

# **Southern Sierra Nevada Fisher Conservation Strategy**

## **Prepared By**

Wayne Spencer  
Sarah Sawyer  
Heather Romsos  
William Zielinski  
Craig Thompson  
Susan Britting

## **Prepared For**

The Fisher Interagency Leadership Team:

Sierra Nevada Conservancy  
USDA Forest Service  
National Park Service  
US Fish and Wildlife Service  
California Department of Fish and Wildlife

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## Editors:

Wayne Spencer, PhD, Conservation Biology Institute  
Sarah Sawyer, PhD, USDA Forest Service  
Jerre Ann Stallcup, MA, Conservation Biology Institute

## Fisher Interagency Leadership Team:

Barnie Gyant, USDA Forest Service Region 5  
Cay Goude, MS, US Fish and Wildlife Service  
Mietek Kolipinski, PhD, National Park Service  
Eric Loft, PhD, California Department of Fish and Wildlife  
Jim Branham, Sierra Nevada Conservancy

## Core Project Support Team:

Diana Craig, MS, USDA Forest Service  
Sarah Sawyer, PhD, USDA Forest Service  
Wayne Spencer, PhD, Conservation Biology Institute  
Mandy Vance, Sierra Nevada Conservancy

## Fisher Technical Team:

Wayne Spencer, PhD (Chair), Conservation Biology Institute  
Jim Baldwin, PhD Pacific Southwest Research Station  
Susan Britting, PhD, Sierra Forest Legacy  
Deana Clifford, DVM, MPVM, PhD, California Department of Fish and Wildlife  
Lindsay Cline, MS, National Park Service  
Roger Powell, PhD, North Carolina State University (Emeritus)  
Kathryn Purcell, PhD, Pacific Southwest Research Station  
Hugh Safford, PhD, USDA Forest Service Region 5 and University of California, Davis  
Sarah Sawyer, PhD, USDA Forest Service Region 5  
Rick Sweitzer, PhD, Great Basin Institute  
Craig Thompson, PhD, Pacific Southwest Research Station  
Jody Tucker, PhD, USDA Forest Service Region 5  
William Zielinski, PhD, Pacific Southwest Research Station

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# Metric Conversions

Unlike the Fisher Conservation Assessment document, this Strategy document presents most measurements in English rather than metric units, as they are more commonly used by the agencies expected to implement fisher conservation measures. Use this table to convert to metric equivalents.

English	Metric
1 acre	0.405 ha
1 ft	0.305 m
1 ft <sup>2</sup>	0.09 m <sup>2</sup>
1 mi	1.609 km
1 mi <sup>2</sup>	2.59 km <sup>2</sup>
1 in	2.54 cm
1 ft <sup>2</sup> /ac	0.229 m <sup>2</sup> /ha

# Abbreviations, Acronyms, and Definitions

Canopy closure	Proportion of the sky hemisphere obscured by vegetation when viewed from a single point on the ground
Canopy cover	Percentage of ground covered by a vertical projection of the tree canopy
CART	Classification and Regression Tree
CBI	Conservation Biology Institute
CDFW	California Department of Fish and Wildlife
CEQA	California Environmental Quality Act
Conservation targets	Numerical objectives concerning the amount, quality, resiliency, and occupancy of fisher habitat to be monitored to measure progress toward conservation goals
Core (fisher core)	Large (>15 mi <sup>2</sup> , 40 km <sup>2</sup> ) contiguous areas of fisher habitat within which fishers can establish home ranges and coningle as a population, generally separated by unsuitable habitat areas.
CSE	Common Stand Exam
CWHR	California Wildlife Habitat Relationships system
dbh	Diameter at breast height
EVEG	Existing Vegetation, the USFS GIS vegetation database
FIALT	Fisher Interagency Leadership Team
Fire severity	Measure of the amount of tree mortality resulting from a fire, expressed as amount of affected tree biomass or basal area
FRID	Fire Return Interval Departure
FVS	Forest Vegetation Simulator
FTT	Fisher Technical Team
GNN	Gradient Nearest Neighbor, a GIS vegetation database
KRFP	Kings River Fisher Project
Linkage area	A delineated polygon of habitats considered likely to facilitate dispersal between fisher core areas, based on least-cost corridor models
LOP	Limited Operating Period
Maxent	A maximum-entropy algorithm used for species distribution modeling
MOU/MOA	Memorandum of Understanding/Memorandum of Agreement
NEPA	National Environmental Policy Act
NPS	National Park Service
NRV	Natural range of variation
PCA	Principal Component Analysis
PSW	Pacific Southwest Research Station of the US Forest Service
SNAMP	Sierra Nevada Adaptive Management Project
SNC	Sierra Nevada Conservancy
SSN	Southern Sierra Nevada
Target habitat (cells)	Specific landscape units (10-km <sup>2</sup> hexagonal cells) identified as high priorities to remain suitable or become suitable to support breeding fishers
USFS	USDA Forest Service
USFWS	US Fish and Wildlife Service
WFDSS	Wildland Fire Decision Support System

# 1 Introduction

The Southern Sierra Nevada Fisher Conservation Strategy provides science-based guidance for conserving and recovering an isolated population of Pacific fisher (*Pekania pennanti*) in the southern Sierra Nevada (Figure 1) by reducing threats and increasing the quality and resiliency of fisher habitat. The strategy is based on the best available scientific information on fishers and their habitats in the area, as summarized in the Southern Sierra Nevada Fisher Conservation Assessment (Spencer et al. 2015; hereafter, Conservation Assessment). Nevertheless, uncertainties remain concerning the potential effects of fires, climate change, management actions, and other factors on fishers and their habitat. The Strategy must therefore be implemented within an adaptive management framework to allow adjustments as new information accrues from monitoring and other sources. The Strategy should therefore be considered a “living document” that is regularly updated with new information. See Sections 9 and 10 for research and analytical tasks to be implemented in the near future, and the results used to update this Version 1.0 Strategy document and associated data sets and decision-support tools.

The Strategy is intended to meet the needs of multiple agencies with an interest in fisher conservation and land management in the Sierra Nevada, including the USDA Forest Service (USFS), National Park Service (NPS), US Fish and Wildlife Service (USFWS), California Department of Fish and Wildlife (CDFW), Sierra Nevada Conservancy (SNC), and other local, state, federal, tribal, and private entities whose actions may affect fishers or their habitat<sup>1</sup>. As such, the Strategy is intended to be compatible with diverse agency missions, objectives, and legal requirements.

The Strategy was developed to be implemented over about 30 years, after which it should be comprehensively re-evaluated to ensure that the conservation measures remain relevant and effective. Some aspects should be reviewed and updated within the first 2-3 years of implementation to refine methods, guidelines, maps, or other aspects as needed. Thereafter, the Strategy should be updated every 4-6 years to support important agency processes, such as land management plan revisions. Essential datasets (e.g., vegetation, fire, and management data) should be updated regularly as part of the adaptive management process—ideally annually or at least every 5 years.

