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

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VOLUME III: Threat Assessment

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Team Leaders:

Laura L. Finley and Robert H. Naney

Interagency Fisher Biology Team:

Peg Boulay (Oregon Department of Fish and Wildlife)
Esther Burkett (California Department of Fish and Game)
Laura L. Finley (USDI Fish and Wildlife Service, Pacific Southwest Region)
Linda J. Hale (USDI Bureau of Land Management, Oregon)
Patricia J. Happe (USDI National Park Service)
J. Mark Higley (Hoopa Tribal Forestry)
Arlene D. Kosic (USDI Bureau of Land Management, California)
Amy L. Krause (USDI Bureau of Land Management, California)
Jeffrey C. Lewis (Washington Department of Fish and Wildlife)
Susan A. Livingston (USDI Fish and Wildlife Service, Pacific Region)
Eric C. Lofroth (British Columbia Ministry of Environment)
Diane C. Macfarlane (USDA Forest Service, Pacific Southwest Region)
Anne Mary Myers (Oregon Department of Fish and Wildlife)
Robert H. Naney (USDA Forest Service, Pacific Northwest Region)
Catherine M. Raley (USDA Forest Service, Pacific Northwest Research Station)
Richard L. Truex (USDA Forest Service, Pacific Southwest Region)
J. Scott Yaeger (USDI Fish and Wildlife Service, Pacific Southwest Region)

Front Cover Photo:

Greg Trouslot

Back Cover Photo:

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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 for the West Coast (Washington, Oregon, and California) Distinct Population Segment (DPS) of fishers (*Martes pennanti*). They stated that a listing 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). 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. The range of fishers in the West Coast DPS is contiguous with the historical range in British Columbia; therefore, fishers will benefit from a coordinated conservation approach that includes both countries. The geographic scope of this conservation effort includes south-central British Columbia in addition to the West Coast DPS. The vision for the Strategy is to provide an effective, integrated, regional approach to achieve self-sustaining 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 [2008–2010]; and Debbie Hollen, Pacific Northwest Region [2010–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).

The steering committee selected individuals from various federal, state, and provincial agencies to participate on the Interagency Fisher Biology Team (members identified here in front matter) and directed the team to compile a conservation assessment highlighting the current state of knowledge on fisher ecology and distribution and to develop a conservation strategy for south-central British Columbia, western Washington, western Oregon, and California (Assessment Area). The Interagency Fisher Biology Team included biologists who had conducted research on fishers in the Assessment Area as well as biologists with natural resource management and project analysis experience.

A Fisher Science Team was also formed to provide scientific consultation and to coordinate an independent peer-review of the Assessment. The team members included 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 Interagency Fisher Biology Team produced 4 documents (Volumes I through IV) during this process. Volume I (Conservation Assessment) is a comprehensive review of best available information on fisher biology and habitat ecology based primarily on research conducted in the Assessment Area and adjacent regions. Volume I describes the current status of fisher populations and provides a broad overview of the physical and human environments in the Assessment Area. Volume II (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. Volumes I and II reference source material produced and available prior to 1 July 2008.

Volume III (Threat Assessment) is an assessment of potential threats affecting fishers and fisher habitat within the Assessment Area. This volume describes an explicit, structured process to link information on fisher ecology and biology from Volumes I and II to information about the ecosystems and human environments in which fishers exist. Volumes I through III are the foundation used to develop an effective and integrated approach to fisher conservation for the Assessment Area.

Volume IV (Conservation Strategy) is being developed based on the information 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 multi-year effort to develop a fisher conservation assessment for south-central British Columbia, western Washington, western Oregon, and California. We thank the Fisher Steering Committee for support and guidance. Bruce Marcot (USDA Forest Service, Pacific Northwest Research Station) and Steve Morey (USDI Fish and Wildlife Service, Pacific Region) provided insights and expertise in structured decision making at a critical time and designed the threats workshop to evaluate and rank threats to fishers. Jo Ellen Richards documented discussions and Cindy Donegan facilitated many Fisher Biology Team meetings. Naomi Nichol edited an earlier version of this document. This volume has benefited greatly from comments and suggestions for improvement provided by the Fisher Science Team and 3 anonymous peer-reviewers. We are also grateful for the many helpful comments received from more than 20 biologists and resource managers with various state, federal, and provincial agencies, private industry, non-government organizations, and independent consultants; and the many fisher researchers, other scientists, and biologists who generously provided their photographs for use in this volume. The federal, provincial, and state agencies associated with members of the Interagency Fisher Biology Team provided support including time and travel for individuals to attend meetings. The USDI Fish and Wildlife Service (Pacific and Pacific Southwest Regions), and the Interagency Special Status and Sensitive Species Program (USDA Forest Service, Pacific Northwest Region and USDI Bureau of Land Management Oregon/Washington) provided additional funding to assist with costs. The map-based figure was expertly produced by Dave LaPlante (Natural Resources Geospatial). Carolyn Wilson (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.


Dave Manson, National Park Service

INTRODUCTION

Background

The fisher's (*Martes pennanti*) range was dramatically reduced in the 1800s and early 1900s through over-trapping, predator and pest control campaigns, and loss and fragmentation of forested habitats by logging, fire, agriculture, and development (Douglas and Strickland 1987, Powell 1993, Powell and Zielinski 1994, USDI Fish and Wildlife Service 2004; see Volume I, Chapter 5). Concern regarding population declines eventually resulted in restrictions or closures of fisher trapping seasons in portions of British Columbia (1982, 2003; see Volume I, Chapter 5), Washington (1934; Aubry and Lewis 2003), Oregon (1937; Aubry and Lewis 2003), and California (1946; Zielinski et al. 1995).

Figure 1. Geographic extent of the Assessment Area in south-central British Columbia, western Washington, western Oregon, and California.

Concern regarding ongoing threats and the decline in distribution and abundance of fishers in the Pacific states (Washington, Oregon, and California) led to petitions to list this species under the U.S. Endangered Species Act (USDI Fish and Wildlife Service 1991, 1996, 2004). The Center for Biological Diversity (2000) petitioned the USDI Fish and Wildlife Service in November 2000 to list the West Coast Distinct Population Segment (DPS) of fishers. In April, 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).

The range of fishers in the West Coast DPS is contiguous with the historical range in British Columbia; therefore, we determined that the appropriate Assessment Area (Fig. 1) for an evaluation of threats includes the south-central portion of British Columbia. Fishers in the northern portion of the Assessment Area were historically found in upland forests of the Thompson and West Okanagan Plateaus and coastal and dry interior forests in British Columbia (Cowan and Guiget 1956, Banci 1989), from sea level to timberline on the Olympic Peninsula in Washington (Scheffer 1938), and in coniferous forests of the Cascade and the Coast ranges of Washington and Oregon (Suckley and Cooper 1860, Bailey 1936, Dalquest 1948). However, Aubry and Houston (1992) reported the historical occurrence in the southern Coast Range of Washington was uncertain. In the southern portion of the Assessment Area, the north Coast Ranges and Klamath-Siskiyou Mountains in Oregon

and California and the Sierra Nevada in California (Grinnell et al. 1937, Powell and Zielinski 1994) were historically occupied by fishers; although, occurrence of fishers in the northern Sierra Nevada was uncertain (Grinnell et al. 1937; see Volume I, Chapter 5).

Just as for many species of conservation concern, there is no single dominant threat to the distribution or abundance of fishers. Anthropogenic and natural stressors (Volume I, Chapters 3 and 4) act on fishers at various scales and intensities throughout the Assessment Area. We defined a threat as any factor that may influence fisher life history attributes and result in wild fisher populations not being sustainable in the geographic area being assessed. We recognized that a comprehensive assessment of threats to fishers had to include 1) identification of documented threats through a review of existing literature, 2) identification of other anthropogenic or natural events that may also be potential threats to fishers using our expertise and professional judgment, 3) identification of which aspects of fisher biology and ecology might be influenced by different threats, 4) identification of anthropogenic activities and natural events that could potentially be mitigated through policy and management, and 5) an evaluation of the role of synergy or interaction among threats. Threats can affect an individual, a population, or environments that support the species of interest. Unless otherwise noted, we use the phrase "effects on fishers" when a threat has a potential negative influence on an individual fisher, a fisher population, or environments capable of supporting fishers.

Anthropogenic and Natural Events That May Have a Negative Effect on Fishers

Linear features, such as roads, can act as filters (semi-permeable) or as barriers (impermeable) to wildlife and may prevent population expansion and gene flow (Woods and Munro 1996, Hayes and Lewis 2006; Plate 1). Major highways, provincial and state highways, and paved forest roads generally have higher speed limits than non-paved roads and are thus a higher potential source of vehicle-caused mortality to wildlife, including fishers (Ruediger 1996, Truex et al. 1998; see Volume I, Chapter 6). Forest roads and trails may be frequently used as travel and hunting corridors by a variety of wildlife species (James and Stuart-Smith 2000, Frey and Conover 2006), including potential fisher predators, which may increase vulnerability of fishers to predation.

Sources of human-caused mortality include non-target captures of fishers in body gripping traps set for other fur-bearing species (Volume I, Chapter 6), fishers becoming trapped in wells or other containers (Truex et al. 1998; Plate 2), and vehicles (Ruediger 1996). Where fisher distribution is adjacent to human settlement, mortality can occur from secondary poisoning intended for other species (Plate 3).

Developments, such as urbanization, conversion to agriculture, ski resorts, or large reservoirs, (Plate 4) permanently remove potential fisher habitat and can disrupt or create barriers to fisher movements. Fishers living adjacent to human development in the urban-rural interface and recreation developments can potentially be exposed to diseases, especially those diseases common to domestic dogs and cats (Riley et al. 2004).

Moderate to dense canopy closure from overstory trees provides key habitat features (e.g., den and rest sites) and contributes to structural complexity of forested environments, both of which are necessary for fishers and their prey (Volume I, Chapter 7). When overstory canopy is reduced, a fisher's exposure to weather extremes (e.g., temperature, wind, precipitation, sun) and potential conflicts with other species or conspecifics may increase (Weir and Harested 2003, Weir et al. 2004, Weir and Corbould 2008). Reducing overstory vegetation may affect fishers' ability to move through forested

Plate 1. Fisher movements may be affected by roads in a variety of ways. Forest roads have slower speeds and lower traffic volume and generally allow fisher movement (A), whereas major highways may present barriers that block most movements (B) and contribute to fisher mortality (C). This Google Earth image presents an example of major highways and other linear features that may cumulatively act as filters or barriers that limit or prevent individual movements and population gene flow (D).

Plate 2. Fisher mortality can result from non-target captures in body gripping traps (A) or other human-caused structures, such as drowning in open water tanks (B).

Plate 3. Reduced fitness or mortality can result when fishers consume prey that have been poisoned by chemicals used for rodent control. Most of these rodenticides are available at garden supply or other stores (A). Rodent control associated with illegal marijuana grows in the forest (B and C) is a growing concern.

Plate 4. Developments, such as large ski areas (A) and large reservoirs (B) can fragment fisher habitat and disrupt individual and population-level movements.

environments and to detect and capture prey, as well as avoid predation (Powell and Zielinski 1994). Overstory reduction can result from vegetation management practices (e.g., timber harvest and fuels treatment), uncharacteristically severe wildfire, or uncharacteristically severe forest insect and disease outbreaks (Plate 5). Once overstory is removed it takes many decades to reestablish the complexity of a multi-layered overstory canopy (Swanson and Franklin 1992).

Moderate to dense forest understory may provide fishers with cover for hunting and protection from predators (Volume I, Chapter 7). Reduction in density, diversity, and abundance of understory vegetation may reduce prey habitat quality and quantity; decrease prey abundance and availability; reduce cover for effective foraging and protection from predation; and likely reduce abundance of seeds, berries, and nuts provided by understory plants (Volume I, Chapter 7). Understory reduction can result from wildfire and vegetation management practices such as timber harvest, silvicultural and fuels treatments, and herbicide application. The recovery of understory, especially on productive sites, takes less time than development of overstory or large trees or snags with cavities.

The most consistently reported fisher habitat association is with large, live trees or snags with cavities used for denning by reproductive females

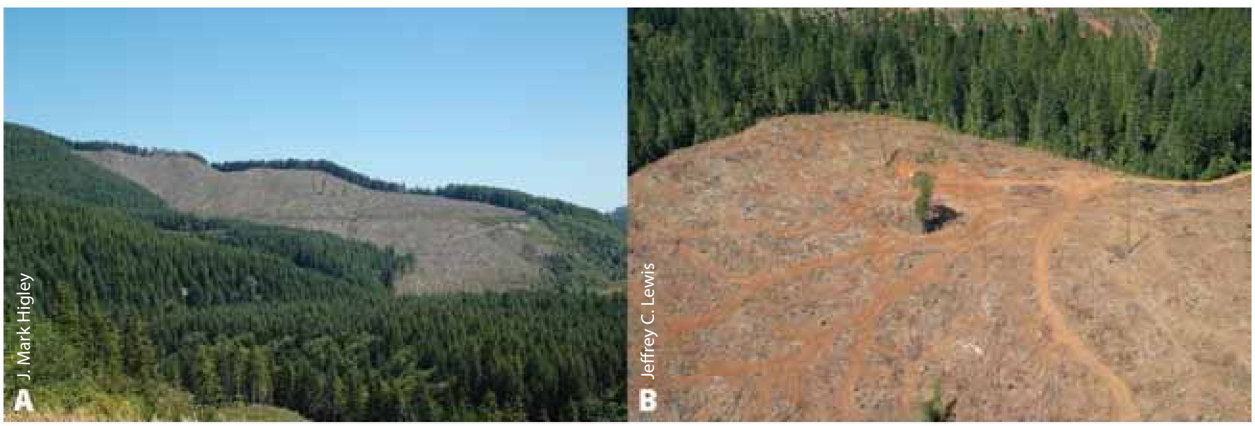


Plate 5. Forest harvesting (A and B) and uncharacteristically severe wildfires (C) can result in loss of overstory canopy which may take many years to restore.

