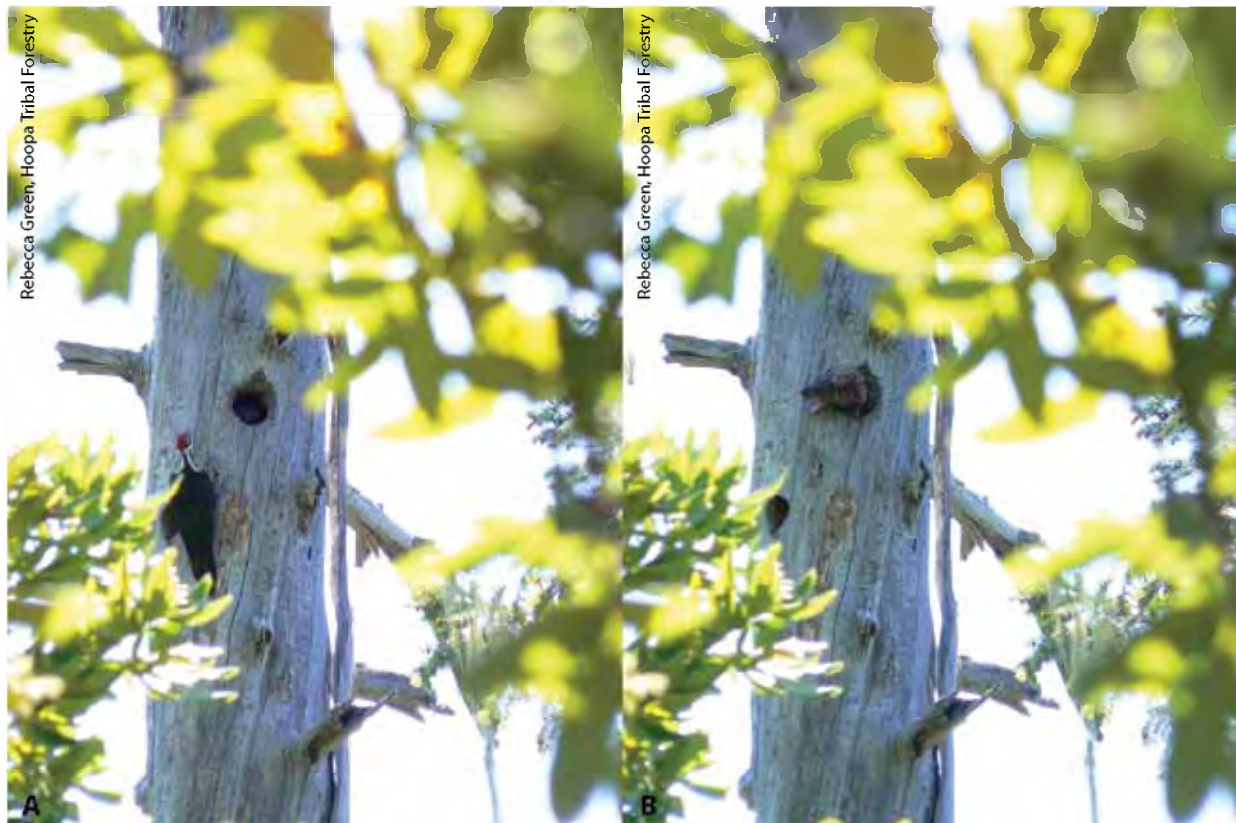


Plate 8.2. A pileated woodpecker investigating an old cavity excavation (A) is surprised by a female fisher using the cavity as a reproductive den (B).

8.3. Processes That Create Platforms for Fishers

Platforms in live trees are created by age, mistletoe and rust brooms (Plate 8.3), and bird and rodent nests. Large-diameter trees with large deformed limbs are typically associated with late-successional forests (Franklin and Spies 1991). However, the growth structure of a tree can be as important as its size in determining its capacity to provide platforms for fishers. For example, Franklin and Spies (1991) found that the deep irregular crowns of large-diameter Douglas-fir trees, often with branches that were irregularly distributed and fan-shaped, were as ecologically important as the diameter of the tree itself in providing resting and nesting platforms for wildlife species.