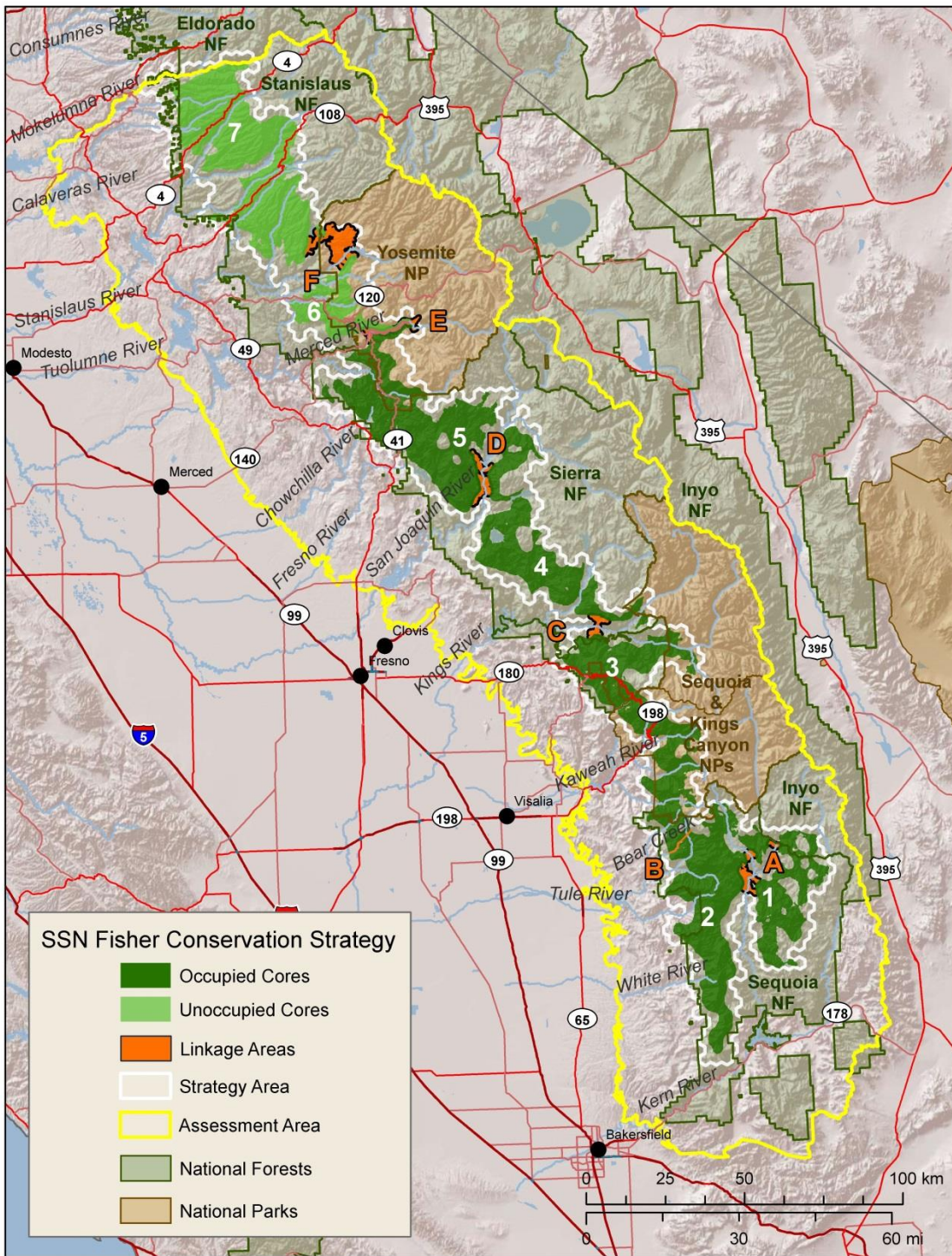
## 1.1 Document Organization

This introductory section summarizes the general approach, guiding principles, and goals and objectives of the Strategy. It establishes the context and rationale for the recommendations that follow without repeating the more detailed scientific review provided in the Conservation Assessment.

Section 2 describes the geography of the fisher population and its habitat as a foundation for conservation planning. Fisher habitat in the southern Sierra Nevada is segmented by major river canyons into a series of seven fisher core areas, five of which are occupied by fishers and two are not (Figure 1). Within core areas, fishers need foraging, resting, and denning habitats, of which denning habitat is most limited. Dispersal habitat in linkage areas facilitates inter-core movements.

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<sup>1</sup>The USFS manages 77.5% of the land in the Conservation Strategy Area (7,823 km<sup>2</sup>, 3,021 mi<sup>2</sup>); the NPS manages 17.2% (1,736 km<sup>2</sup>, 670 mi<sup>2</sup>); and other public, private and tribal entities manage 5.3% (531 km<sup>2</sup>, 205 mi<sup>2</sup>).



**Figure 1—Southern Sierra Nevada Fisher Conservation Assessment and Strategy areas.** The Conservation Strategy Area (white boundary) encompasses modeled fisher core and linkage areas based on a grid of female breeding territory-sized (10-km<sup>2</sup>, 4-mi<sup>2</sup>) hexagon cells. It represents the area where fisher conservation measures apply. Individual cores are numbered, and linkage areas are lettered.

Section 3 introduces a spatial grid system developed to help guide the dispersion and phasing of management actions and to track the capacity of each core area to support fishers over time. The system uses a grid of hexagonal cells about the size of female breeding territories and a habitat suitability metric that scores the suitability of each cell to support a breeding female. This multivariate metric can be used to evaluate the individual and cumulative effects of fires, management actions, or other disturbance and succession<sup>2</sup> processes on fisher carrying capacity, and to track these changes over time. The system is designed to adapt management actions to changing conditions in pursuit of fisher habitat quality and resiliency<sup>3</sup> goals.

Section 4 describes fisher habitat conservation and enhancement measures. It briefly reviews current and desired habitat conditions and describes a process for assessing management priorities and planning habitat improvements at multiple scales. Home range-scale to landscape-scale guidance is provided by the management grid system introduced in Section 3, with a focus on maintaining a targeted amount and distribution of well-connected female habitat areas. Finer-scale guidance is provided for vegetation management projects to improve fisher habitat quality and resiliency, restore fire as a natural disturbance process, promote fisher habitat elements and heterogeneity, and limit disturbance to mothers and kits during the denning season.

Section 5 presents recommendations for reducing specific human-influenced stressors and mortality factors, including vehicle strikes, pesticide exposure, and predation, which may be unnaturally high due to human changes to habitats. Section 5 also addresses how to minimize potential effects of human infrastructure on fishers and fisher habitat.

Section 6 discusses potential direct fisher population interventions, such as assisted migration and captive rearing. It endorses development of a well-designed translocation plan to facilitate northward population expansion that considers demographic and genetic effects on the existing and translocated populations. In the meantime, it also endorses proposals to rear orphaned fisher kits, release them north of the Merced River, and monitor them with telemetry.

Section 7 discusses potential management actions to increase fisher prey populations, especially for larger prey species such as squirrels and porcupines. Porcupines, which are a major fisher prey species in other regions, appear to be nearly extirpated from the Strategy Area. Population intervention for porcupines (e.g., translocation) is discussed as a possible contingency action if warranted based on additional research and analysis.

Section 8 provides a framework and recommendations for developing a detailed monitoring program to track the fisher population, habitat values, and management actions, and to evaluate effects and

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<sup>2</sup> Succession is the more or less predictable process of change in community composition and structure following disturbance via regeneration, growth, competition, and other interactions. Due to stochasticity, succession should not be viewed as a highly predictable, deterministic process leading to a “climax condition” as once theorized by some ecologists (e.g., Clements 1916, Gleason 1926).