(Volume I, Chapter 7). These and other structural elements (e.g., large live trees with mistletoe brooms, broken tops, heart rot, cavities, large branches, rodent nests; large snags with cavities; and logs with cavities, or piles of logs) also provide rest structures, shelter from predators and inclement weather, and contribute to prey habitat (Volume I, Chapter 7). Reduction in abundance and distribution of structural elements may negatively affect the energy budgets of fishers by increasing travel distances required to locate suitable dens or rest sites, thermal refugia, and safe places to consume prey (Green et al. 2008; Volume I, Chapter 7). Structural elements may be lost as a result of vegetation management practices (e.g., timber harvest, fuels and silvicultural treatments) or stand-replacing wildfire (Hann et al. 1997, Franklin et al. 2002*a*, Green et al. 2008, Wisdom and Bate 2008). Typically, decades are required to develop these various structural elements, and it may take more than a century to develop large, hollow trees that are suitable for reproductive dens (Volume I, Chapter 8).

Vegetation diversity contributes to habitat for a wide variety of fisher prey species (Volume I, Chapter 7). Reduction in vegetation diversity can decrease the variety of tree species available to provide cavities (for fisher denning and resting habitat), reduce the resilience of forests to insects and diseases, and reduce the diversity of environments capable of supporting fisher prey species. Reduction in vegetation diversity can result from uncharacteristically severe wildfire or vegetation management practices. The time necessary to restore vegetation diversity is variable and depends on the process that caused the loss, subsequent management, and site productivity (Franklin et al. 2002*a*).

Uncharacteristically severe wildfire and fire suppression activities can affect large areas of the landscape, removing structural elements, overstory cover, and other key components of fisher habitat (see Volume I, Chapters 3 and 4). Increases in fire size, intensity, and frequency can change abundance and distribution of these forest components and result in conditions that may not support successful reproduction or survival of fishers (Volume I, Chapter 4). Landscapes fragmented by uncharacteristically severe wildfire may change landscape permeability for fishers, either permanently through vegetation type conversion, or temporarily until vegetation recovery occurs (Green et al. 2008). Changes in landscape permeability can affect fisher daily movements, home range establishment, breeding season movements, and juvenile dispersal. Fire suppression activities, such as snag felling, permanent fire breaks, and burnouts (Plate 6), can reduce the abundance of large structural elements across the landscape. In post-fire landscapes, the recovery time necessary to develop forest conditions capable of supporting fishers is variable and depends on the intensity of the fire, subsequent management (e.g., salvage operations or reforestation), and productivity of the site (Agee 1991, Franklin and Spies 1991, Spencer et al. 2008).

The amount of contrast, size, and location of forest patches interact to create patterns of fragmentation (Lehmkuhl and Ruggiero 1991), which in turn influence how individuals of a species select home ranges and use the landscape. Fragmentation of a species' habitat may lead to population isolation and reduce the chance of genetic exchange between adjacent populations (Norse et al. 1986). For fishers, fragmentation of forested landscapes may degrade habitat quality by creating patches of unsuitable environments within which individuals may not be able to forage, find rest or den sites, or travel through. Fragmentation may also affect prey species composition, abundance, and availability (Buskirk and Powell 1994, Hayes and Lewis 2006, Weir and Corbould 2008). This may increase energetic costs to fishers, which could ultimately affect survival, reproduction, and recruitment (Weir and Corbould 2008). The need to travel through unsuitable environments (e.g., lack of cover), or additional travel time needed to circumnavigate such areas, may

Plate 6. Wildfire suppression practices, including construction of permanent firebreaks (A), burnouts (B), or large tree or snag felling (C), may reduce the abundance of potential structures that fishers can use for denning and resting.

increase predation risk (Weir and Corbould 2008). This may be exacerbated by increased abundance of predators associated with fragmented and early-seral forest conditions (Lehmkuhl and Ruggiero 1991). Changes in landscape patterns result from many anthropogenic activities (e.g., timber harvest, conversion of forested lands to agriculture, residential development, and highways; Green et al. 2008; Plate 7; see Volume I, Chapter 4) and natural disturbances (e.g., uncharacteristically severe insect and disease outbreaks). These changes may temporarily or permanently affect the ability of fishers to occupy a given landscape.

Forest insects and diseases can create gaps in forest overstory, may cause shifts in vegetation composition of forest communities, and operate on individual trees to create structural elements used by fishers as reproductive den and rest structures (e.g., live and dead trees with cavities, limb deformities, platform branches; see Volume I, Chapter 8). However, at uncharacteristically high levels, insects and disease can cause broad-scale loss of overstory trees and vegetation diversity, which may fragment or remove forested environments capable of supporting fishers (Plate 8). The effects are potentially long lasting and can cover large spatial extents (Carroll et al. 2003, Raffa et al. 2008). The recovery time necessary in affected vegetation communities is variable and depends on subsequent management and site productivity (Franklin and Spies 1991).

Climate change will affect temperature, precipitation, and wind patterns, which are among many factors that influence vegetation structure and composition (Aldous et al. 2007) and fire behavior (Agee 1993). Climate change may have beneficial or detrimental effects on fishers. For example, in parts of California, some hardwood species that provide structural elements for fishers may benefit from climate change as a result of increased temperatures and dormant season precipitation (Lenihan et al. 2003), but the effects may be less beneficial for conifer species and forest structure (Safford 2007). These beneficial effects, however, may be offset by increases in wildfire intensity and frequency and insect and disease events (Safford 2007). In other parts of the Assessment Area,

Plate 7. Timber harvesting (A and B), and conversion of forests to agricultural use (e.g., vineyards) that no longer support fishers (C), can change landscape patterns and fragment fisher habitat.

the diversity and abundance of fisher prey species could be affected by changes in dominant tree species composition that provide food and shelter (Ritchie et al. 2009). McKenzie et al. (2004) suggested that higher summer temperatures and less precipitation would result in more extensive fires that would reduce connectivity and extent of late-successional forests and could threaten the viability of species associated with dense, multi-layered, old forests. In British Columbia, Gayton (2008) reported that the effects of climate change will manifest over relatively long periods and are likely to affect the entire range of many species, including fishers.

Goals and Objectives

Our overarching goal for this threat assessment was to identify conservation risks to fishers. We evaluated information on the type of threats that exist in the Assessment Area, and whether there were variations in the magnitude (spatial extent), intensity (severity

Plate 8. Large scale insect outbreaks, such as shown here in British Columbia, result in loss of overstory cover and can reduce the capability of forests to support fishers.

within the spatial extent), and duration (the time fishers are affected) of threats because of differences in the physical and human environments.

The objectives of this threat assessment were to:

1. Identify threats (real or potential) to fishers in the Assessment Area.
2. Describe the criteria we used to evaluate each threat and its potential influence on fishers.
3. Identify how each threat may differ geographically within the Assessment Area.
4. Rank threats using a systematic process.
5. Consider if threats acting in combination with other threats (synergistic affects) potentially create greater conservation risks to fishers.

We recognized that there is little empirical information on anthropogenic or natural events that negatively affect fisher distribution and abundance. Thus, to achieve our goals we applied our expertise and professional judgment to help identify threats, their influence on fisher biology and ecology, and how their influence on fishers may differ geographically within the Assessment Area.

METHODS

Identifying Threats to Fishers

We reviewed information in Volumes I and II, other fisher conservation assessments (Volume I, Chapter 1), and relevant literature to determine historical factors that contributed to the current conservation status of fishers in the Assessment Area. We also used principles of conservation biology (Thomas et al. 1990, Meffe and Carroll 1997), landscape ecology (Lindemayer et al. 2008), forest ecology (Franklin et al. 2002*b*), and professional judgment to identify potential threats to fishers in the Assessment Area. We interpreted potential threats to fishers in conjunction with current knowledge of fisher distribution, abundance, habitat ecology, and other aspects of fisher biology.

We identified key aspects of fisher biology and ecology that were likely to influence individual fitness and persistence of populations (Table 1). We then created 6 broad categories of anthropogenic activities or natural phenomena (Table 2) that potentially threaten at least 1 aspect of fisher biology and ecology. For example, we identified an anthropogenic activity as a threat to fishers if it was likely to increase risk of mortality, incidence of disease, or vulnerability of fishers to predation; decrease reproductive output or prey availability; or interfere with dispersal movements or establishment of home ranges. We did not evaluate non-anthropogenic factors, such as disease and predation that occur naturally in fisher populations, as threats, except when those factors are potentially exacerbated by anthropogenic activities (e.g., development or linear features).

Table 1. Aspects of fisher biology and ecology that may be affected by threats.

Term	Definition
Mortality	Death of an individual.
Survival	Individual is able to meet all requisite life history needs and lives to within the natural range of full life expectancy.
Reproduction	An individual successfully breeds and produces young.
Recruitment	Young survive to reproductive age and produce offspring.
Disease	Virus, bacteria, fungus, parasites, etc., that weaken individuals.
Daily movement	Movements made by an individual fisher in a 24-hr period.
Breeding season movement	Movements made by males or females during the breeding season to find suitable mates.
Dispersal movements	Movements, generally by subadults, away from their natal areas to establish their own home range.
Home range establishment	Ability of animal to find and establish a stable area to meet daily and annual life history requirements.
Prey availability	Prey species are available in an environment in which an individual fisher can safely and successfully hunt (i.e., availability and accessibility of prey).
Predation	Individual is killed by other wildlife species or conspecifics.
Competition	Demand by 2 or more organisms for limited environmental resources, such as food or living space.

Table 2. Anthropogenic and natural events identified as potential threats to fishers in the Assessment Area.

Threat category	Threat subcategory	Definition	Temporal consideration
Linear features	Major highways	Multi-lane highways, generally > 90 km/hr (55 mph).	Existing
	Provincial and state highways	2-lane provincial and state highways.	Existing
	Forest roads (paved, gravel, dirt), utility corridors, canals, pipelines, railroads, etc.	All forest roads and other linear features.	Existing
Human-caused mortality and reduction in fitness	Lethal events and activities	Hunting, trapping, poaching, poisoning, drowning in water tanks.	Existing
	Sub-lethal events and activities	Poisoning; predation or harassment by domestic dogs; secondary effects from predator control; animal damage control.	Existing
	Activities that affect behavior	Off Highway Vehicles and Over Snow Vehicles; other mechanical noise; people recreating; smoke from fires.	Existing
Development	Urbanization (rural, residential)	Development of new rural or residential structure and infrastructure.	Existing and future
	Agriculture	Conversion of forest to agriculture.	Existing and future
	Large reservoirs	Inundation of forested lands from dams and impoundments used to create hydro-electric power.	Existing and future
	Non-timber resource extraction	Mining, oil and gas, quarries.	Existing and future
	Recreation	Ski area development; cabins; trails; campgrounds.	Existing and future
Wildfire and fire suppression	Uncharacteristically severe wildfire	A fire that is outside the range of normal variation (larger in size or intensity).	Existing and future
	Suppression and rehabilitation activities	Snag felling, backfires, fuel breaks, fire lines.	Existing and future
Vegetation management: fuels reduction and timber production	Overstory reduction	Loss of dominant and co-dominant trees; decrease in canopy closure.	Existing and future
	Understory reduction	Loss of shrubs, saplings, suppressed trees, intermediate trees and structural diversity.	Existing and future
	Reduction of structural elements	Reduction in occurrence of large live and dead trees with mistletoe, broom rusts, heart rot, cavities, or pest and disease damage; reduction in occurrence of large down wood.	Existing and future
	Reduction in vegetation diversity	Loss of floristic or tree species diversity.	Existing and future
Changes in landscape patterns and ecosystems	Increase in fragmentation	An increase in the fragmentation of the pattern, distribution, and patchiness of environments used by fishers.	Existing and future
	Climate change	Global changes in climate that will potentially change vegetation communities, fire frequency, fire intensity, etc.	Existing and future
	Uncharacteristic forest insect and disease condition or events	Insect outbreaks and disease events that are outside the range of normal variation (e.g., sudden oak death, epidemic outbreak of mountain pine beetle, etc.).	Existing and future

Threat Descriptions

For each of the 6 threat categories, we identified subcategories based on differences in the type of activity and potential effects on fishers. We divided linear features into 3 threat subcategories and only considered existing conditions in the Assessment Area (Table 2). We considered highways and forest roads, as well as railroads, canals, power lines and pipelines, to be permanent fixtures on the landscape. Most linear features represent some level of permanent removal or change of potential fisher habitat. We identified 3 threat subcategories associated with human-caused mortality and reduction in fitness and only considered existing conditions (Table 2). Lethal events encompass activities that directly cause fisher mortality, whereas sub-lethal events represent activities that may add new stressors (e.g., disease or poisoning that does not lead to death) or activities that affect behavior that may increase energy costs due to induced changes in behavior (e.g., displacement from habitats or interference with rearing young). We divided development into 5 threat subcategories and considered both existing and future conditions in the Assessment Area (Table 2). We assumed that all development activities permanently convert land to non-fisher habitat or create filters or barriers to fisher movements. We divided wildfire and fire suppression activities into 2 threat subcategories and considered both existing and future conditions (Table 2). We defined uncharacteristically severe wildfire as fire occurring beyond the historical range of natural variation (magnitude, intensity, and duration) and suppression activities to include fire line construction, burnouts, backfires, and hazard tree felling. Uncharacteristically severe wildfire and fire suppression activities represent threats that potentially alter vegetation communities and reduce the availability of structures suitable for resting and denning. We identified 3 threat subcategories associated with changes in landscape patterns and ecosystems and considered both existing and future conditions (Table 2). We defined fragmentation as the increase in isolation or alteration of the configuration, spatial distribution, or abundance of forested environments capable of supporting fishers. Uncharacteristic insect and disease outbreaks and climate change both have the potential to negatively affect fishers by altering landscape patterns.

We identified 4 subcategories associated with vegetation management and considered both existing and future conditions (Table 2). We used a different approach to identify and organize threat subcategories associated with vegetation management. The 4 subcategories represent reduction in or loss of habitat components important to fishers and are outcomes of different vegetation management activities. We believed that this was the best approach to identify and evaluate threats resulting from a wide variety of vegetation management techniques (e.g., management that would result in the reduction of structural elements). We defined overstory reduction as the loss of canopy closure provided by dominant and co-dominant trees, and understory reduction as the loss of vertical and horizontal diversity provided by other vegetation. Reduction in structural elements included loss of large live and dead trees, logs, and reduction in vegetation diversity included both within-stand diversity of trees, shrubs, and herbs and diversity of vegetation communities within a landscape.