In the Assessment Area, brooming in live trees is most often caused by dwarf mistletoes (*Arceuthobium* spp.) or rust fungi (*Chrysomyxa* spp. or *Melampsorella* spp.). Dwarf mistletoes can cause the death of heavily infected trees, but until death occurs, infected trees provide a source of food and cover that is directly beneficial to many wildlife species (Bull et al. 1997). Dwarf mistletoe brooms with the greatest potential for use by fishers are those large enough to form platforms. Broom rusts have not been studied as extensively as dwarf mistletoes but provide similar habitat benefits (Bull et al. 1997). Dwarf mistletoes are parasitic plants that spread by the transport of seeds to nearby trees and, eventually, can adversely affect the health of many trees in a stand (Bull et al. 1999). Broom rusts are pathogenic fungi, require an alternate host to complete their life cycle, and can infect a single tree without spreading to adjacent trees (Ziller 1974, Bull et al. 1997). Thus, retention of trees with broom rust does not have the same negative timber management implications as does the retention of trees with dwarf mistletoe (Bull et al. 1997). Engelmann spruce, white spruce (*Picea*

glauca), subalpine fir (*Abies lasiocarpa*), and grand fir (*Abies grandis*) are common hosts of rust fungi in interior western forests (Parks and Bull 1997). However, dwarf mistletoe infections are more common and affect various tree species including Douglas-fir, western hemlock, lodgepole and ponderosa pines, none of which are hosts to broom-causing rusts (Parks and Bull 1997). Broom rusts appear to be more important to fishers in northern regions, such as central-interior British Columbia (Weir 1995, Weir and Corbould 2008), where they are more prevalent. Elsewhere in the Assessment Area and adjacent regions, mistletoe appears to provide important resting structures for fishers (e.g., Jones 1991, Aubry and Raley 2006). Nevertheless, in many younger and managed forests, these important microstructures will only exist if conifer trees with deformed limbs and platforms are retained and the ecological processes that create them are maintained.

8.4. Implications for Conservation

1. Fishers rely on a complex web of ecological processes including disturbances, diseases, and the activities of other organisms, that create and maintain important forest structures such as large live and dead trees with cavities for reproductive dens. Furthermore, many decades are required for forests to develop structural complexity. Many of the structures important to fishers develop via infection of trees by organisms typically considered undesirable pathogens in forest management. To be successful, conservation efforts must recognize the importance of various ecological processes in creating and maintaining forest structures that are important to fishers and their prey, and the temporal and spatial scales at which these processes operate. They may also, at times, require consideration of management intervention to promote processes that develop important structures.



Plate 8.3. Dense branching, platforms, or brooming caused by mistletoe infections (A–B) and rust fungi (C) are important microstructures used by fishers for resting.

2. Trees that develop heartwood decay are critical for fisher reproduction. The species of trees most likely to develop heartwood decay and, subsequently, cavities will vary among localities and over time as forest composition (species and age structure) and other environmental conditions (including climate) change. To be successful, conservation planning should include expertise in forest pathology and ecology to help identify current sources of key fisher structures, and to plan for future inputs.
3. Clean, hygienic forestry which relies on production of young, vigorous forests with short rotation times (relative to natural disturbance regimes) is not conducive to the production of critical habitat structures for fishers. Conservation measures that identify opportunities for management to maintain or promote the development of such forest structures prior to and following timber harvest activities will benefit fisher populations.
4. Forests management activities that alter disturbance regimes (e.g., fire, insect dynamics) can substantially alter fisher habitat potential. Ecosystems whose disturbance regimes are altered such that they experience severe catastrophic disturbances may be less likely to leave important structural legacies and, thus, be less capable of providing important components of fisher habitat.



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APPENDICES

Appendix 6.1. Disease exposure and parasites documented for fishers in North America.