<sup>3</sup> Resilience is the capacity of an ecosystem (or vegetation community) to resist and/or recover from a disturbance (e.g., fire or drought) and to retain or return to essentially the same function, structure, identity, and feedback processes as before the disturbance (Walker et al. 2004).



effectiveness of the various recommended conservation measures. Monitoring and adaptive management are essential to tracking performance and improving conservation measures over time.

Section 9 describes research needs to fill information gaps about fisher biology, effects and effectiveness of conservation measures, and other topics important to fisher conservation in the Strategy Area.

Section 10 summarizes roles and responsibilities of various agencies in implementing the fisher Conservation Strategy, and outlines a potential role for the Southern Sierra Nevada Working Group (SSNFWG) as a coordinating and deliberative body to help guide implementation and refinement of the Strategy as part of the adaptive management process.

Appendix A describes data and methods used for new analyses and maps produced for this Strategy, which are more briefly summarized in the main text; Appendix B is the charter of the Southern Sierra Nevada Fisher Working Group (SSNFWG); and Appendix C is a list of priority fisher research topics developed by the SSNFWG.

## 1.2 Strategic Approach

The Strategy recommends actions to ameliorate specific fisher mortality factors identified in the Conservation Assessment—such as vehicle strikes and rodenticide poisoning—as well as management actions to restore and sustain fisher habitat value and resilience across multiple spatial and temporal scales. The approach to habitat management recognizes that the fisher’s mid-elevation, mixed-conifer<sup>4</sup> forest habitat is at high risk of stand-replacing wildfires and other large disturbance events due to land management actions and climate change, which have shifted forest conditions and ecological processes outside their natural range of variation (Safford et al. 2012, Mallek et al. 2013, Safford 2013, Safford and van de Water 2013). These shifts have included a major departure from historically shorter fire return intervals, overall increases in forest density and homogeneity, decreases in the abundance of large trees and shade-intolerant pines, and increases in small trees and shade-tolerant firs and cedars. Current vegetation conditions selected by fishers—including dense, multi-storied tree canopies and abundant dead-wood structures—are often targeted for alteration through vegetation treatments (e.g., mechanical thinning, prescribed fire) to increase forest resilience and reduce wildfire risks to human communities, wildlife habitat, and other valued resources. Recognizing that vegetation treatments intended to reduce these risks may adversely affect fishers or fisher habitat, at least locally and temporarily, they should be designed to minimize and mitigate such potential effects while reducing the risks of large, severe disturbance events—which can decrease fisher habitat value over larger areas and longer time periods. For habitat-altering management actions not designed to improve fisher habitat quality and resiliency, conservation measures presented in the Strategy could be applied as mitigation measures within the project area or other locations in the Strategy Area to help achieve fisher conservation objectives.

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<sup>4</sup> This document uses the term *mixed-conifer forest* in a general sense to encompass all forest types generally considered part of the west slope, Sierra Nevada mixed-conifer and yellow pine ecosystem, including various mixtures of ponderosa pine, sugar pine, white fir, red fir, Douglas fir, incense cedar, giant sequoia, and black oak, but excluding higher-elevation stands dominated by, for example, red fir or lodgepole pine. *Mesic mixed conifer* includes species mixes (e.g., fir-pine) on more mesic sites that are favorable to white fir and sugar pine; *xeric mixed conifer* includes more yellow pine-dominated stands (ponderosa or Jeffrey pine) on drier sites. Fishers are primarily associated with mesic mixed conifer forests, often with inclusions of more xeric, pine-dominated habitats or other vegetation types within their home ranges.



In addition to specific guidance for individual vegetation treatments, the Strategy provides landscape-scale guidance for dispersing and phasing treatments over time, with a goal of increasing the capacity of the landscape to support a breeding fisher population. The approach uses a spatial grid system and guidelines to minimize the individual and cumulative effects of management actions on the fisher population, while maximizing their effectiveness at restoring and sustaining resilient habitat conditions. The spatial grid system, coupled with a habitat quality metric that uses readily available spatial data, also provides a means of tracking changes in fisher habitat value and distribution at the fisher home range (>2,500 ac) to landscape scale (>10,000 ac). The focus of this approach is on sustaining and increasing the capacity of the landscape to support reproductive female fishers and to facilitate fisher dispersal between suitable habitat areas while also increasing habitat resiliency. As a decision-support tool, the management grid system allows some discretion in prioritizing where and when conservation measures are most needed to achieve habitat resiliency and fisher conservation goals in response to changing conditions.

### 1.3 Guiding Principles

The goals, objectives, and specific conservation measures described in this Conservation Strategy are based on the following foundational principles about fishers, their habitat, and forest ecology in the Strategy Area. See the Conservation Assessment (Spencer et al. 2015) for detailed scientific information supporting these principles.

- 1. Increasing population size and connectivity are essential to sustaining and recovering the fisher population.** Small populations are inherently at risk of extirpation, and population subdivision can increase this risk. The Sierra Nevada fisher population is small (<500 animals), reduced in distribution from historical times, and isolated with low genetic diversity and limited gene flow between subpopulations (core areas) separated by major river canyons (Spencer et al. 2011, 2015; Tucker et al. 2014).
- 2. Reducing mortality factors may help expand the fisher population.** The southern Sierra Nevada fisher population may be experiencing unnaturally high mortality rates due to a variety of human-influenced factors, including vehicle strikes, rodenticide poisoning, and elevated predation rates due to habitat alteration. Mitigating these effects may increase population growth rates and resiliency to help expand and recover the population (Spencer et al. 2011, 2015, Sweitzer et al. 2015).
- 3. Current habitat conditions selected by fishers may not reflect historical or desired conditions.** Due to extensive changes in the composition and structure of Sierra Nevada forests caused by previous land uses and management actions (e.g., logging, grazing, tree planting, fire suppression), we do not know if conditions currently selected by fishers reflect optimal conditions or those they would have selected prior to these changes. Current patterns of fisher habitat use should not be assumed to represent the ideal condition, but can be used to inform future desired conditions and management decisions. Uncertainties about ideal fisher habitat conditions and effects of management dictate that changes in habitat and fisher occupancy patterns be monitored and used to refine management actions as we learn more, in a formal adaptive management process.
- 4. Current habitat conditions are not resilient.** The changes in forest structure and composition due to past management actions and climate change have increased the risks that large disturbances, such as extended droughts and increased fire size and severity, could reduce fisher habitat value over large

areas for many decades (Miller et al. 2009, Churchill et al. 2013). Management to restore more natural disturbance regimes, forest heterogeneity, and resiliency is needed to sustain fisher habitat.