Threat Evaluation Areas

We identified 11 Threat Evaluation Areas (TEA; Table 3) within the Assessment Area based on differences in biophysical environment, human modifications to those environments, current fisher distribution, and political jurisdiction (Volume I, Chapters 3, 4, and 5). Three TEAs encompassed extant fisher populations: 1) Cascade Range, Oregon, 2) Northern California-Southwestern Oregon, and 3) Southern Sierra Nevada. The population status of fishers in the South Thompson Similkameen area of south-central British Columbia is uncertain (Volume I, Chapter 5); we considered this population extirpated for the purposes of this threat assessment.

Table 3. Status of fisher populations and geographic extent of 11 Threat Evaluation Areas (TEA) in the Assessment Area.

TEA	Fisher population status	Geographic description
British Columbia		
South-Central	Unoccupied	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.
Washington		
Coastal	Unoccupied	Canadian border south to the Columbia River and west of Interstate 5 but excluding the Puget Trough. Includes the west and east sides of the Olympic Mountains.
West Cascades	Unoccupied	West side of the Cascade Range from the Canadian border south to the Columbia River and east of Interstate 5, but excluding the Puget Trough.
East Cascades	Unoccupied	East side of the Cascade Range from the Canadian border south to the Columbia River.
Oregon		
Coastal	Unoccupied	West of Interstate 5 from the Columbia River south to about the main stem of the Rogue River but excluding the Willamette Valley.
West Cascades	Unoccupied	West side of the Cascade Range from the Columbia River south to the Upper Rogue River drainage basin (about Crater Lake National Park) and east of Interstate 5, excluding the Willamette Valley.
East Cascades	Unoccupied	East side of the Cascade Range in Oregon.
Cascade Range, Oregon	Extant	The Rogue-Umpqua Divide and the Upper Rogue River drainage basin on the west side of the Cascade crest south to the Mount McLoughlin area and east across the Cascade crest to Wood River valley and Upper Klamath Lake.
California		
Northern California-Southwestern Oregon	Extant	In Oregon, from about the Rogue River south to the California border and west of Interstate 5 to the coast. In California, the southern Cascade Range to Lassen County, west to the coast and south into Lake County.
Northern Sierra Nevada	Unoccupied	From the southern end of the Cascade Range in California (Lassen County) south to central Yosemite National Park.
Southern Sierra Nevada	Extant	From central Yosemite National Park to the southern extent of the Sierra Nevada.

We did not evaluate threats to fishers in the Puget Trough (Washington) or Willamette Valley (Oregon) because these landscapes have been dominated by urban and agricultural developments for many decades and we believed it is improbable that they will provide current or future forested habitats capable of supporting fisher populations (Volume I, Chapter 4).

Evaluation of Threats

We used a modified Delphi process (a method using expert opinion; Dalkey and Helmer 1963) to structure the evaluation of potential threats we identified on fishers. Potential threats on fishers were interpreted in conjunction with current knowledge of fisher distribution, abundance, habitat ecology, and other aspects of fisher biology. We used a facilitated workshop with the Interagency Fisher Biology Team as the panel of 13 experts (Appendix 1). Panelists were familiar with the geography, natural resources, and management policies in the Assessment Area, and, for each TEA, at least 1 panelist had expert knowledge. All panelists were familiar with fisher biology and ecology and 6 had expert knowledge gained from conducting research on extant populations within the Assessment Area.

Prior to the modified Delphi process, we established the following criteria to ensure panel members consistently evaluated and scored threat subcategories:

1. The panel evaluated threat subcategories within the context of current physical and human environments (Volume I, Chapters 3 and 4) and current land management practices.
2. The panel evaluated which aspects of fisher biology and ecology (Table 1) were potentially affected by a particular threat (Table 2).
3. Panelists used the effects of each threat (Table 2) on aspects of fisher biology and ecology (Table 1) as the basis for evaluating threats at the spatial scale of the TEA (but not at smaller spatial scales e.g., fisher home range, stand).
4. For TEAs not currently occupied by fisher populations, panelists scored each threat subcategory as if fishers occupied 30% of the landscape. We used 30% because individual panelists working in TEAs with extant populations estimated that approximately 30% of those areas were occupied by fishers.
5. When scoring, panelists considered the magnitude, intensity, and duration of each threat subcategory in each TEA.
6. Panelists scored each threat subcategory based on a 100% probability that the threat occurred in a given TEA; i.e., panelist scores did not incorporate differential probabilities of a threat occurring in an area.
7. Panelists scored each threat subcategory independent of potential interactions or synergistic effects with other threat categories.
8. Panelists primarily considered the direct effects of a threat subcategory on fishers. For example, major highways, provincial and state highways, and forest roads were evaluated based on the direct effects of loss of habitat along road corridors, and whether traffic or habitat modification along road corridors created barriers to daily or seasonal movements. Indirect effects (e.g., development and disturbance activities associated with roads or utility corridors) were evaluated as part of the human-caused mortality and reduction in fitness and development categories.
9. Panelists evaluated existing conditions for some threats. For example, panelists evaluated roads based on existing infrastructure. For other threats, such as urban development, panelists evaluated threats based on existing and new developments occurring or likely to occur given current growth trends (Table 2; Volume I Chapter 4).

We used a 3-stage procedure to implement the modified Delphi process. During the first stage, each panelist independently scored the effect of various threats on fishers by considering the magnitude, intensity, and duration of each threat subcategory in each TEA. Panelists scored threats on a relative scale ranging from '0' (no presumed threat) to '10' (very high presumed threat). The primary purpose of this stage was for panelists to familiarize themselves with the process and we have not presented these scores. Following the initial scoring, workshop moderators facilitated a discussion during which panelists briefly described how they arrived at their individual scores (stage 2). These disclosure discussions were not designed to influence panelists to change their scores. Rather they were an opportunity for panelists to share their expertise and to clarify the scoring process. During stage 3, the final stage, panelists were provided an opportunity to independently reevaluate their threat scores. We used these as the final scores for our analysis.

We did not attempt to gain consensus in threat scores, but used a systematic approach to organize complex information across a large region, capture collective knowledge, and gain insights on how various threats may affect fishers. We documented the variability in the range of panelist scores, which in part reflected uncertainty of how a threat might be manifested in a TEA. Based on panelists' scores, we classified each threat subcategory in each TEA as low-presumed threats (median score of 0–3), moderate-presumed threats (median score of 4–6), or high-presumed threats (median score of 7–10). We used the magnitude of the range of a threat's score as the measure of variability in that threat's score. If the variability was low (differences of 0–4), we considered confidence or agreement among panelists to be high, whereas high variability (differences of 5–10) indicated less confidence or agreement.

Threat Interaction and Synergy

We did not consider interaction and synergistic effects of threats during the modified Delphi process. During that process, we ranked each threat in isolation of others, fully recognizing that in a given landscape, multiple threats may exist and interact. We combined the outcomes of the panelists' evaluation of threats and effects influencing aspects of fisher biology and ecology (Table 1) from the modified Delphi process with our professional expertise to assess the potential for synergistic and cumulative threat effects. We qualitatively evaluated the complexity of interactions among threats to determine combinations of threats that might increase conservation risks to fishers. We considered that each situation could be different; the combined effects of some threats may be additive, whereas others may be synergistic. For example, highways in association with development and recreation may be a greater threat to fishers than when they occur in isolation of other human activities (Plate 9). In some cases, the effects of 1 threat subcategory (e.g., loss of structural elements) may be so great that no other threats would have meaningful or measurable effects and conservation actions to address the less prominent threats would be ineffective until the dominant threat was ameliorated or eliminated (Plate 10). There are likely threat thresholds beyond which fishers can no longer persist.

When evaluating the synergistic effects of threats, we also considered how threats may affect fishers in different ways at smaller spatial scales (e.g., home range, stand, site, and structure; Fig. 2). For example, forest roads potentially increase the chance of predation to an individual fisher (James and Stuart-Smith 2000, Frey and Conover 2006), or reduction in the abundance or availability of structural elements in an individual home range may affect the reproductive success of an individual female.

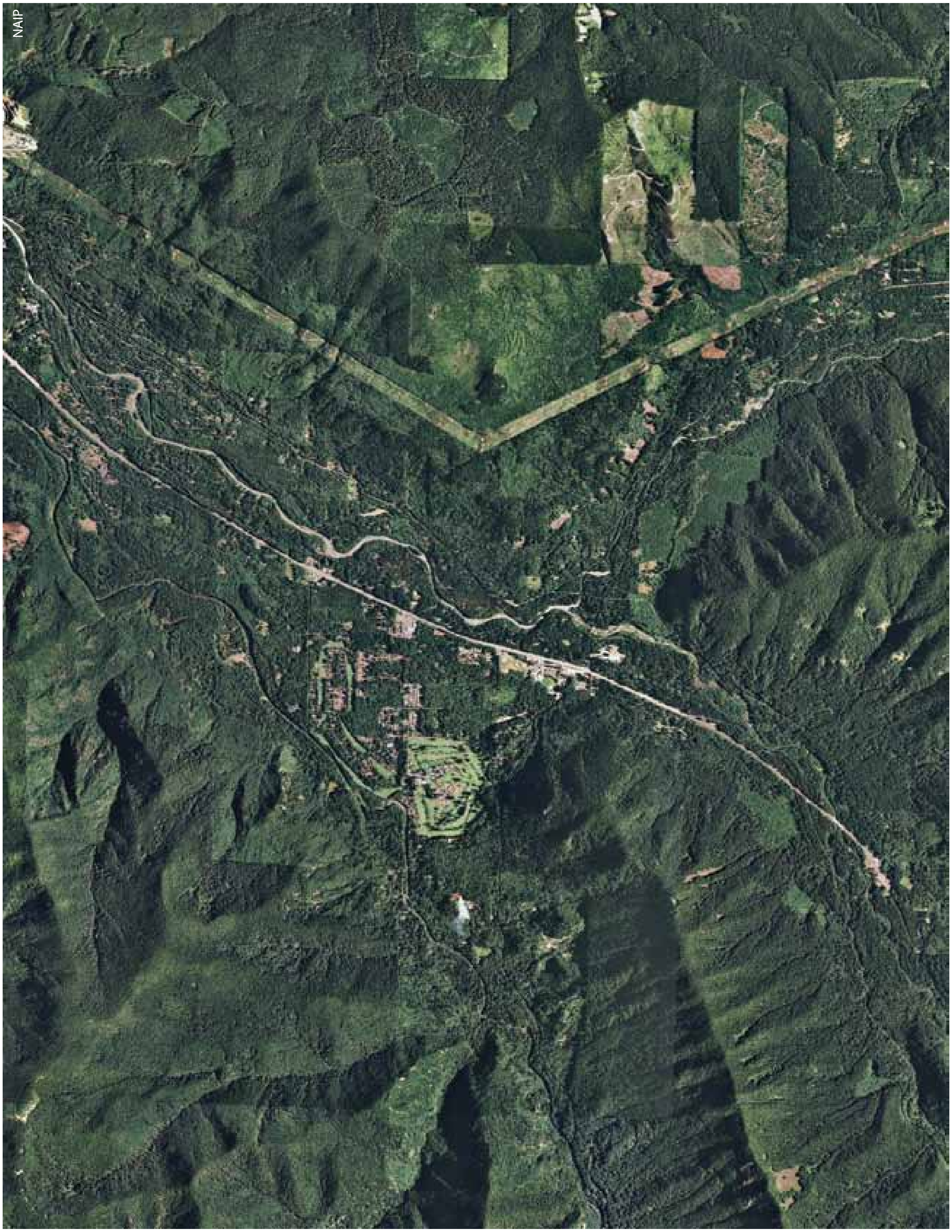
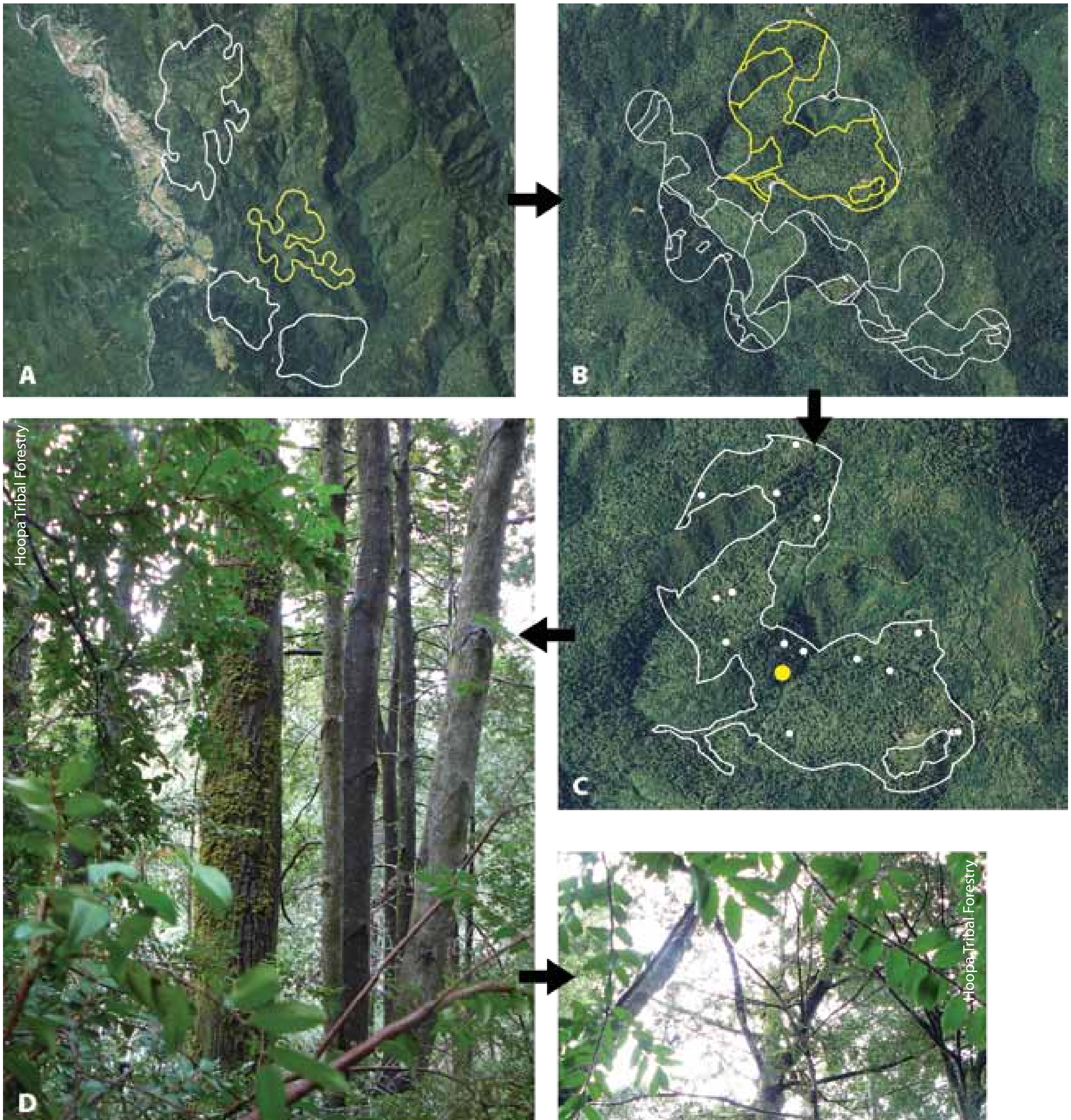


Plate 9. Multiple threats in a given area, such as highways, powerlines, railroads, and community development shown in this image, may have a greater negative impact on fishers than when any of them occur in isolation of other threats.