Disease or parasite	Scientific or alternate name	Transmission	Source
Viral diseases			
Distemper	Canine distemper virus	Direct contact with saliva, nasal discharge, or feces	Brown et al. 2006, 2008
Herpes	Canine herpes virus	Saliva, nasal discharge, or feces	Brown et al. 2008
infectious hepatitis	Canine adenovirus	Direct contact with bodily discharge, urine or feces	Philippa et al. 2004; Brown et al. 2006, 2008
Parvoviral enteritis	Canine parvovirus or other related parvoviruses	Contact with feces, or objects contaminated with feces	Douglas and Strickland 1987; Brown et al. 2006, 2008
Rabies	Rabies virus	Saliva via bite wounds	Krebs et al. 2003, Philippa et al. 2004
West Nile viral encephalitis	West Nile virus	Via mosquito bite, potentially tick bite, predation	Brown et al. 2008
Bacterial diseases			
Granulocytic anaplasmosis	<i>Anaplasma phagocytophilum</i>	Tick bite	Brown et al. 2008
Leptospirosis	<i>Leptospira interrogans</i>	Contact with urine or urine contaminated water sources	Douglas and Strickland 1987
Lyme borreliosis	<i>Borrelia burgdorferi</i> sensu lato	Tick bite	Brown et al. 2008
Rocky Mountain spotted fever or related diseases	<i>Rickettsia rickettsii</i> or <i>Rickettsia</i> spp.	Tick bite	Brown et al. 2008
Tularemia	<i>Francisella tularensis</i>	Predation on infected muscle tissues of infected prey	Dick and Leonard 1979, Dick et al. 1986
Protozoai diseases			
Coccidiosis	<i>Isospora</i> spp.	Ingestion of infected oocytes	de Vos 1952
Toxoplasmosis	<i>Toxoplasma gondii</i>	Ingestion of infective tissue cysts in prey or infective oocysts	Dietz et al. 1993, Douglas and Strickland 1987, Frank 2001, Burns et al. 2003, Philippa et al. 2004, Sedlak and Bartova 2006, Brown et al. 2008
Trematodes			
intestinal fluke	<i>Alaria mustelae</i>	Ingestion of metacercariae in a snake, frog, or small mammal	Dick and Leonard 1979
Liver fluke	<i>Metorchis conjunctus</i>	Ingestion of metacercariae in fish	Dick and Leonard 1979, Dick et al. 1986
Cestodes			
Intestinal tapeworm	<i>Mesocostoides variabilis</i>	Ingestion of larvae in intermediate hosts (canids, felids, rodents and snakes)	deVos 1952
Intestinal tapeworm	<i>Taenia siberica</i> and <i>Taenia</i> spp.	Ingestion of tissue cysts in rodents and insectivores	Dick and Leonard 1979



Appendix 6.1. continued.

Disease or parasite	Scientific or alternate name	Transmission	Source
Nematodes			
Bladder worm	<i>Capillaria plica</i>	Ingestion of infective eggs	Butterworth and Beverley-Burton 1980
Hook worm	<i>Placoconus (Arthrocephalus) lotoris</i>	Larval worms penetrate intact skin	Hamilton and Cook 1955
Hook worm	<i>Uncinaria stenocephala</i>	Larval worms penetrate intact skin	Hamilton and Cook 1955
Intestinal ascaris	<i>Ascaris mustelorum</i>	Ingestion of infective eggs	Dick and Leonard 1979
Intestinal ascaris	<i>Baylisascaris devosi</i>	Ingestion of infective eggs	deVos 1952, Dick and Leonard 1979
Intestinal nematode	<i>Capillaria mustelorum</i> , <i>C. putorii</i>	Ingestion of infective eggs	Hamilton and Cook 1955, Butterworth and Beverley-Burton 1980
Intestinal strongyle	<i>Molineus patens</i>	Ingestion of infective eggs	Dick and Leonard 1979
Giant kidney worm	<i>Dioctophyma renale</i>	Ingestion of infective eggs	Douglas and Strickland 1987
Lung worm	<i>Crenosoma petrowi</i>	Ingestion of infected snails and slugs	Craig and Borecky 1976
Lung worm	<i>Trilobostrongylus bioccai</i>		Craig and Borecky 1976
Lung worm	<i>Sobolevinygylus</i> sp.		Craig and Borecky 1976
Nasal sinus worm	<i>Skrjabinigylus petrowi</i>	Ingestion of infected slugs and snails	Koubek et al. 2004
Stomach worm	<i>Physaloptera maxillaris</i>	Ingestion of infected intermediate hosts (arthropods) or paratenic hosts (birds, snakes)	deVos 1952, Hamilton and Cook 1955, Dick and Leonard 1979
Stomach worm	<i>Soboliphyme baturini</i>	Ingestion of infected intermediate hosts (arthropods) or paratenic hosts (birds, snakes)	Dick and Leonard 1979, Koehler 2006
Trichinosis	<i>Trichinella spiralis</i>	Ingestion of infected prey	Dick and Leonard 1979, Dick et al. 1986, Douglas and Strickland 1987
Thread worm	<i>Dracunculus insignis</i>	Ingestion of infected copepod host in water	Douglas and Strickland 1987
Arthropods			
Sarcoptic mange mites	<i>Sarcoptes scabiei</i>	Direct contact	O'Meara et al. 1960
Fleas	<i>Oropsylla arctomys</i>	Fleas occur in leaf litter, dens, burrows or on prey	Holland 1949
Ticks	<i>Ixodes cookei</i> , <i>I. gregsoni</i> , <i>I. marxi</i> , <i>I. pacificus</i>	Ticks quest from vegetation, dens, or at rest sites; predators also exposed to ticks crawling on prey	de Vos 1952, Lubelczyk et al. 2007, Rand et al. 2007, Brown et al. 2008