- 5. Adult female fishers are the most important demographic class for population viability, and females have more stringent habitat requirements than males.** Because only females can produce and raise kits, adult females are the most important demographic class for sustaining and increasing the population (Spencer et al. 2011). Compared with males, female fishers have smaller home ranges, use a narrower range of elevations and habitat conditions, have more limited dispersal abilities, and are constrained by the need to raise kits (Spencer et al. 2015). Consequently, management should focus on meeting the specific needs of females to improve population resilience and expansion.
- 6. The quality and location of fisher habitat areas will change over time.** Sierra Nevada forests are naturally dynamic, human actions alter these dynamics, and fisher habitat conditions will continue to change with or without human intervention (Beaty and Taylor 2007, Millar et al. 2007). Historically, natural disturbance regimes and ecological processes—including fires of varying size and severity, droughts, insect and disease outbreaks, and vegetation succession—led to patchy forest dynamics and heterogeneous habitat conditions (van Wagtenonk and Fites-Kaufman 2006, Beaty and Taylor 2007). The combination of human-caused and natural disturbances, along with forest succession, will continue to alter fisher habitat conditions indefinitely. Consequently, some places suitable for fishers now may not be in the future, and some currently unsuitable areas may become suitable in the future, depending on site productivity (e.g., soil conditions), management actions, climate change, and other factors.
- 7. Management should enhance fisher habitat conditions and resiliency even in some places fishers don't currently occur.** Due to historic extirpation, not all potential fisher habitat in the Strategy Area is occupied by breeding fishers (Spencer et al. 2011, 2015). Expanding the population northward into unoccupied habitat areas to increase population size and resilience necessitates managing some currently unoccupied areas (e.g., on Stanislaus National Forest) to maintain or enhance their future potential to support fishers. Unoccupied areas, whether currently suitable as fisher habitat or not, may represent opportunities for more extensive, intensive, or experimental management actions than would be recommended in fisher-occupied areas, because they could adversely affect fishers or habitat value in the near term. However, this potential opportunity for more aggressive or innovative management actions in unoccupied areas must be balanced against the goal of expanding the population into unoccupied areas as soon as possible.
- 8. A robust monitoring program is needed to assess effects and effectiveness of fisher conservation measures.** The Conservation Strategy must be implemented within a formal adaptive management framework with a robust monitoring program to assess the efficacy of conservation measures and progress toward conservation goals and objectives. Conservation recommendations are necessarily based on current understanding of fisher habitat requirements and population processes, but gaps in our understanding, and uncertainties about desired conditions and how best to establish them, require additional research and systematic monitoring of both fishers and fisher habitat. Regional monitoring of population occupancy patterns and trends (e.g., Zielinski et al. 2012) should continue in concert with monitoring of habitat status and trends. This monitoring program is essential to evaluate the effectiveness of the conservation measures and to determine if changes to the measures are needed.

- 9. Resource managers face numerous constraints and must meet multiple mandates and resource objectives in addition to fisher conservation objectives.** Agencies are more likely to successfully implement a species conservation strategy that acknowledges and reconciles, to the extent possible, other resource management objectives and policy constraints. Although this fisher conservation strategy focuses specifically on how to conserve and recover the southern Sierra Nevada fisher population, it recognizes that achieving fisher conservation goals requires tackling diverse ecological and practical realities bearing on its implementation.

## 1.4 Goals and Objectives

Considering the Guiding Principles described above, the desired future condition for fishers in the Strategy Area is:

*a thriving (healthy, resilient, and expanding) population of fishers, well distributed throughout available habitat and interbreeding among subpopulations, whose forest habitat is heterogeneous and resilient to disturbances at the landscape scale and over the long term (decades to centuries).*

Given that habitat conditions are dynamic—with fires, management actions, ecological succession, climate change, and other processes constantly rearranging landscape conditions over different spatial and temporal scales—the goal is not to maximize fisher habitat value simultaneously everywhere, but to promote a resilient and dynamic mosaic of vegetation that can support fishers through time while minimizing the risk that large and severe disturbances increase the population’s extinction risk. A thriving fisher population also requires minimizing potential adverse effects of management actions on fishers and their habitat and reducing human-influenced mortality factors that may be limiting population size and resiliency.

More specifically, the Conservation Strategy has the following biological goals and objectives. The objectives were designed to advance the goals in measurable ways. Each objective is followed by examples of relevant conservation measures and monitoring metrics, which are described and expanded on in subsequent sections. Some conservation measures will help achieve multiple objectives, and all objectives require multiple conservation measures.

**Goal 1.** Sustain and increase the size and distribution of the fisher population.

**Objective 1.1.** Increase the geographic extent of occupied fisher habitat, especially via northward expansion into currently unoccupied habitat cores (see Section 2).

**Conservation measures.** Manage for increased quality and quantity of fisher habitat, and mitigate dispersal impediments (Section 4.5). Reduce mortality risks by, for example, installing road-crossing structures, removing pesticides, and managing vegetation to reduce predation risk (Section 5.3).

**Monitoring metrics.** Occupancy patterns from the regional fisher monitoring program.

**Objective 1.2.** Maintain or increase fisher carrying capacity within each core area.

**Conservation measures.** Manage vegetation to restore fine-scale habitat heterogeneity, promote denning habitat quality and extent, retain and recruit essential fisher habitat elements, increase

and diversify the fisher prey base, promote growth and recruitment of black oaks, and increase forest resilience to climate change and disturbance events (Sections 4.5.2. and 4.5.3).

**Monitoring metrics.** Number of suitable female home range units within each core area using the female home range template accounting system (Section 3.1); occupancy patterns from regional monitoring program coupled with home range template results.

**Goal 2.** Maintain the genetic diversity of the fisher population.

**Objective 2.1.** Increase dispersal potential within and between core habitat areas.

**Conservation measures.** Where site conditions permit in delineated linkage areas (Section 2.2), maintain or increase tree canopy cover and retain and promote recruitment of downed logs, standing trees, and shrub patches to provide hiding and escape cover in non-forested portions; prevent new impediments to movement (e.g., wide openings, reservoirs; Section 4.5.1); protect linkage areas from stand-replacing fire (Section 4.5.2). In both core and linkage areas, provide or improve road-crossing structures for fishers and other wildlife (Section 5.3.4).

**Monitoring metrics.** Genetic diversity, population segmentation, and evidence of inter-core dispersal through periodic genetic analyses, using hair samples collected by the regional monitoring program.

**Goal 3.** Restore and maintain high quality and resilient fisher habitat conditions.

**Objective 3.1.** Improve fisher habitat resiliency and restore fire as a key ecological process.

**Conservation measures.** Reduce hazardous fuel conditions and increase habitat heterogeneity patterns that reflect how topography, soil, and other factors affect vegetation characteristics and fire behavior; implement ecological restoration concepts described in GTR 220/237<sup>5</sup> to promote conditions that allow fire to serve its natural ecological role in maintaining resilient and heterogeneous forest conditions; maximize use of prescribed fire or wildfire managed for resource benefits at large scales and under conditions that promote resiliency and fisher habitat values (Section 4.5.2).

**Monitoring metrics:** Number of suitable female home range units within each core area using the female home range template accounting system (Section 3.1); forest composition and structure metrics to compare with historical and desired conditions using FIA data, other pre- and post-treatment plot data, or remote sensing (e.g., LiDAR) data; trends in forest acres burned at different severity levels over time.

**Objective 3.2.** Maintain or increase important fisher habitat elements.

**Conservation measures.** Retain and promote recruitment of large trees, coarse woody debris (large snags and logs), trees with cavities and other defects, large black oaks, dense tree clusters and gaps at fine (<0.5 ac) resolution, and clumps of multi-storied tree canopies (Section 4.5.3).