Laura Finley, U. S. Fish and Wildlife Service

Plate 10. Some threats, such as a loss of structural elements from timber harvest, may have such a large effect on fishers that amelioration of other threats may not be as effective. In this example, it will take decades to restore large live and dead trees that fishers would be able to use for denning and resting.



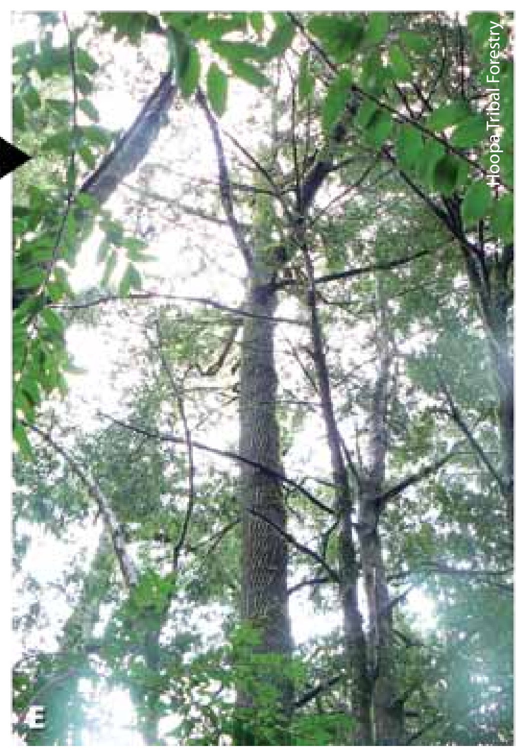


Figure 2. Examples of 5 spatial scales at which data are frequently collected when investigating habitat selection by fishers: the landscape scale (A; the graphic depicts a number of fisher home ranges within a population); the home range scale (B; the graphic depicts a fisher home range and the forest 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.

Olympic Fisher Project

RESULTS

Panelists evaluated all aspects of fisher biology and ecology to be affected by at least 1 threat. Panelists' evaluations indicated that some aspects of fisher biology, such as home range establishment, daily movements, and prey availability, were affected by most threats, whereas others, such as disease, were affected by only a few (Fig. 3).

Median scores for all threat subcategories were at least '1', except for major highways in the Southern Sierra Nevada TEA (Fig. 4). This area was scored '0' (no presumed threat) because there were no major highways. The Northern Sierra Nevada TEA had the most moderate and high threats to fishers (14 of 20 threat subcategories). The Southern Sierra Nevada and South-Central British Columbia TEAs each had 10 threat subcategories rated moderate or high, whereas the Washington Coastal, Oregon Coastal, Washington West Cascades, Oregon West Cascades, and Cascade Range, Oregon TEAs had the fewest ($\leq$7) threat subcategories rated as moderate or high (Fig. 4). All threat subcategories in vegetation management were scored as moderate or high in all TEAs.

In some TEAs, there was greater variability in threat scores among the panelists for some threat subcategories (Fig. 5). The greatest variability occurred in the South-Central British Columbia, Washington Coastal, Oregon East Cascades, and Cascade Range, Oregon TEAs. Panelists were most confident with scores in the Washington West Cascades and Oregon West Cascades (Fig. 5). The threat subcategories with the most variability in scores were understory reduction, reduction in vegetation diversity, fragmentation, and uncharacteristic forest insect and disease (Fig. 5). Variability in panelists' scores likely represented differences in professional judgment among members, uncertainty in how a threat subcategory affected fishers in a particular TEA, or the level of panelists' understanding of conditions in a TEA. Variation in size of TEAs may have contributed to some scores being more scale dependent than others, and thus may have influenced scores. The effects of uncharacteristically severe wildfire, for example, may have greater negative consequences to fishers in a small area such as the Southern Sierra Nevada compared to large areas such as Northern California-Southwestern Oregon.

Linear Features

The aspects of fisher biology and ecology attributes most affected by linear features were mortality, home range establishment, movements (daily, breeding season, and dispersal), and predation (Fig. 3). Overall, linear features were scored as a low to moderate threat in all TEAs (Fig. 4).

Human-Caused Mortality and Reduction in Fitness

Aspects of fisher biology and ecology most affected by anthropogenic activities were home range establishment, daily movements, survival, reproduction, and recruitment (Fig. 3). In most TEAs, panelists scored the threat subcategories as low; however, lethal events and activities were scored as a high threat in South-Central British Columbia and as a moderate threat in the Cascade Range, Oregon and the Northern Sierra Nevada.

Development

Development was evaluated by most panelists to affect fishers by influencing home range establishment, altering prey availability, disrupting movements, increasing predation risk and competition, and increasing exposure to disease (Fig. 3). Because development occurs at relatively small spatial scales in forested landscapes within the Assessment Area, development threat subcategories were generally evaluated to be a low threat (Fig. 4).

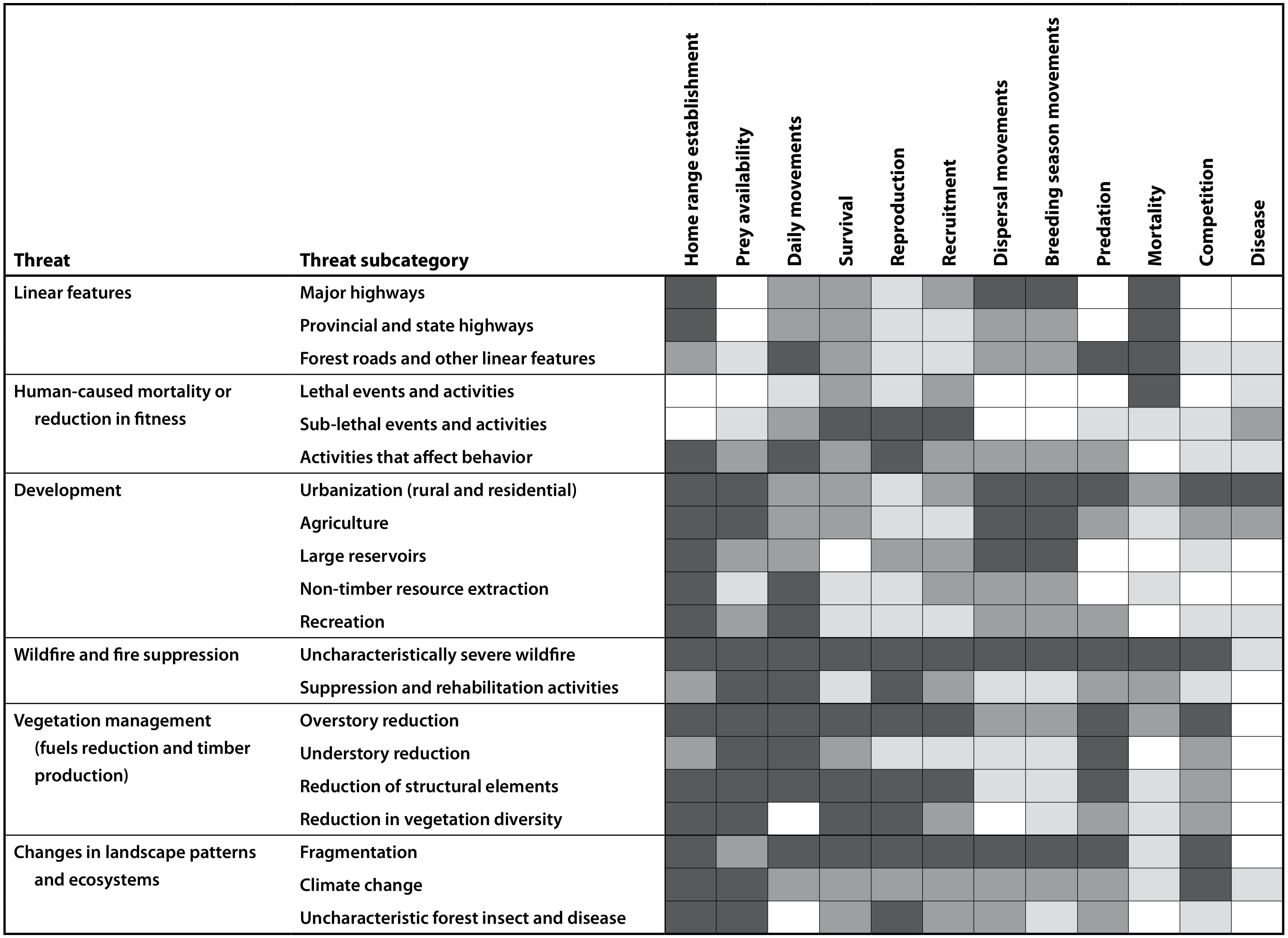


Figure 3. Aspects of fisher biology and ecology affected by different threat subcategories. Number of panelists that thought a threat affected a particular attribute: 0 (white), 1–3 (light gray), 4–7 (medium gray), 8–13 (dark gray). Adapted from Appendix 1.

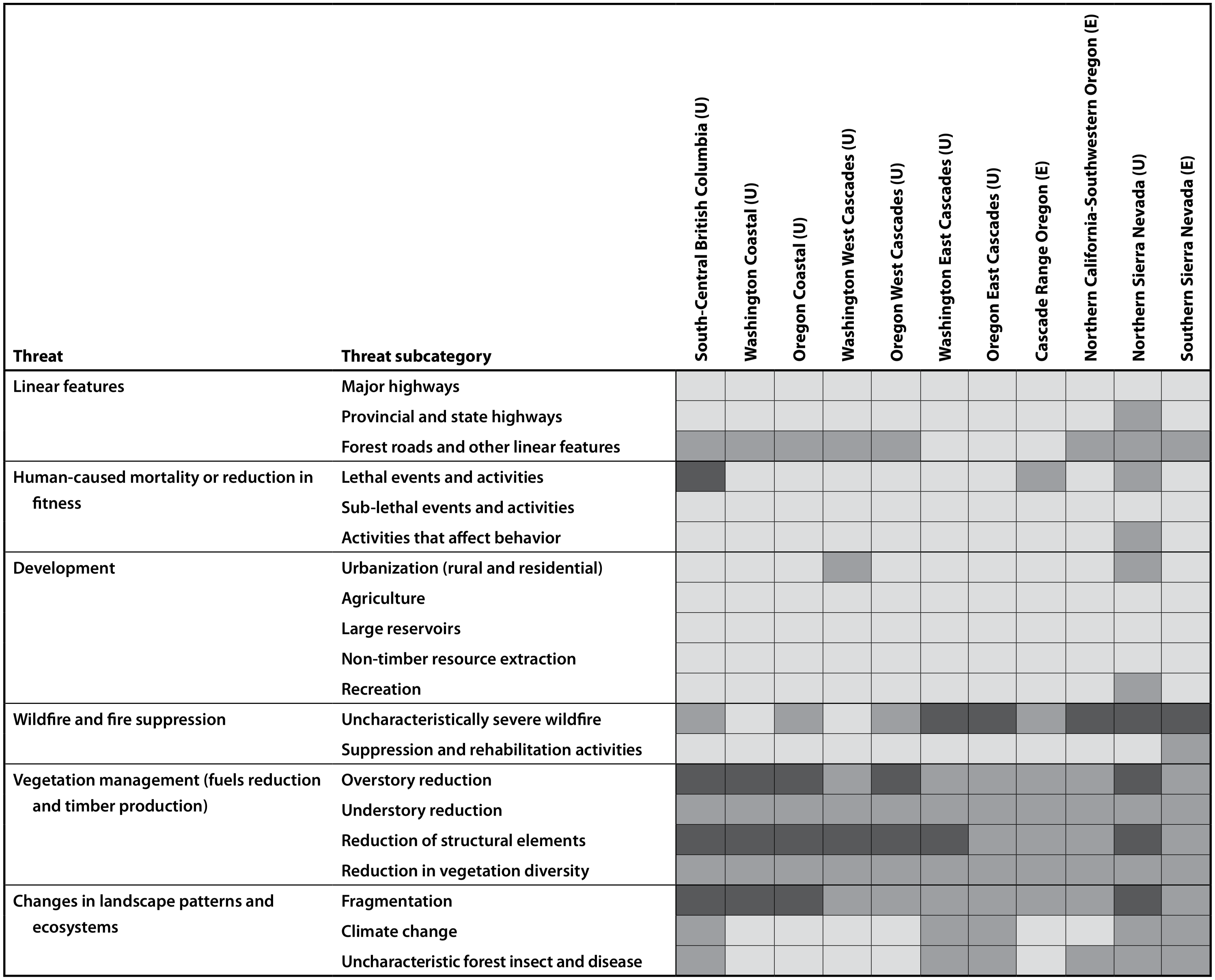


Figure 4. Median threat scores (n=13 panelists) for threat subcategories by TEA. Scores were on a scale of 0 to 10: 0–3 = low threat (light gray), 4–6 = moderate threat (medium gray), and 7–10 = high threat (dark gray). E = TEA with an extant fisher population; U = TEA is un-occupied. Adapted from Appendix 1.