Appendix 6.2. Frequency of occurrence (%) of prey taxa and other food items identified in fisher scats and gastrointestinal tracts in the Assessment Area (studies in Oregon and California) and adjacent regions (studies in British Columbia, Montana, and Idaho) in western North America.

Food item	Annual			Winter						Spring	Summer	Fall
	OR ^a	CA ^b	CA ^c	BC ^d	MT ^e	ID ^f	ID ^g	CA ^h	CA ^c	CA ^c	CA ^c	CA ^c
Mammals	82.6	93.0	78.6						91.7	73.6	78.6	76.9
Insectivora	5.2	20.9	4.5							5.7	5.1	3.8
Soricidae, <i>Sorex</i> spp.	0.8	1.5	2.5	14.9						1.9	3.1	3.8
Talpidae	1.3	19.8										
<i>Scapanus latimanus</i>			2.0					12.5		3.8	2.0	
<i>Scapanus</i> spp.		14.7										
<i>Neurotrichus gibbsii</i>	2.1	5.7										
Chiroptera		0.8										
Vespertilionidae (<i>Myotis</i> spp.)		0.5										
Lagomorpha	22.7	4.1	0.5				50.0			1.9		
Leporidae	22.5	4.1	0.5							1.9		
<i>Lepus americanus</i>				39.1	49	28.6	50.0					
<i>Sylvilagus bachmani</i>								12.5				
Ochotonidae (<i>Ochotona princeps</i>)	0.2											
Rodentia	40.8	49.7	47.8						58.3	39.6	54.1	30.8
Sciuridae	33.9	26.8	20.4						20.8	24.5	19.4	15.4
<i>Marmota flaviventris</i>						14.3	5.5					
<i>Tamiasciurus hudsonicus</i>				33.5		14.3	22.2					
<i>Tamiasciurus douglasii</i>	2.6	3.4	7.5					3.8	11.3	6.1	3.8	
<i>Tamias</i> spp.	2.8	11.3	1.5		3		5.5				1.0	7.7
<i>Glaucomys sabrinus</i>	1.8	4.1	0.5	8.4							1.0	
<i>Sciurus griseus</i>	0.2	4.9	4.0					12.5	8.3	1.9	4.1	3.8
<i>Spermophilus beecheyi</i>	11.1		4.0							5.7	4.1	3.8
<i>Spermophilus lateralis</i>	2.6											
<i>Spermophilus</i> spp.	2.3	1.0					5.5					
Unkown Sciuridae	6.2	0.8										
Geomyidae (<i>Thomomys</i> spp.)	0.5	1.3	5.0				5.5			5.7	6.1	3.8
<i>Thomomys bottae</i>			5.0							5.7	6.1	3.8
Castoridae (<i>Castor canadensis</i>)				18.6		28.6	5.5					
Cricetidae		20.1	22.4						41.7	15.1	26.1	7.7
<i>Peromyscus maniculatus</i>				15.8								
<i>Peromyscus leucopus</i>						14.3						
<i>Peromyscus</i> spp.	0.5	2.8	10.4		14			25.0	8.3	5.7	16.3	
<i>Myodes gapperi</i>				23.3		28.6	5.5					
<i>Myodes</i> spp.	0.2	0.5										
<i>Microtus</i> spp.	0.5	3.4	5.5	7.9	3				12.5	5.7	5.1	
Unknown voles		1.5					27.7					
<i>Arborimus</i> spp.		3.9										
<i>Reithrodontomys megalotis</i>								12.5				
<i>Neotoma cinerea</i>			0.5	1.9								3.8
<i>Neotoma</i> spp.	0.2		5.2		7							
<i>Ondatra zibethicus</i>	2.3			17.2								
Dipodidae (<i>Zapus</i> spp.)	0.2						5.5					

Appendix 6.2. continued.