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<sup>5</sup> Together, USFS General Technical Reports (GTR) 220 (North et al. 2009) and 237 (North et al. 2012) describe approaches for restoring more naturally heterogeneous and resilient conditions in Sierra Nevada mixed-conifer forests. The USFS, in collaboration with scientists and stakeholders, is attempting to implement these recommendations while learning about their effects on wildlife habitat.

**Monitoring metrics.** Predicted resting habitat suitability using the FIA-based model developed by Zielinski et al. (2010); distribution and abundance of important fisher habitat elements (e.g., canopy cover and heterogeneity, tree size diversity, large snags, black oaks) obtained from FIA plot data, other plot data, or remote sensing (e.g., LiDAR) data.

**Goal 4.** Reduce human-influenced mortality and disturbance factors to increase fisher survival and reproduction.

**Objective 4.1.** Minimize human-caused disturbances in denning habitat and season to increase fisher reproduction and kit survival.

**Conservation measures.** Implement best management practices and strategic Limited Operating Periods (LOPs) for management actions that may harm or disturb mothers or kits during the denning season, such as performing prescribed fires when wind conditions will minimize smoke and avoiding sustained noisy actions (e.g., mastication) in denning habitat during denning season (Section 4.5.4).

**Monitoring metrics.** Wind conditions during prescribed burns; compliance with guidelines and LOP in Section 4.5.4.

**Objective 4.2.** Reduce exposure of fishers to predators, especially in denning habitat.

**Conservation measures.** Maintain or increase understory heterogeneity to promote escape cover for fishers, such as by retaining and promoting shrub patches, coarse woody debris, and slash piles; minimize long, continuous stretches of “hard” (open/dense) habitat edges and permanent linear openings (roads, trails); remediate or mitigate linear openings by breaking their visual continuity with berms, large logs, or shrub patches (Section 5.3.2).

**Monitoring metrics.** Amount of shrub and other woody cover from vegetation plot data; miles of roads and trails remediated; miles of contiguous open/dense habitat edges in fisher denning habitat.

**Objective 4.3.** Reduce levels of pesticide poisoning.

**Conservation measures.** Increase law enforcement to reduce the number of trespass marijuana grow sites; interrupt grow operations as early in the season as possible to minimize pesticide exposure; clean up all trash and contaminants at grow sites (Section 5.3.1).

**Monitoring metrics.** Pesticide exposure rates in necropsied fishers or other opportunistically collected wildlife that serve as surrogates for fisher exposure rates; number and area of trespass marijuana grow sites discovered and cleaned up annually; pesticide levels measured in soil and water.

**Objective 4.4.** Reduce the number of fishers killed by vehicles.

**Conservation measures.** Install road-crossing structures or improve efficacy of existing road-crossing structures (e.g., culverts); manage vegetation along roads and research other measures to discourage above-ground crossings and funnel fishers to crossing structures (Section 5.3.4).

**Monitoring metrics.** Number of dead fishers detected annually along key stretches of road in fisher habitat (e.g., Highway 41/Wawona Road, Highway 198/General’s Highway); frequency of fisher detections using unbaited camera traps at crossing structures.

## 2 Fisher Core and Linkage Areas<sup>6</sup>

Fisher habitat in the southern Sierra Nevada is segmented into a series of core habitat areas separated primarily by major river canyons, across which fishers may occasionally disperse via linkage areas (Figure 1). The cores were delineated using a landscape-level habitat model to reflect current fisher occupancy patterns, genetic subdivisions in the population (Tucker et al. 2014), and significant breaks in fisher habitat. They exclude small, isolated patches of habitat that are unlikely to support more than a few individual fishers. Linkage areas were delineated using models that represent the least costly or risky potential dispersal areas between cores, based on mapped habitat features. Modeled least-cost corridors produced for the Conservation Assessment are generalized for management purposes in Figure 1 as more easily interpretable linkage polygons (e.g., by removing small “donut holes” in the model outputs).

Cores comprise “live-in” habitat, where fishers can establish home ranges and meet their various life requisites, including food, shelter, and mates. Within each occupied core, fishers are expected to comingle, interbreed, disperse, and establish home ranges relatively freely, but dispersal between cores appears to be rare, especially for females (Tucker 2013). Although fisher dispersal is not well studied in the field, evidence suggests that fishers will not move through large areas lacking overhead cover, and genetic analyses suggest that female fishers primarily disperse through dense forest stands with large trees (Tucker 2013). Fisher experts expect that shrubs (e.g., chaparral) may provide sufficient hiding and escape cover for dispersing fishers, especially males, in non-forested portions of linkage areas.

Data from fisher field studies in the region have also facilitated mapping of foraging, resting, and denning habitats (Spencer et al. 2015), which together comprise fisher live-in habitat (Figure 2). Foraging habitat is the most widespread type, because nearly any vegetation community within the Strategy Area supports some fisher prey and may be exploited by foraging fishers—although fishers generally avoid entering or crossing large open areas<sup>7</sup>. Resting habitat is associated with forest stands having dense canopy cover (>60%), complex horizontal and vertical forest structure, and a diversity of tree sizes, including large trees. Resting typically occurs in the largest available live trees, snags, or logs that provide cavities, platforms, or other deformities used by resting fishers.