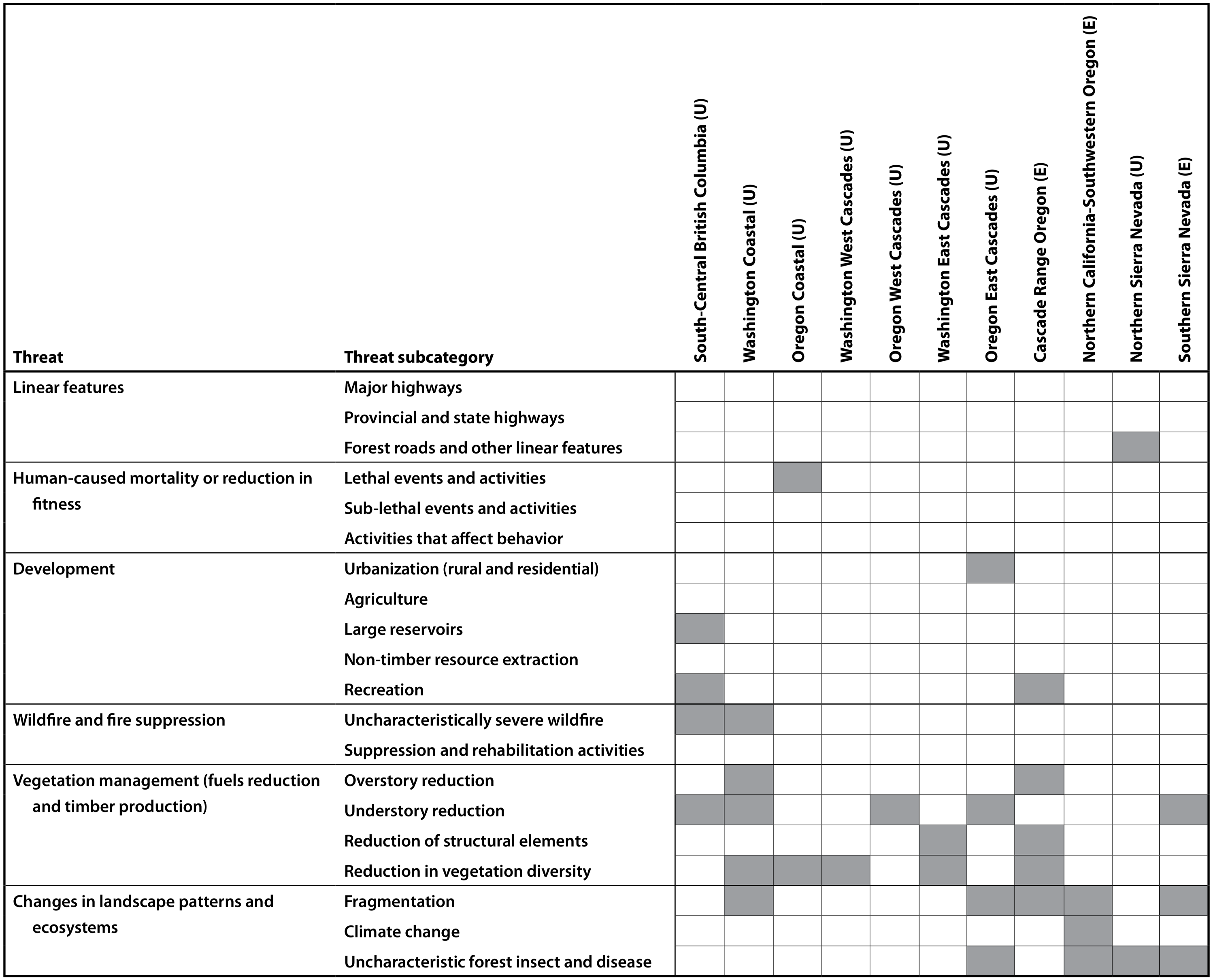


Figure 5. Variability in panelists' threat evaluation scores: white = low variability (difference between the minimum and maximum scores was ≤ 4), gray = high variability (difference was ≥ 5). E = TEA with an extant fisher population; U = TEA is un-occupied. Adapted from Appendix 1.

Development, however, was evaluated to be a moderate threat in those areas where fisher habitat occurred close to rapidly growing urban and suburban areas. Four threat subcategory and TEA combinations had highly variable scores among panelists (Fig. 5): large reservoirs and recreation in South-Central British Columbia, urbanization in Oregon East Cascades, and recreation in Cascade Range, Oregon.

Wildfire and Fire Suppression

The threat of uncharacteristically severe wildfire was evaluated to affect all aspects of fisher biology and ecology except disease, whereas fire suppression activities were determined to primarily affect prey availability, daily movements, and reproduction (Fig. 3). Uncharacteristically severe wildfire was scored a moderate to high threat in all TEAs except the Washington Coastal and Washington West Cascades, where it was scored a low threat. In only 2 TEAs, South-Central British Columbia and Washington Coastal, were panelists' scores highly variable on the effects of uncharacteristically severe wildfire on fishers.

Vegetation Management: Fuels Reduction and Timber Production

Panelists were highly confident that vegetation management activities that reduce large structures and overstory cover would negatively affect fisher reproduction, survival, recruitment, availability of prey, as well as many other aspects of fisher biology and ecology (Fig. 3). All vegetation management threat subcategories were scored as moderate or high threats in all TEAs (Fig. 4). There was more variability in threat scores by TEA among panelists in the vegetation management threat category than other threat categories (Fig. 5). Panelists consistently evaluated overstory reduction as being a relatively high threat to all aspects of fisher biology and ecology, except dispersal and breeding season movements, mortality, and disease (Fig. 3). Panelists scored overstory reduction as a high threat in South-Central British Columbia, Oregon West Cascades, Washington and Oregon Coastal and Northern Sierra Nevada, and a moderate threat in all remaining TEAs (Fig. 4). Panelists' scores were highly variable for Washington Coastal and Cascade Range, Oregon TEAs (Fig. 5). Panelists evaluated understory reduction to have the greatest effect on daily movements, prey availability, and predation (Fig. 3). Understory reduction was ranked as being a moderate threat to fishers throughout the Assessment Area (Fig. 4). There was high variability in panelists' threat scores for understory reduction in 5 of 11 TEAs (Fig. 5). Reduction of structural elements was evaluated to be the greatest threat to fishers (Fig. 4). Panelists consistently evaluated reduction of structural elements to primarily affect home range establishment, prey availability, daily movements, survival, reproduction, recruitment, and predation (Fig. 3). It was scored as a high threat in South-Central British Columbia, Washington and Oregon West Cascades, Washington and Oregon Coastal, Washington East Cascades, and Northern Sierra Nevada, and a moderate threat in the remaining TEAs (Fig. 4). There was high variability in panelists' scores for the Washington East Cascades and Cascade Range, Oregon (Fig. 5). Most panelists evaluated the reduction in vegetation diversity to affect home range establishment, prey availability, survival, and reproduction (Fig. 3). Panelists scored reduction in vegetation diversity to be a moderate threat in all TEAs (Fig. 4). There was high variability in panelists' threat scores for reduction in vegetation diversity for 5 of 11 TEAs (Fig. 5).

Changes in Landscape Patterns and Ecosystems

Most of the panelists evaluated fragmentation to affect all aspects of fisher biology and ecology, except prey availability, mortality, and disease (Fig. 3). Fragmentation was scored a high threat in South-Central British Columbia, Washington Coastal, Oregon Coastal, and Northern Sierra Nevada, and a moderate threat in the remaining TEAs (Fig. 4). Panelists' scores for fragmentation

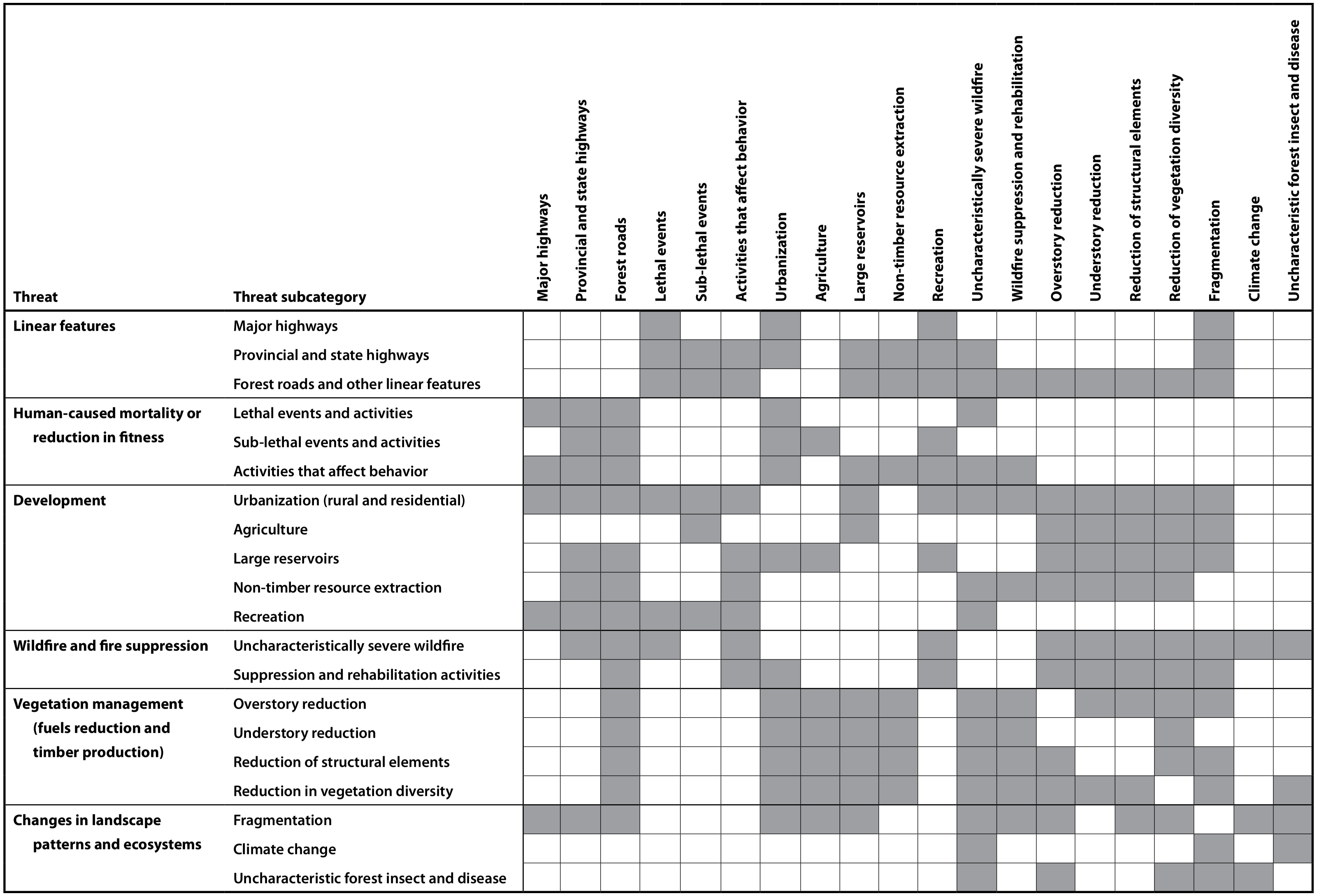


Figure 6. Potential synergistic relationships (gray shading) among threats evaluated for fishers in the Assessment Area.

were highly variable in 5 of 11 TEAs (Fig. 5): Washington Coastal, Oregon East Cascades, Cascade Range Oregon, Northern California-Southwestern Oregon, and Southern Sierra Nevada. The majority of panelists evaluated climate change to affect home range establishment, prey availability, and competition (Fig. 3). There was little variability in panelists' scores of the threat of climate change on fishers with the exception of Northern California-Southwestern Oregon (Fig. 5). Uncharacteristic forest insect and disease conditions were evaluated by most panelists to affect home range establishment, prey availability, and reproduction (Fig. 3). Panelists scored uncharacteristic forest insects and diseases as a moderate threat in South-Central British Columbia, Washington East Cascades, Oregon East Cascades, and all areas in California (Fig. 4).

Threat Interaction and Synergy

We concluded that threats acting in concert generally resulted in greater effects on fishers than threats acting independently (Fig. 6). Threat subcategories determined to act synergistically with over 50% of all threat subcategories included forest roads, urbanization, large reservoirs, uncharacteristically severe wildfire, overstory reduction, reduction of structural elements, reduction in vegetation diversity, and fragmentation.

Fisher Reintroduction Northern Sierras

DISCUSSION

The Overarching Challenge: Small, Isolated Fisher Populations

Perhaps the most immediate and challenging threat to fishers in the Assessment Area is their current population status. Extant fisher populations are generally small and isolated. Although the threat of small population size was not explicitly evaluated in this process, the current distribution of fishers largely reflects the effects of past anthropogenic stressors (Volume I, Chapters 4 and 5). The 3 extant populations do not appear to have expanded their distribution over the past several decades, and it is uncertain whether population processes, suitability of habitat, or a combination of these and other factors are currently limiting population expansion.