Food item	Annual			Winter						Spring	Summer	Fall
	OR ^a	CA ^b	CA ^c	BC ^d	MT ^e	ID ^f	ID ^g	CA ^h	CA ^c	CA ^c	CA ^c	CA ^c
<i>Zapus princeps</i>							5.5					
Erethizontidae (<i>Erethizon dorsatum</i>)	1.8			19.5	6		5.5					
Unknown Rodentia					6							
Carnivora	2.6	22.4	21.4									
Canidae		2.1										
<i>Urocyon cinereoargenteus</i>		2.1										
Mustelidae ⁱ	2.6	7.7	21.4						8.3	30.2	15.3	38.5
<i>Martes</i> spp.			20.4		7				8.3	28.3	15.3	34.6
<i>Martes pennanti</i>				9.8								
<i>Martes americana</i>				10.7								
Unknown Mustelid ⁱ		7.7		0.5	6		5.5			1.9		
<i>Spilogale putorius</i> ⁱ			0.5									3.8
<i>Mephitis mephitis</i> ⁱ		1.0										
Unknown skunk ⁱ	2.6	2.9										
Procyonidae (<i>Procyon lotor</i>)		1.0										
Felidae (<i>Felis silvestris</i>)							5.5					
Artiodactyla	8.5	20.9	4.0									
<i>Odocoileus</i> spp.			4.0	9.8	3	14.3	11.1	25.0	25.0	3.8		
<i>Cervus elaphus</i>						28.6	5.5					
<i>Alces alces</i>				14.9		14.3	11.1					
Domestic cattle				1.9			5.5	12.5				
Unknown ungulate						28.6	22.2					
Unknown mammal	15.0							12.5				
Birds	28.2	26.0	39.8						25.0	32.1	51.0	26.9
Galliformes				8.8								
Piciformes		1.0										
Passeriformes		0.3										
Unident. birds	28.2	24.7	39.8			14.3	16.6		25.0	32.1	51.0	26.9
Reptiles	6.5	24.5	20.4							37.7	20.4	3.8
Squamata		24.2	15.4							30.2	15.3	
Sauria		14.4	13.4									
Serpentes		3.6	2.0							7.5		
Amphibians		2.1										
Unknown vertebrate		10.3										
Insects	25.6	55.2	55.7				22.2	25.0	41.7	52.8	62.2	50.0
Orthoptera		4.9	2.5							1.9	3.1	3.8
Hymenoptera	15.0	33.0	22.4				22.2		16.6	15.1	23.5	38.5
Coleoptera		20.9	18.4					25.0	8.3	22.6	22.4	3.8
Lepidoptera	6.0								4.2	1.9		
Plants	13.7								20.8	11.3	16.3	53.8
Seeds/Fruit		33.8	20.4				16.6					
Leaves and bark		82.5						50.0				
Fungi								50.0				
Other items												
Egg shell		3.9	5.0							5.7	6.1	3.8
Woody debris			16.4							13.2	12.2	23.1
Rock		33.2	6.5					62.5		5.7	5.1	7.7
Artificial (man-made)		14.2										

- a Analysis of fisher scats from male and female fishers combined ($n = 387$) across all seasons in the Cascade Range of southern Oregon (Aubry and Raley 2006).
- b Analysis of fisher scats from male and female fishers combined ($n = 388$) across all seasons collected from 4 study areas in the Klamath bioregion of northwestern California (Golightly et al. 2006).
- c Analysis of fisher scats from male and female fishers combined ($n = 201$) across all seasons and by season in the southern Sierra Nevada of California (Zielinski et al. 1999).
- d Analysis of prey items ($n = 551$) in the stomachs of male and female fishers ($n = 215$) collected during winter from south-central to northern British Columbia (Weir et al. 2005).
- e Analysis of fisher scats ($n = 80$) collected during winter and spring in northwestern Montana (Roy 1991).
- f Analysis of gastrointestinal tracts of fishers ($n = 7$) collected during winter in north-central Idaho (Jones 1991).
- g Analysis of fisher scats ($n = 18$) collected during winter in north-central Idaho (Jones 1991).
- h Analysis of fisher stomachs ($n = 8$) collected during winter in northwestern California (Grenfell and Fasenfast 1979).
- i During several of these studies, skunks were still classified as members of the family Mustelidae rather than their current classification in the family Mephitidae.

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