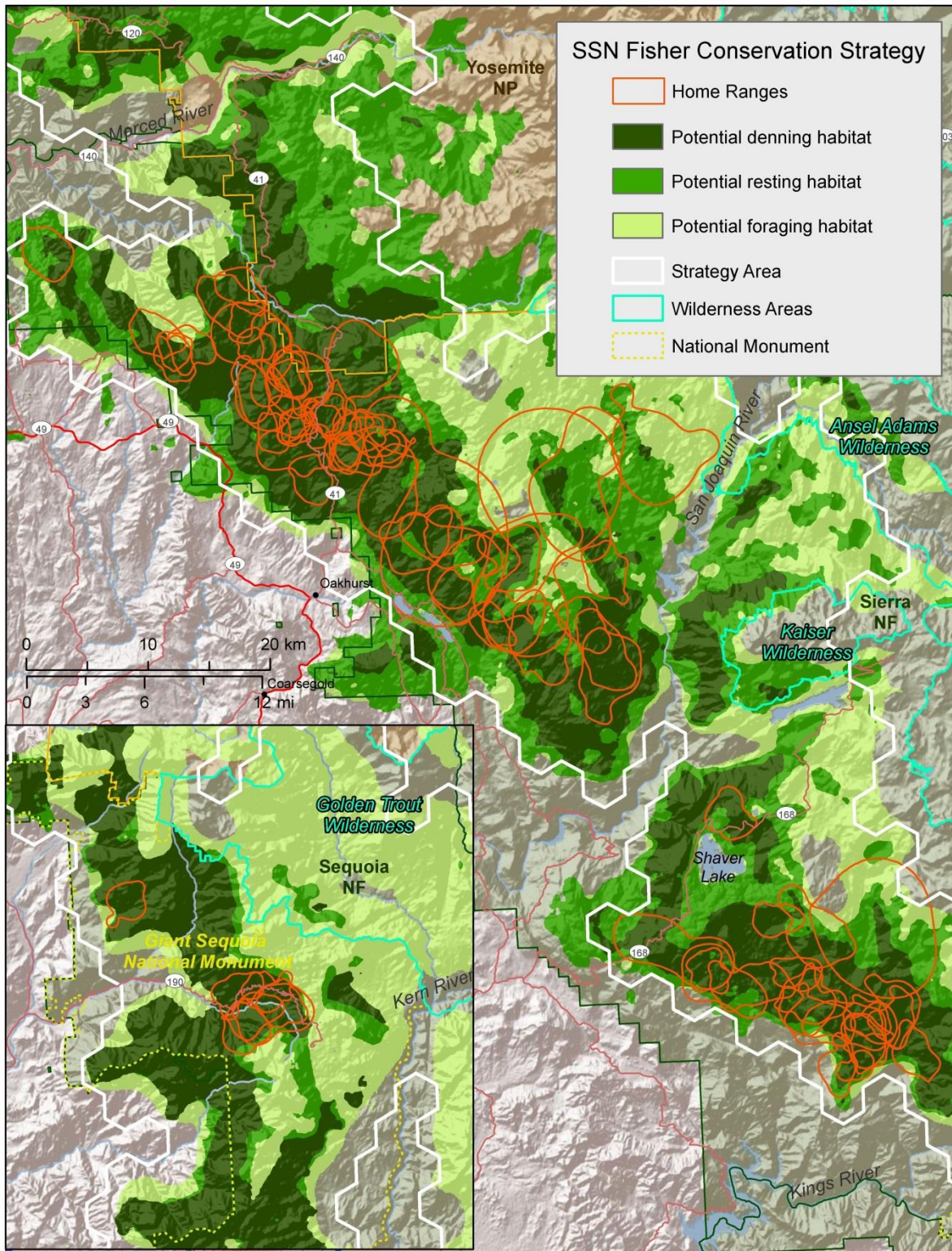
Denning habitat, used by females while raising young (mid-March to late June), is the most limiting habitat type. It appears to be a subset of resting habitat (which is used by both sexes, year-round), and is even more restricted to forest stands with dense canopy cover, structural diversity, and large trees, and perhaps with a bias toward a lower and narrower elevation range, especially where there is an intermix with black oaks. Dens are usually cavities in large, live or dead trees in stands with dense canopy cover (mean 72% at the 0.25-ac scale, Zhao et al. 2012). Results of telemetry studies demonstrate that female home ranges are clustered within modeled denning habitat (Figure 2), and denning habitat comprises the majority of acreage within female home ranges (mean 85% ± 22% SD, N = 83).

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<sup>6</sup> Methods for delineating fisher core and linkage areas and various functional habitat categories (foraging, resting, denning, and dispersal) are detailed in the Conservation Assessment (Spencer et al. 2015).

<sup>7</sup> Quantitative data on fisher use of open areas are lacking in the Strategy Area, but literature and expert opinion suggest that fishers avoid moving through areas with ≤30% canopy cover that are ≥500 ft wide or 2 ac in size (Freel 1991, Heinemeyer and Jones 1994).





**Figure 2—Fisher foraging, resting, and denning habitat illustrated in Cores 4 and 5 (large map) and Core 2 (inset). Female home ranges from three fisher telemetry studies covering multiple years are shown in orange to illustrate that they are strongly associated with denning habitat.**

## 2.1 Fisher Core Areas

Table 1 summarizes key characteristics of the seven fisher core areas, which are described in detail in the Conservation Assessment (Spencer et al. 2015). Cores 1-5 (4,198 km<sup>2</sup> [1,621 mi<sup>2</sup>] total area) are occupied currently by breeding fisher populations; Cores 6 and 7 (1,677 km<sup>2</sup> [647 mi<sup>2</sup>] total area) currently are not occupied by breeding fisher populations, although fishers are detected occasionally in Core 6.

**Table 1—Characteristics of delineated fisher core habitat areas.**

Core	Occupied	Area in km <sup>2</sup> (mi <sup>2</sup> )	Mean (SD) predicted habitat quality	Area of denning habitat in km <sup>2</sup> (mi <sup>2</sup> )	Primary (secondary) jurisdiction
1	yes	430 (166)	0.504 (0.072)	0 (0)	Sequoia NF (Inyo NF)
2	yes	936 (361)	0.622 (0.110)	466 (180)	Sequoia NF
3	yes	985 (380)	0.564 (0.937)	464 (179)	Sequoia NP (Sequoia NF)
4	yes	751 (290)	0.551 (0.090)	334 (129)	Sierra NF
5	yes	1,096 (423)	0.574 (0.097)	611 (236)	Sierra NF (Yosemite NP)
6	no	321 (124)	0.542 (0.103)	172 (66)	Yosemite NP (Stanislaus NF)
7	no	1,357 (524)	0.573 (0.094)	587 (226)	Stanislaus NF (Yosemite NP)

Sections below briefly summarize fisher habitat, population status, and management considerations in each core without repeating the details contained in the Assessment.