Small, isolated populations are inherently at higher risk of extirpation owing to stochastic phenomena and uncertainty (Stacey and Taper 1992). Shaffer (1981, 1987) summarized 4 general factors that influence small population persistence: 1) demographic stochasticity–the effect of random events on individual survival and reproduction; 2) environmental stochasticity–unpredictable events that influence food resources, populations of competitors, available habitat, etc.; 3) genetic uncertainty, including phenomena such as genetic drift, inbreeding depression, and founder effects; and 4) catastrophic events–extreme cases of environmental stochasticity. Independently, each of these factors can lead to extirpation of small, isolated populations, even though they operate at different spatial and temporal scales (Shaffer 1981). Demographic stochasticity and genetic uncertainty typically have negative effects on small populations (e.g., <100 individuals), and these effects may not manifest for several generations (Shaffer 1981). Environmental stochasticity can have pronounced short-term deleterious effects on small populations (Shaffer 1981). This is particularly true when environmental stochasticity is correlated over space and time (Shaffer 1981). Drought cycles, for example, often influence large areas and continue for multiple years, potentially creating cascading effects in the ecosystem and increasing the risk of wildfire (Shaffer 1981). Stochastic phenomena can interact with anthropogenic stressors to alter the risk of further decline or extirpation (Shaffer 1981).

High Threats Prevalent Throughout the Assessment Area

Our evaluations of the magnitude, intensity, and duration of overstory reduction, reduction of structural elements, and fragmentation were primarily influenced by land ownership patterns (Plate 11), management practices, and tree regeneration time. For example, vegetation management threats were higher in TEAs that had a higher proportion of commercial (private) timber lands where even-aged regeneration harvests were more common management strategies, or in areas where tree regeneration times were longer. Most vegetation management activities were evaluated based on the degree to which they caused reduction of structural elements and overstory trees. Thus, regardless of variation in land ownership and management practices, the outcome of these activities on fishers was similar: 1) loss of important structures for denning and resting, 2) loss of overstory cover, and 3) reduction in the recruitment rate of future forest structure.

There is considerable information on the importance of structural elements (e.g., large live and dead trees with cavities) for fishers. As stated in Volume I of this Assessment, "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

Plate 11. Management priorities typically differ by landownership and can change landscape patterns (e.g., checkerboard ownership resulting in a checkerboard pattern of forested and non-forested environments) and fragment fisher habitat.

with kits." All known fisher reproductive dens are in cavities in live trees or snags. Reproductive dens are typically in the oldest and largest trees available. These den trees require extensive time periods to develop, because of size and time for ecological processes to occur that create cavities (Volume I, Chapters 7 and 8). Structural elements (e.g., large trees with cavities and platforms) are also used extensively by males and females for resting (Volume I, Chapter 7). There are no reported empirical thresholds at which reduction of structural elements may begin to negatively affect fishers.

Moderate to dense canopy closure provides key habitat features, and overstory trees provide one of the key components of this cover. They also contribute to the structural diversity of forested environments. Overstory trees also contribute to current and future structural elements and prey species abundance and diversity. One of the most consistent predictors of fishers appears to be expanses of forest with moderate to high canopy cover (Volume I, Chapter 7).

Fragmentation (at the population scale) was a more challenging threat to evaluate because many vegetation management practices and human development activities can fragment forested landscapes. Fragmenting large, contiguous blocks of fisher habitat may contribute to the overarching concern about fisher conservation status in the Assessment Area. Fragmentation from timber harvest or fire (depending on harvest method, fire intensity, and site potential) can persist for various time periods, ranging from 1 fisher lifetime (about 10 yrs) in forested systems that regenerate quickly to more than 60–80 yrs (Agee 1991, Franklin and Spies 1991, Spencer et al. 2008). Evaluating the effects of fragmentation on any species is a function of several interacting factors: 1) the scale of fragmentation in relation to the scales at which an animal interacts with its environment, 2) the pattern and extent of fragmentation within a given scale, and 3) the degree of contrast between the focal habitat and the surrounding areas (Franklin et al. 2002*b*). Fishers have relatively large home ranges, use habitat at multiple spatial scales, and typically avoid areas with little or no contiguous cover (Volume I, Chapter 7). Fragmented landscapes may affect landscape permeability, either permanently through vegetation type conversion or temporarily until vegetation recovery occurs (Green et al. 2008). Anthropogenic (e.g., urban development) and natural features (e.g., large rivers; Wisely et al. 2004) can also act as filters to fisher movements. We concluded that fragmentation can affect fishers' use of the landscape because moderate to high amounts of contiguous cover are a consistent predictor of fisher occurrence at large spatial scales (Volume I, Chapter 7).

High Threats That Are More Prevalent in Some Threat Evaluation Areas Than Others

Our evaluation of the magnitude, intensity, and duration of uncharacteristically severe wildfire, uncharacteristic forest insect and disease, and climate change reflected intrinsic variability in the physical environments of the Assessment Area, including differences in climate, geography, historical fire regimes, and fire suppression policies. Within the Assessment Area, precipitation and temperature vary from north to south and from the west to east (Volume I, Chapter 3). Historical fire regimes are linked to climate; forests in cool moist climates tend to have longer fire return intervals than do forests in warm dry climates (Volume I, Chapter 3). During the 20th century, fire suppression efforts were greatest in more xeric forest systems that have short fire-return intervals, resulting in increased fuel loads (Taylor and Skinner 2003). Subsequently, these forests systems are inherently more susceptible to uncharacteristically severe wildfire and uncharacteristic forest insect and disease. Although uncharacteristically severe wildfire events can occur in moister forests that have not shifted dramatically from historical fire regimes (Moeur et al. 2005), we concluded that the magnitude and intensity of the impact on fisher habitat would likely be less than in xeric forests.

The temporal scale of wildfire effects vary according to site potential and post-fire condition (Kennedy and Fontaine 2009). Uncharacteristically severe wildfires can affect large areas, and potentially remove or modify forest structure, including large overstory trees, snags, logs, canopy cover, and understory vegetation, especially when followed by post-fire salvage logging (Monsanto and Agee 2008, Kennedy and Fontaine 2009). Such events affect almost all aspects of fisher biology and ecology (Fig. 3). Habitat changes resulting from large-scale wildfire may reduce well-distributed cover for fishers, increasing predation risk (Lyon et al. 1994). Wildfire can also affect prey species abundance and community composition (Lyon et al. 2000, Green et al. 2008). Prey may not be as available owing to changes in the foraging environment (e.g., loss of cover and resting sites; Kennedy and Fontaine 2009) although abundance of some prey species may increase (Chang 1996). These changes may affect fisher fitness because of increased energy expenditures to locate and capture prey.

Fires have always occurred in fisher habitat; however, panelists considered threats from wildfire to be more significant in regions where current vegetation has departed from historical conditions and may contribute to increased fire severity and extent (Baker and Ehle 2001,Taylor and Skinner 2003, Hessburg et al. 2007; Plate 12). In general, recovery time of forests in xeric environments after uncharacteristic events may be longer than for forests in mesic environments because of inherently lower site productivity or shifts to non-forest vegetation communities for longer periods (Plate 13).

Although uncharacteristic insect and disease events change forest structure important to fishers, the magnitude and intensity of such events on fishers was evaluated to be lower than that for uncharacteristically severe wildfire, even though they may operate at larger spatial scales than wildfire (Raffa et al. 2008). We also recognized that wildfire or salvage logging frequently follow severe insect and disease outbreaks

Plate 12. Wildfire has often been a part of resilient landscapes (A). Past management practices, in many cases, have resulted in increased fuel loads and contributed to conditions that can result in uncharacteristically severe wildfires (B).

Plate 13. Fire events in xeric forests, such as this fire that burned in the Klamath Mountains in the 1950s, may take many years to recover the important components of fisher habitat.

and may further reduce fisher habitat quality (Plate 14). Tree mortality resulting from forest insect and disease outbreaks can be host specific (Hagle et al. 2003). Some areas, such as Washington East Cascades, consistently have insect outbreaks and some panelists may have considered such frequency of outbreaks to be within the range of natural variability, and thus did not rank them as a high threat.

Panelists' scores for climate change reflected not only intrinsic variation in the physical environments of the Assessment Area, but the range of variation of various model predictions (Kerr and Packer 1998, McKenzie et al. 2004, Safford 2007, Solomon et al. 2007) as to where and how climate change could affect forests of western North America. Although climate change is occurring, its effect on forest ecosystems within the Assessment Area is not entirely clear. Changes in climate may result in increased risk of weather events such as extreme temperatures, droughts, and floods, which are expected to increase in both frequency and severity (Gayton 2008). The northern portion of the Assessment Area (approximately Oregon/California border and north) is expected to have increased winter precipitation (Gayton 2008), whereas the southernmost portion of the Assessment Area is expected to have reduced summer precipitation and reductions in snowpack (Cayan et al. 2006,

Plate 14. Loss of overstory cover resulting from large insect outbreaks (as in this example) has a negative effect on fisher habitat quality, but habitat quality may be further reduced when such events are followed by salvage logging and the removal of large structures.

Safford 2007). Increased climate variability, especially variation in temperature and precipitation (McKenzie et al. 2004), may result in longer fire seasons, increases in area burned, and significant changes in the distribution and abundance of dominant plant species. Climate change is potentially changing the pattern and increasing the frequency of insect infestations in the Assessment Area (Carroll et al. 2003, Taylor and Carroll 2004).

The potential magnitude of climate change is great, intensity is unknown, and duration is anticipated to be long term (Gayton 2008). The effects of climate change on fishers are likely to be greatest at the margins of their range and in areas on the margins of habitat suitability (e.g., in areas where elevation, precipitation, etc., begin to limit occurrence of forests communities used by fishers; Gayton 2008).

Moderate Threats Prevalent Throughout the Assessment Area

Evaluations of the magnitude, intensity, and duration of understory reduction and reduction in vegetation diversity were influenced, to some degree, by existing land ownership patterns and management practices. However, these activities were challenging to evaluate because they interact with other vegetation management activities (overstory reduction and reduction of structural elements). These challenges were reflected in the relatively high variability in panelists' scores for many of the TEAs (Fig. 5).

In spite of variability in TEA scoring, there was consensus among panelists that understory vegetation is important to fishers. Management activities that reduce or remove understory vegetation may, among other things, decrease prey availability, disrupt daily movement patterns of fishers, and increase vulnerability of fishers to predation (Fig. 3). In some geographic areas, fisher selection of rest sites and sites when active was associated with understory cover, thus reduction in understory vegetation is likely to influence home range use (Volume 1, Chapter 7).

Panelists agreed that vegetation species diversity is probably important for fisher denning, resting, and prey habitat (Fig. 3). For example, tree species most likely to form cavities differ by region, stand age, tree age, and site conditions (Volume I, Chapters 7 and 8). Thus, greater tree species diversity would likely increase the availability of cavities for reproductive dens and resting, and habitat for prey species. In some TEAs, hardwoods provide important denning habitat and may also be important for sustaining relatively high densities of various prey species (Volume I, Chapter 7). Although little information is available on these potentially complex relationships, management activities that reduce vegetation diversity were perceived to have potentially substantial negative effects on fisher home range establishment, prey availability, survival, and reproduction (Fig. 3).

Low to Moderate Threats Prevalent Throughout the Assessment Area

Major highways and provincial and state highways may be barriers (either semi-permeable or impermeable) to fisher population-level movements (e.g., home range establishment, juvenile dispersal, breeding season movements by males), as well as sources of vehicle-collision mortality (Fig. 3; Truex et al. 1998; see Volume I, Chapter 6). Although other linear features, such as utility corridors, canals, and pipelines, were included in the same category as forest roads, most panelists' scores reflected the effect of forest roads. Thus, the threat to fishers was scored higher in TEAs that had greater densities of forest roads (Fig. 4).

Besides permanently removing potential fisher habitat, development can disrupt or create barriers to fisher movements. In general, development-related activities were scored a low threat to fishers because we considered them to typically occur at relatively small spatial scales in forested areas. However, 2 TEAs (Washington West Cascades and Northern Sierra Nevada) are close to large human population centers, and development in the urban-rural interface is currently removing potential fisher habitat. The threats from recreation activities to fishers were also scored higher in areas close to large population centers. Other concerns associated with human development in the urban-rural interface is the potential increase in the incidence of disease in fishers, especially those diseases common to domestic dogs (e.g., canine distemper virus, parvoviruses; Riley et al. 2004; see Volume I, Chapter 6) and increased need for fuel reduction projects.

There are no legal trapping seasons for fishers within the Assessment Area, but fishers are curious and have a tendency to be captured in traps set for other mammals. Thus, we scored lethal events a greater threat in areas where the use of body-gripping traps and snares are still permitted. In South-Central British Columbia, lethal events were scored a high threat; however, after reviewing additional information on trapping activities throughout the Assessment Area (Volume I, Chapter 4), we recognized that the threat to fishers in South-Central British Columbia is probably only moderate and no greater than the threat in the Cascade Range, Oregon. Based on the number of trapping permits and the use of body-gripping and leg-hold traps, the threat from incidental trapping in other areas of Oregon may be somewhat greater than our original assessment of low (Volume I, Chapter 4).

Non-trapping related lethal events were scored a moderate threat in the Northern Sierra Nevada because of the high level of human activities in those forest systems that could result in negative human-fisher interactions. All these activities are influenced by the presence of roads and development. Forests that are close to urban development and large population centers typically receive higher recreational use (Volume I, Chapter 4). In general, greater densities of forest roads provide greater access to forests where fishers may occur. In such areas, the threats to fishers from poaching, off-highway and over-snow recreational vehicles, and other types of human activities may be greater. The threats from lethal and sub-lethal events, and activities that alter fisher behavior, are greater at the scale of individual animals than at the scale of a population.

Some fire suppression activities occur on a relatively small spatial scale (e.g., felling of single trees), whereas others occur over much larger areas (e.g., linear fire breaks, defensible fuel zones, burnout operations; Plate 6). Consequently, it was unclear how much potential fisher habitat is currently being removed through these activities. The lack of available information was reflected in the variability of scores among panelists (Fig. 5). However, these activities can remove large structures that are potential fisher denning and resting habitat, and reduce overstory and other habitat components. Suppression activities are also likely to increase, especially in forests where fuel loads are above historical levels, and in areas where insect and disease outbreaks have created high fuel loads (Taylor and Carroll 2004). New information on the extent of these activities would facilitate an improved evaluation of potential threats to fishers.