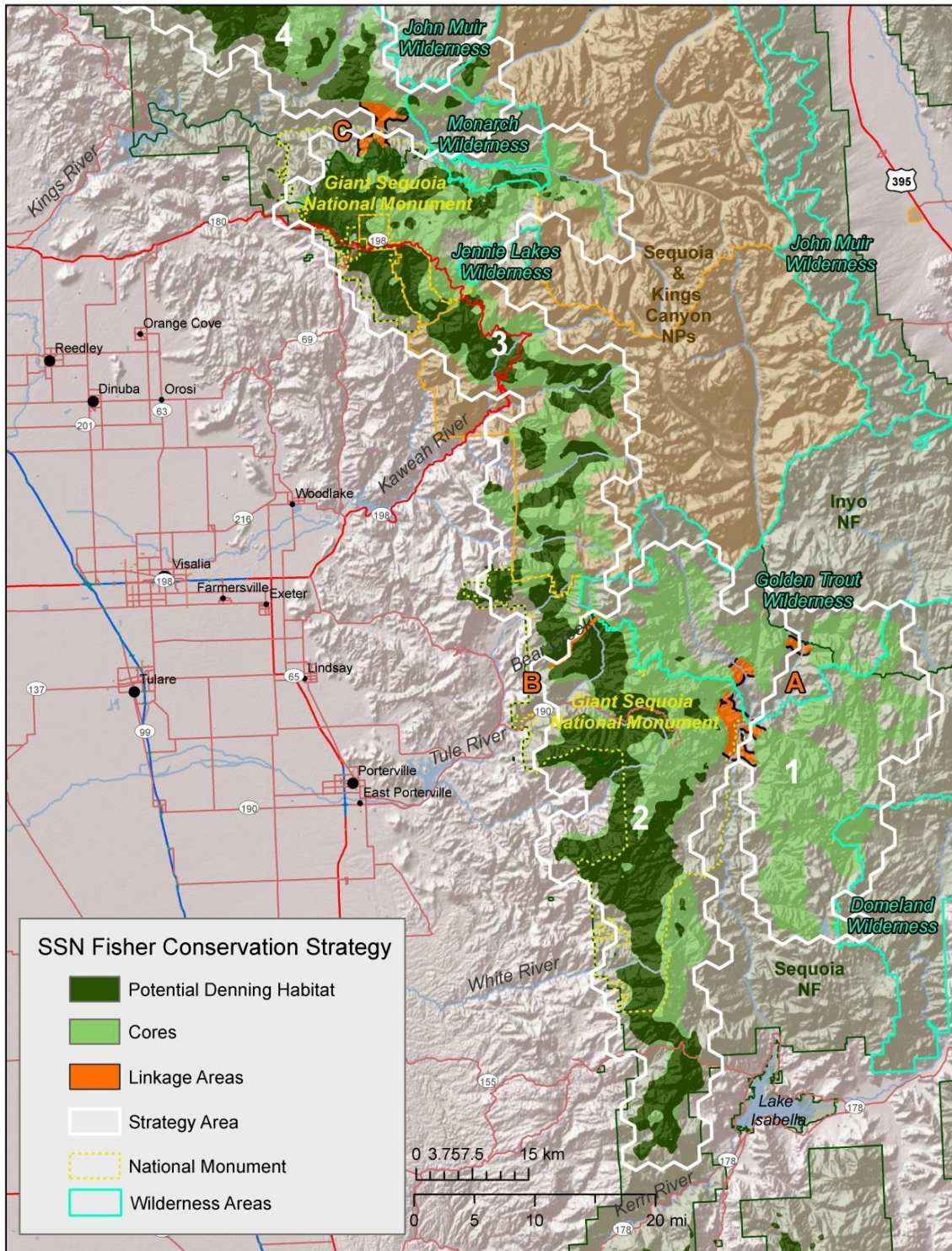
### 2.1.1 Core 1

Core 1 is on the Kern Plateau, primarily on the Sequoia National Forest but with a small portion on the Inyo National Forest (Figure 3). It is the only core not on the west slope of the Sierra Nevada, and its location on the Kern Plateau supports unique environmental conditions compared to the west-slope cores (Miles and Goudey 1998). Due to differences in climate, geology, and vegetation, and the paucity of fisher data from Core 1, habitat models developed using data in other cores may not accurately predict habitat value here. For example, the denning habitat model developed using den locality data from Cores 4 and 5 predicts no denning habitat in Core 1, despite that some reproduction must occur there.

Pinyon-juniper woodlands, canyon oak woodlands, and birch-leaf mountain mahogany are a greater component of the vegetation of the Kern Plateau than other portions of the Assessment Area, and California black oak, an important component of fisher habitat where it occurs, is rare or absent. Multiple fires, including the 61,000-hectare (ha) (150,700-acre [ac]) McNally Fire in 2002, and post-fire salvage and planting over a small fraction of the burned area, have contributed to a complex mosaic of mixed-age forest stands intermixed with open areas and shrublands. Hanson (2013, 2015) found evidence of fishers using habitats inside burn perimeters 10-15 years following fires in Core 1, but it is unclear to what degree fishers preferentially use recently burned areas—especially large, severely burned patches—and it is unlikely that fishers can establish home ranges and obtain all their life requisites (e.g., den sites) within severely burned areas due to diminished canopy cover.

Occupancy modeling shows this core to have the lowest occupancy rates in the region (Zielinski et al. 2013a), suggesting lower population densities here than elsewhere. This core also is the smallest occupied





**Figure 3—Fisher Cores 1, 2, and 3 showing modeled denning habitat and linkage areas between cores. Note the absence of modeled denning habitat in Core 1. See the Conservation Assessment for methods and details.**

core and has the lowest average predicted habitat value of any core (Table 1). Tucker et al. (2014) did not find evidence of population subdivision between Cores 1 and 2, despite the apparent break in habitat contiguity across the Kern River Valley.

Additional research and more intensive monitoring are warranted in Core 1 to better understand fisher habitat selection and population characteristics. The current deficiency of data in Core 1 makes management recommendations uncertain, but in general, management to favor tree growth, increased canopy cover, and recruitment of essential habitat elements is likely to benefit the population.

### 2.1.2 Core 2

Core 2 includes the southwestern tip of the Sierra Nevada and Greenhorn Mountains—between the Kern River and Bear Creek in the Tule River watershed—mostly on Sequoia National Forest and Giant Sequoia National Monument (Figure 3). It has the highest recorded fisher occupancy rates (Zielinski et al. 2013a), highest predicted average habitat quality (Table 1), and highest genetic diversity (Tucker et al. 2014) in the Assessment Area. Genetic patterns suggest this area may have served as a refuge for fishers following European settlement—perhaps due to steep terrain that limited human impacts compared to other areas (Beesley 1996)—and the population may have re-expanded northward from this area during the 20th century.

Zielinski et al. (2004a) found fishers to have smaller home ranges in Core 2 than in other regions, which they suggested may be due to high quality habitat (dense mixed-coniferous forests, large trees, and abundant black oak). Statistical analysis of female home range composition shows that home ranges in the high-quality habitat in the western portion of Core 2 have higher average tree basal area, greater black oak basal area, greater diversity of tree diameter classes, more dense (>70%) canopy cover, and a greater coverage of high-value fisher CWHR (California Wildlife Habitat Relationships) reproductive habitat than home ranges in Cores 4 and 5. These results probably reflect the greater availability of old-forest habitat conditions from which fishers can select home range areas, compared with other cores.

This core may be less in need of fisher habitat restoration than others, but management should help maintain habitat resiliency, ideally using fire as a natural process. Much of the core is within the Giant Sequoia National Monument and Golden Trout Wilderness, where current management calls for restoration of essential ecological processes and patterns that enhance forest ecosystem resilience to stressors (e.g., uncharacteristic wildfire, climate change) and protect or enhance high-value wildlife habitat. Management treatments include the use of prescribed fire, wildfire managed for resource objectives, or mechanical treatments to increase resiliency and help restore fire as an ecological process.

### 2.1.3 Core 3

Core 3 is separated from Core 2 by Bear Creek to reflect the genetic discontinuity identified by Tucker et al. (2014) at the latitude of the Mountain Home Demonstration State Forest (Figure 3). Otherwise, Cores 2 and 3 were modeled as one contiguous polygon of high-value fisher habitat on the steep west slope of the Sierra Nevada, south of the Kings River Canyon. It is possible that the genetic subdivision is an artifact of the history of population contraction-expansion across the region, rather than reflective of a current dispersal impediment (J. Tucker, personal communication). Core 3 is largely within Sequoia National Park and adjacent portions of Sequoia National Forest and Giant Sequoia National Monument.

Fishers have not been studied intensively in Core 3, but it probably has relatively high population densities due to high habitat value (Table 1). Compared to more northerly cores, Core 3 has more mature forest conditions, high average basal area, dense canopies, and abundant black oaks; however, the band of habitat is fairly narrow due to the steep elevation gradient.

Much of Core 3 is within Sequoia National Park and Sequoia National Monument, where current management calls for the restoration of essential ecological processes and patterns to enhance forest resilience and protect or enhance high-value wildlife habitat. Management treatments include prescribed fire, wildfire managed for resource objectives, and mechanical treatments where needed to increase habitat resiliency. Other areas on Sequoia National Forest should be managed to restore and maintain old forest conditions while enhancing resiliency to fires, climate change, and other disturbances.