Differences in Threats Between Areas With and Without Extant Fisher Populations

There were differences in the magnitude of threat scores between TEAs with extant fisher populations and those without extant fisher populations (Fig. 4). In general, overstory reduction and reduction of structural elements were scored as having a slightly lower effect on fishers in the occupied TEAs (moderate threats) than in most of the unoccupied areas (high threats). In the Cascade Range, Oregon, these differences may have reflected the small TEA size compared to other areas and the greater proportion of federal ownership including late-successional reserves (USDA Forest Service and USDI Bureau of Land Management 1994) and congressionally reserved lands (e.g., National Parks, wilderness) relative to other TEAs. The TEAs with extant fisher populations have not been as heavily affected by human activities (e.g., roads, proximity to cities) as forests in the unoccupied areas (Volume I, Chapter 4). This may be a major contributing factor to the continued presence of fishers in some areas and not others. This was particularly evident in California where state-level highways, lethal events, human activities that affect fisher behavior, urbanization, and recreational developments were all scored low threats in the occupied Southern Sierra Nevada but moderate threats in the unoccupied Northern Sierra Nevada.

Threat Interaction and Synergy

Our primary concern for the long-term conservation of fishers in the Assessment Area is the fundamental challenge faced by relatively small, isolated populations. The potential effects of stochastic events on such populations will likely exacerbate the effects of individual and cumulative threats in a manner difficult to envision or predict. Although it is difficult to quantify interactions and synergy among different threats, the potential for adjusting management strategies (adaptive management) must be considered when developing and implementing a conservation strategy. Because of the large number and complexity of potential threat interactions and their synergistic effects on fishers, we provide only a few examples for users to consider. Interaction among threats, and their effects on fishers, will likely be different in different geographic areas.

1. Uncharacteristically severe insect outbreaks can create a higher risk of uncharacteristically severe wildfire, which can reduce structural elements; the reduction of structural elements can be further exacerbated by salvage harvest. Where this occurs within the bounds of a small population, the effects on fishers could be substantial.
2. Developing or increasing the capacity of highways in fisher habitat may increase fisher mortality because of greater traffic volumes and increased speed limits. Highway development or improvements occasionally increase residential development, which may also increase the occurrence of human-caused wildfires.
3. A single linear feature may have a small effect on fisher movements, but multiple linear features (e.g., paved highways, railroad rights-of-way, and rivers) nearby may create more formidable barriers to movement (Plate 1).
4. Forest roads (for firewood cutting or timber harvesting), urbanization (removal of large trees for development, increased need for firewood), agriculture (land clearing), large reservoirs (flooding of forested lands), recreation (hazard tree removal), and uncharacteristically severe wildfire and fire suppression, all potentially result in the reduction of structural elements. When these activities occur within the same area, effects on fishers may be substantially greater than those caused by any single activity.
5. Developments, large reservoirs, urbanization, and uncharacteristically severe wildfire that create extensive breaks in fisher habitat can increase fragmentation.
6. Small-scale developments such as housing subdivisions may reduce fisher habitat in a given area by a few hectares, but when other activities associated with development are considered (e.g., more roads, free roaming pets that may increase risk of disease in fishers, increases in domestic dog and fisher interactions, an increased risk of human-caused wildfires, and fuel reduction projects to protect structures) the loss of effective habitat is much greater (Plate 15).

Plate 15. Small scale developments in forested areas can remove habitat and contribute to other factors that reduce fisher fitness (e.g., introduction of free-roaming pets that may carry diseases or exposure to poisons).

IMPLICATIONS FOR CONSERVATION

We have only addressed the conservation implications of high to moderate threats that are prevalent throughout the Assessment Area, and low to moderate threats that have potentially greater negative impacts on fishers when interactions and synergistic effects are considered.

1. The overarching concern for fisher conservation in the Assessment Area is the small and isolated nature of extant fisher populations. This necessitates a long-term conservation strategy–protect existing populations and encourage expansion. Extant fisher populations may be capable of persisting for many generations but are vulnerable to stochastic phenomena and anthropogenic threats. Buffering these populations by improving population fitness and spatial extent will be critical to achieve the goal of self-sustaining, interacting fisher populations. A conservation strategy must include measures to maintain permeable forested landscapes that facilitate reproduction, dispersal, and genetic interchange that will be essential for sustained growth and expansion of fishers within the Assessment Area.
2. Our threat assessment suggests that conservation actions for fishers may involve similar approaches throughout the Assessment Area. However, variation in threats by geographic area (e.g., risk of uncharacteristically severe wildfire), existing laws, policies, and regulations will likely result in variation in how threats are ameliorated in different geographic regions.
3. Threats that were scored moderate to high in most of the TEAs must be a high priority for development of conservation measures to ameliorate the effects of those threats.
4. Fifty percent of the threat subcategories in the Southern Sierra Nevada TEA were scored as moderate to high. The small, isolated fisher population in this area must be a high priority for ameliorating existing threats.
5. Reduction in structural elements was the highest ranked and geographically most consistent threat. Conservation measures must address this critical element of fisher reproductive and resting habitat throughout the Assessment Area to assure suitable denning and resting structures are available and well distributed across the landscape. Where structural elements are deficient in abundance and distribution, conservation measures must include provisions for the recruitment of large trees that will develop the type of microstructures used by fishers for reproduction and resting.
6. Overstory reduction was a high threat in nearly 50% of the TEAs. A conservation strategy must include measures to maintain or restore moderate to high levels of overstory in areas with extant fisher populations and in other high-priority fisher habitat areas within the Assessment Area.
7. Uncharacteristically severe wildfire can affect large areas of the landscape, removing key fisher habitat elements. This threat was perceived to have the greatest affect in TEAs east of the Cascades and in California. An effective conservation strategy must provide guidance to develop effective fuel reduction techniques that reduce the potential for uncharacteristically severe wildfire, while maintaining productive fisher habitat. The long-term goal of these measures should be to develop resilient landscapes that provide future fisher habitat.
8. Reducing the density, diversity, and abundance of understory vegetation and the loss of vegetation diversity were both scored as moderate threats in all TEAs. A successful conservation

strategy must include measures that recognize the importance of understory vegetation to support abundant prey populations and provide adequate fisher cover, and the contribution of diverse native vegetation to fisher habitat and in the maintenance of resilient landscapes. In TEAs where hardwoods are an important component of fisher habitat, conservation measures must address opportunities to maintain and promote them.

9. The short- and long-term effects of climate change on forest ecosystems within the Assessment Area are not clear. Climate change was scored as a moderate threat in 5 TEAs in the eastern portion of the Assessment Area and low elsewhere. Because of the uncertainty of how climate change may affect fisher habitat across the Assessment Area, the conservation strategy must incorporate measures to develop and maintain diverse and resilient landscapes and incorporate management strategies to be responsive to changing vegetation patterns and new science.

10. Development of a conservation strategy must consider the interactions of multiple threats. Conservation measures must be developed to emphasize and encourage coordination at all levels (agencies, landowners) so consideration of important fisher habitat is addressed in all plans. Proposed developments should be planned to result in the smallest amount of habitat affected through direct loss (houses and surrounding landscape and roads) and minimal effects on fisher movement and dispersal. Indirect modification to fisher habitat through fuels treatments to protect developments must also consider fisher movement and dispersal. New highways must consider wildlife movement and reduce potential vehicle collisions with fishers.

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Olympic Fisher Project

APPENDIX 1

Fisher Threats Workshop Report

Bruce G. Marcot, USDA Forest Service,
PNW Research Station
Steve Morey, USDI Fish and Wildlife Service,
Science Support Program
Bob Naney, USDA Forest Service,
Okanogan/Wenatchee NF
Laura Finley, USDI Fish and Wildlife Service,
Yreka Fish and Wildlife Office

April 12, 2007

Summary

The Fisher Conservation Strategy Biology Team (fisher biology team) held an "expert panel" workshop on February 6–8, 2007, to conduct a "threats analysis" for fishers within the West Coast Distinct Population Segment (DPS) and British Columbia. The fisher biology team, rank-ordered the 20 types of threats (Table 1) previously identified as having the potential to influence fisher populations and fisher life-history attributes (Table 2). Overall, the fisher biology team ranked the greatest threats to be uncharacteristically severe wildfire, overstory reduction, reduction of structural elements, and forest habitat fragmentation (not listed here in any specific order), although the severity of threats varied by geographic areas (as defined in the draft Interagency Fisher Conservation Assessment). The team expressed the greatest uncertainty (differences of threat scores) for effects of understory reduction, reduction in vegetation diversity, forest habitat fragmentation, and uncharacteristic forest insect and disease

The fisher life history attributes (Table 2) that the team deemed to be most severely affected by more than half of the 20 types of threats included home range establishment and prey availability. However, all of the fisher life history attributes were thought to be influenced by at least one of the threat categories.

This workshop was designed to provide a structured process for assessing threats, not for providing decisions. As such, the results identify areas of uncertainty or information gaps and plausible working hypotheses about threats to fishers. The results also provide an initial basis for ranking of the most important threats and developing conservation actions. Outcomes are displayed with all the team's rank values and are summarized into three classes based on equal divisions of the possible ranks (0–10), although the classes are not intended to suggest that any threat categories be omitted from further consideration. The next phase of the project may entail interpreting the threat rankings to devise conservation strategies for reducing threats.

Methods

Definitions of Terms

Prior to the meeting, the fisher biology team had compiled and defined a list of 20 potential threat sub-categories organized into 6 general categories (linear features, human-caused mortality and/or reduction in fitness, development, wildfire and fire suppression, vegetation management for fuels reduction or timber production, and miscellaneous). Most, but not all, of the threat sub-categories were anthropogenic in nature. The term "threat" was defined as any of the effects on fisher life history attributes that may result in fishers not being sustainable in the geographic area being assessed.

The list of fisher life history attributes developed for the workshop was based on the known biology and ecology of fishers. These attributes were used to

assist panelists with considering both the intensity and scale of the potential effects of the threat sub-category.

The team also delineated 11 geographic areas ranging from British Columbia to the southern Sierra Nevada Mountains of California, within which each threat sub-category would be evaluated. Of the 11 geographic areas, three currently contain extant populations of native west coast fisher (northern California extending into southwest Oregon, the currently-occupied portion of the southern Sierra Nevada, and British Columbia). In addition the Cascade Mountains of southern Oregon contains an reintroduced population. The remainder of the DPS is considered to be currently unoccupied but presumed occupied historically.

Expert Panel Procedures

The threat evaluation took the form of an expert panel, using the team members as species, geographic and subject-area experts. Thirteen of the 14 total team members were present and participated in the expert panel session. Team members knowledgeable about each geographic area were present. The meeting began with a review of all terms for threat sub-categories (Table 1), definitions of threat, fisher life history attributes (Table 2), and delineations of each geographic area (Table 3) .

Marcot and Morey moderated the panel using a Delphi procedure, which entailed the following steps. In the first step, the team members were asked to silently record a score value that represented the effect of each threat sub-category on fisher populations in each of the geographic areas. The score values were integers ranging from 0 to 10, where 0 = no threat, 10 = maximum threat, and intermediate values were graded according to relative, perceived threat levels. The team members were directed to independently score each threat sub-category by geographic area rather than rank-ordering geographic areas with each threat sub-category. After a group discussion, the geographic areas classed as unoccupied by fisher were scored as if one-third of the potential fisher habitat within the geographic area was occupied

The panelists also denoted which fisher life history attributes might be adversely affected by each threat sub-category; this was not scored on a scale, but merely denoted by a checkmark if an effect was expected. This revealed how each team member, while evaluating each threat sub-category, conceptualized how the threat was affecting aspects of fisher biology.

In the second step, the panel engaged in a moderated disclosure of their first-round threat scores. This allowed each panelist to articulate reasons for their scoring, to hear how and why others scored as they did, and to briefly ask each other clarification questions. Each panelist also briefly noted which fisher life history attribute is influenced by each threat sub-category.

In the third step, each team member conducted a second-round, silent, final scoring of threat effects on fisher populations by geographic area (using 0–10 scoring) and on fisher life-history attributes (denoting expected effects just with a checkmark). In both the first-round and second-round scoring, we allowed the panelists to pass on denoting threat scores if they felt they had poor to no experience or information on a threat sub-category for a particular geographic area.

Analysis of Results

From both the first-round and second-round scoring of threats, we entered the individual panelists' threat scores and threat-life history attribute effects into a spreadsheet.

We summarized the threat scores for combinations of threat sub-categories and geographic areas in the following ways: sample size of number of voting team members, median score values, and minimum, maximum, and range (maximum minus minimum) of score values. The median score values displayed central tendencies of the panel as a whole, and the range of score values displayed the degree of variation and uncertainty among panelists. High ranges of score values among panelists suggested greater levels of variation and uncertainty among the panelists.

We color-coded the summaries of median and range of threat scores to help simplify interpretation of potential priorities of threat sub-categories. The mean threat scores were color-coded into high, moderate, and low levels, where high = threat scores 7–10, moderate = 4–6, and low = 0–3. The range of threat scores were also color-coded into high and low range values, where high = >5 and low is 5 or less. However, we retained and displayed the actual median and range values to allow exploration of different cutoff values for evaluating threat scoring outcomes.

We summarized the 13 team members' denoting of effects of threat sub-categories on fisher life history attributes by tallying the number of panelists that checked each combination. Higher tallies suggested greater consistency in how panelists thought that a threat sub-category might adversely affect fishers. We color-coded these tallies into high (8–13), moderate (4–7), and low (0–3) levels but also provide actual tallies if different cutoff values or if a different number of levels were desired.

Only the final, second-round scores are analyzed and presented in the following section.

Results

Threats by Score Levels

The median values of threat scores (Table 4) suggested that the threat sub-categories with the highest scores in at least four of the geographic areas (red cells in Table 4) were uncharacteristically severe wildfire, overstory reduction, reduction of structural elements, and fragmentation (listed here in the order they appeared in the tables). Other threat sub-categories with moderate median score levels (Table 4) in at least four of the geographic areas included forest roads and other linear features, understory reduction, reduction in vegetation diversity, and uncharacteristic forest insect and disease. The remaining threat sub-categories either had variable moderate and low median scores, or more consistently low median scores, among the geographic areas.

Levels of Uncertainty Regarding Threat Sub-categories

Threat sub-categories garnering the greatest range in panelists' score values, and thus implying a greater level of uncertainty among panelists (shown in Table 5 as dark gray cells for four or more geographic areas) included understory reduction, reduction in vegetation diversity, fragmentation, and uncharacteristic forest insect and disease. It is noteworthy that, of this list, only fragmentation was ranked high in median scores. The rest of the threat sub-categories listed above as having highest median threat scores garnered low ranges of score values, which may mean that they were most consistently understood and scored by the panelists.

Effects of Threats on Fisher Life History Attributes

Tallies of threat sub-categories by fisher life history attributes (Table 6) suggest that most of the threat sub-category have unique effects on fisher populations. The threat sub-categories having the highest tallies (red cells in Table 6) on more than half of the life history attributes included urbanization, uncharacteristically severe wildfire, overstory reduction, reduction of structural elements, and fragmentation. However, each threat sub-category had a highest effect on at least one of the fisher life history attributes; there was no completely benign threat sub-category.

The fisher life history attributes affected by more than half of the threat sub-categories included home range establishment and prey availability. However, each of the fisher life history attributes was most affected by at least one of the threat sub-categories.

Discussion and Interpretation

Results of this evaluation of threats on fisher populations should be interpreted as a survey of informed expert judgment. The panelists became informed by studying journal articles and reports on fisher ecology, biology, and conservation; by listening to presentations by expert researchers; and, for some panelists, by having conducted surveys or research on fishers directly. In this way, and by dint of the formal Delphi panel method used, results constitute far more than guesses or subjective opinions.

However, the ranking of threat sub-categories by geographic area or by range of uncertainty nonetheless are derived from querying the knowledge and judgment of experts, not from direct empirical field data per se. Thus, results might be better interpreted as providing plausible and potentially testable working hypotheses, and providing a basis for building conservation measures and actions that could prioritize addressing higher-scoring threats.

Cutoff values – the color-coded groupings shown in Tables 4–6 – were intended to guide understanding of the score values, not to provide definitive thresholds of effects. To this end, we have also displayed actual score values, if users of this information wish to use different cutoff values or numbers of categories, for prioritizing threats. The authors of this report have retained in a spreadsheet the individual threat scores of each panel member, available upon request.

Table 1. Categories, sub-categories, and definitions of threats used in the fisher threat assessment.

Threat Category	Threat Sub-Category	Definition
Linear features	Major highways	Multi-lane highways, generally > 55mph
	State highways	Two-lane state highways
	Forest roads (paved/gravel/dirt), utility corridors, canals, pipelines, railroads, etc.	All forest roads and other linear features
Human caused mortality and/or reduction in fitness	Lethal events/activities	Hunting, incidental trapping, poaching, poisoning, water tanks, fur trapping (cultural, recreational, and profit)
	Sub-lethal events/activities	Poisoning, research activities, domestic dogs, secondary effects from predator control, animal damage control
	Activities that affect behavior	OHV/OSV vehicles, other mechanical noise, people recreating and smoke
Development	Urbanization (rural/residential)	Installation of new rural/residential structure and infrastructure
	Agriculture	Conversion of forest to agriculture
	Large reservoirs	inundation
	Non-timber resource extraction	Mining, oil, etc
	Recreation	Ski area development, cabins, trails, campgrounds
Wildfire / fire suppression	Uncharacteristically severe wildfire	Probability of fire outside the range of variation (larger in both size and intensity)
	Suppression and rehabilitation activities	Snag felling, backfires, fuel breaks, fire lines
Vegetation management: fuels reduction, timber production	Overstory reduction	Dominant and co-dominant trees; differentiate in comments canopy vs. stem density
	Understory reduction	Loss of shrubs, saplings, intermediate, and suppressed trees, structural diversity
	Reduction of structural elements	Reduction in occurrence of mistletoe, heart rot, pest/disease; reduction in large down wood
	Reduction in vegetation diversity	Floristic/tree species diversity
Miscellaneous	Fragmentation	Pattern, distribution, and patchiness of environments and habitats used by fishers
	Climate change	Potential changes to vegetation communities, fire frequency and fire intensity
	Uncharacteristic forest insect & disease	Sudden oak death, mountain pine beetle, etc

Table 2. List and definitions of fisher life history attributes used in the fisher threat assessment.

Fisher life history attribute	Definition
Mortality	Death of an individual
Survival	Able to meet all requisite annual life history needs; living to full life expectancy
Reproduction	Successfully breeding and producing young.
Recruitment	Young survive to reproductive age and produce offspring
Disease	Virus, bacteria, fungus, parasites that weaken individuals
Daily movement	Average movements an individual makes in a 24-hour period
Breeding season movement	Movements males and/or females make during the breeding season
Dispersal movements	Movements, generally by subadults, away from parent home range to establish new home range
Home range establishment	Stable area where individuals are able to meet daily and annual life requirements
Prey availability	Fisher prey available in an environment in which they can safely and successfully hunt.
Predation	Killed by other wildlife species
Competition	Species present that compete for food and habitat with fishers.

Table 3. List and definitions of geographic areas used in the fisher threat assessment. Occupancy status refers to whether fisher are currently present, introduced, or absent.

Geographic area name (occupancy status)	Definition
So. BC (unoccupied)	Area between the Fraser and Thompson Rivers and the Okanagan Country. The Fraser lowlands are permanently alienated.
WA- Coastal (unoccupied)	Canadian border to Oregon border and west of Highway 101 and Interstate 5. Includes the Olympic Peninsula
WA East Cascades (unoccupied)	Cascade Mountains. Canadian border to the Oregon border east of the Cascade Mountain crest.
WA West Cascades (unoccupied)	Cascade Mountains. Canadian border to the Oregon border west of the Cascade Mountain crest to Interstate 5
OR - Coastal (unoccupied)	Interstate 5 west from the Columbia River to the California border
OR East Cascades (unoccupied)	Cascade crest east in the Cascade Mountains. The Willamette Valley proper is outside of fisher habitat.
OR West Cascades (unoccupied)	Interstate 5 east to the Cascade crest
OR (introduced)	Primarily on the Rogue River National Forest, Jackson Co., Oregon
NW CA & SW OR (extant)	Oregon south of hwy 199, Lassen west to coast, South into Lake County.
Sierra (unoccupied)	Lassen south to central Yosemite
Sierra (extant)	South of central Yosemite.

Table 4. Results of Team scoring of threat sub-categories by geographic area. Values shown are median threat scores among 13 panelists. Threat scores ranged 0–10, where 0 = no threat and 10 = maximum threat on fisher populations. Higher median score values suggest more salient effects of a threat sub-category on fishers.

Threat	Threat Sub-Category	So. BC (unoccupied)	WA - Coastal (unoccupied)	WA East Cascades (unoccupied)	WA West Cascades (unoccupied)	OR - Coastal (unoccupied)	OR East Cascades (unoccupied)	OR West Cascades (unoccupied)	OR - (introduced)	NW CA & SW OR (extant)	Sierra (unoccupied)	Sierra (extant)
Linear features	Major highways	3	2	2	3	2	1	2	1	2	2	0
	State highways & paved forest roads	3	3	3	3	3	3	3	2	2	5	3
	Forest roads (gravel/dirt), utility corridors, canals, pipelines, railroads, etc.	4	4	3	4	4	3	4	3	4	5	4
Human caused mortality and/or reduction in fitness	Lethal events/activities	7	2	2	2	3	3	3	4	3	4	3
	Sub-lethal events/activities; related to rural interface	2	2	2	2	2	2	2	3	2	3	2
	Activities that affect behavior	2	2	2	3	2	2	2	3	2	4	2
Development	Urbanization (rural/residential)	2	3	2	4	3	3	3	2	2	5	2
	Agriculture	1	1	1	1	2	1	2	1	1	2	1
	Large reservoirs	1	1	1	1	1	1	1	1	2	1	1
	Non-timber resource extraction	1	1	1	1	1	1	1	1	1	1	1
	Recreation	1	2	2	3	2	2	2	2	2	4	3
Wildfire / fire suppression	Uncharacteristically severe wildfire	5	2	7	2	4	7	4	5	7	7	8
	Suppression and rehabilitation activities	2	2	3	2	3	3	3	3	3	3	4
Vegetation management: fuels reduction, timber production	Overstory reduction	7	7	6	6	8	6	7	5	6	7	6
	Understory reduction	5	5	5	4	6	6	5	5	5	5	5
	Reduction of structural elements	8	8	7	7	7	6	7	6	6	7	6
	Reduction in vegetation diversity	4	5	4	4	5	4	5	4	5	4	4
Miscellaneous	Fragmentation	7	7	6	6	8	6	6	5	6	8	6
	Climate change	5	2	4	3	3	4	3	3	3	5	5
	Uncharacteristic forest insect & disease	6	2	4	2	2	4	2	1	5	4	4

threat levels 7–10 | threat levels 4–6 | threat levels 0–3

Table 5. Results of Team scores of threat sub-categories by geographic area. Values shown are ranges of score values (maximum minus minimum score values) among panelists. Higher range values suggest greater variation or uncertainty of threat scores among panelists.

Threat	Threat Sub-Category	So. BC (unoccupied)	WA - Coastal (unoccupied)	WA East Cascades (unoccupied)	WA West Cascades (unoccupied)	OR - Coastal (unoccupied)	OR East Cascades (unoccupied)	OR West Cascades (unoccupied)	OR - (introduced)	NW CA & SW OR (extant)	Sierra (unoccupied)	Sierra (extant)
Linear features	Major highways	4	3	4	4	4	1	3	3	5	3	2
	State highways & paved forest roads	3	4	4	4	4	5	5	3	3	3	3
	Forest roads (gravel/dirt), utility corridors, canals, pipelines, railroads, etc.	4	4	4	4	4	3	4	3	3	6	3
Human caused mortality and/or reduction in fitness	Lethal events/activities	4	3	3	3	6	4	5	4	4	4	5
	Sub-lethal events/activities; related to rural interface	4	2	4	3	3	4	5	4	3	4	4
	Activities that affect behavior	4	3	4	4	4	3	3	3	3	2	3
Development	Urbanization (rural/residential)	2	3	3	5	4	6	4	2	3	5	2
	Agriculture	3	4	3	3	5	2	2	3	3	3	4
	Large reservoirs	6	2	4	3	2	2	3	2	4	4	3
	Non-timber resource extraction	2	2	3	2	3	3	2	2	2	3	2
	Recreation	7	3	4	3	5	4	3	6	3	4	5
Wildfire / fire suppression	Uncharacteristically severe wildfire	6	6	5	5	3	4	4	5	4	5	4
	Suppression and rehabilitation activities	5	3	3	4	4	4	4	4	4	3	3
Vegetation management: fuels reduction, timber production	Overstory reduction	3	6	5	2	4	5	3	6	4	3	4
	Understory reduction	6	8	3	4	5	6	6	4	3	4	6
	Reduction of structural elements	5	5	6	3	5	5	4	7	3	5	4
	Reduction in vegetation diversity	5	8	6	6	6	5	3	7	5	3	3
Miscellaneous	Fragmentation	5	6	5	5	4	6	5	7	6	5	6
	Climate change	5	5	5	4	5	5	4	4	6	5	5
	Uncharacteristic forest insect & disease	4	4	4	4	4	7	5	5	6	6	6

high range (spread of threat scores >5)   high range (spread of threat scores <=5)

Table 6. Tally of panelist scores of potential adverse influence of threat sub-categories on fisher life history attributes. Total possible score is 13 (with 13 panelists).Higher tallies suggest greater consistency in panelists' interpretation of how a threat sub-category can adversely affect fisher populations.

		Fisher Life History Attributes											
Threat	**Threat Sub-Category**	**Mortality**	**Survival**	**Reproduction**	**Recruitment**	**Disease**	**Daily movement**	**Breeding season movement**	**Dispersal movements**	**Home range establishment**	**Prey availability**	**Predation**	**Competition**
Linear features	Major highways	13	6	3	6	0	6	9	13	8	0	0	0
	State highways & paved forest roads	13	7	2	2	0	7	7	7	9	0	0	0
	Forest roads (gravel/dirt), utility corridors, canals, pipelines, railroads, etc.	9	5	1	2	3	9	4	5	6	2	10	2
Human caused mortality and/or reduction in fitness	Lethal events/activities	13	6	3	5	2	1	0	0	0	0	0	0
	Sub-lethal events/activities; related to rural interface	3	8	10	9	6	5	0	0	0	3	3	2
	Activities that affect behavior	0	4	8	5	2	12	5	4	8	4	4	2
Development	Urbanization (rural/residential)	4	6	3	4	9	6	10	11	13	12	9	8
	Agriculture	3	5	3	3	5	7	8	11	13	12	7	6
	Large reservoirs	0	3	4	4	0	6	10	10	11	6	0	1
	Non-timber resource extraction	3	3	2	4	0	8	5	6	9	3	0	0
	Recreation	0	2	3	2	3	10	7	4	9	4	5	3
Wildfire / fire suppression	Uncharacteristically severe wildfire	11	10	10	10	2	11	13	12	13	10	9	9
	Suppression and rehabilitation activities	4	2	9	7	0	8	2	1	4	9	4	1
Vegetation management: fuels reduction, timber production	Overstory reduction	4	9	13	11	0	10	5	7	13	9	10	8
	Understory reduction	0	4	1	2	0	8	1	1	4	13	9	5
	Reduction of structural elements	3	8	13	10	0	10	3	2	12	9	8	4
	Reduction in vegetation diversity	1	9	9	7	0	1	2	0	9	13	4	7
Miscellaneous	Fragmentation	2	11	9	10	0	12	13	13	13	7	11	10
	Climate change	2	6	5	4	2	4	4	5	12	12	6	8
	Uncharacteristic forest insect & disease	0	5	9	7	0	1	2	4	9	10	5	1

"high," scores 8–13   "moderate," scores 4–7   "low," scores 0–3