#### 2.1.4 Core 4

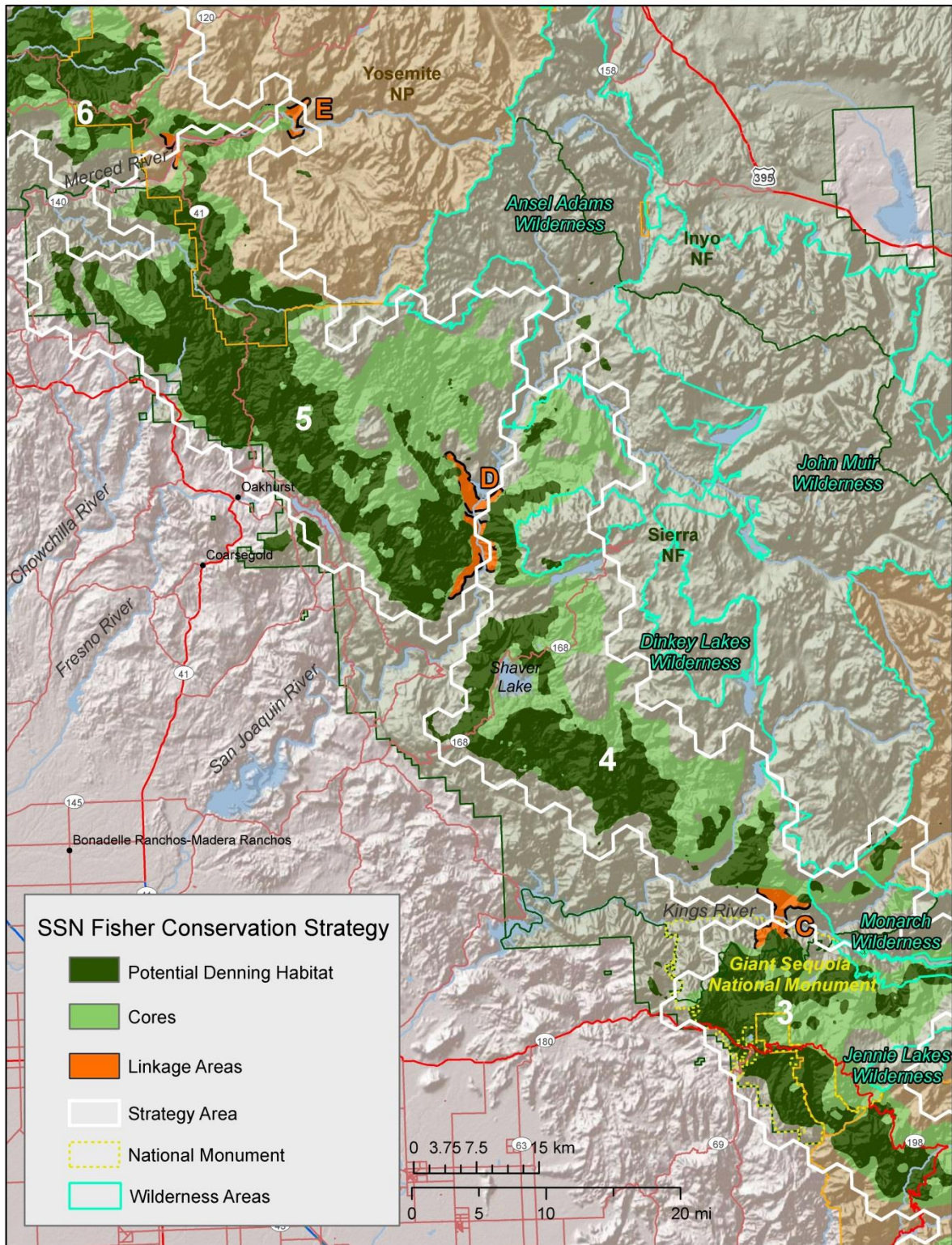
Core 4, between the Kings and San Joaquin river valleys on the Sierra National Forest (High Sierra Ranger District), has moderate fisher occupancy rates (Zielinski et al. 2013a), moderate predicted average fisher habitat value (Table 1), and moderate genetic diversity (Tucker et al. 2014). Denning habitat tends to be concentrated in lower elevation (western) portions of the core. Denning habitat is relatively contiguous and broadly distributed in the central portion of the core, but occurs in smaller and more fragmented patches in the northern and southern “tails” of the core near the San Joaquin River (vicinity of Shaver Lake, Huntington Lake, and Kaiser Wilderness Area) and near the Kings River (Figure 4).

Fisher ecology has been studied intensively in the central portion of this core since 1995 (Boroski et al. 2002, Mazzoni 2002, Zielinski et al. 2006, Jordan 2007), including the Kings River Fisher Project (KRFP) (Purcell et al. 2009, Thompson et al. 2010, 2012). Extrapolating the modal population density calculated for the KRFP study area (Thompson et al. 2012) provides an estimated total fisher population size of ~78 fishers in Core 4.

The northern portion of the core, in and around the Kaiser Wilderness, appears to be partially separated from the rest of the core near Big Creek/Huntington Lake. Genetic evidence suggests some slight genetic differentiation, but it is unclear if this differentiation is due to dispersal impediments or if it is an artifact of a founder effect from population expansion (Tucker et al. 2014). In 2013, the 9,300-ha (23,000-ac) Aspen Fire burned much of this northern sub-segment and potential dispersal habitats connecting Cores 4 and 5 in a mosaic of mostly low to moderate severity, with some high-severity patches. Monitoring fisher habitat use and movement in the aftermath of this fire could provide valuable information on effects of fires and post-fire management actions.

Vegetation in much of the central portion of this core has been or is being treated by a variety of mechanical and prescribed fire treatments, coupled with monitoring of fisher responses. Adaptive management is iteratively improving project siting and design. The rich data set and ongoing research associated with the Dinkey Collaborative Forest Landscape Restoration project and KRFP make this core especially suited for testing development of new tools and approaches to fisher conservation. Vegetation management near the two tails of the core, south of the North Fork of the Kings River and North of Shaver Lake, should maintain or improve dispersal potential between Core 4 and Core 3 to the south (across the Kings River Canyon, Linkage C), and Core 4 and Core 5 to the north (across the San Joaquin River, Linkage D).





**Figure 4—Fisher Cores 4 and 5 showing modeled denning habitat and linkage areas.** See Fisher Conservation Assessment for methods and details. Modeled habitat has not been updated following 2013-2014 fires.

### 2.1.5 Core 5

Core 5 lies between the San Joaquin and Merced rivers on the Sierra National Forest (Bass Lake Ranger District) and the southwestern portion of Yosemite National Park (Figure 4). It is the northernmost currently occupied habitat area and the largest and broadest of the occupied cores, with generally less steep terrain than others. It has relatively high predicted habitat quality (Table 1). Denning habitat is broader in the northern half of the core and narrower and slightly more fragmented in the southern half. Core 5 also has fairly extensive wildland-urban intermix (WUI) and numerous high-value resources at risk from wildfires, especially along the Highway 41 corridor, which runs north-south through the heart of the highest-value fisher denning habitat.

Survey results and genetic evidence suggest that fishers re-colonized this core area from the south during the 1990s (Tucker et al. 2014). However, the northward expansion appears to have stalled at the Merced River (Yosemite Valley) since then, possibly due to a combination of mortality factors, reducing the potential number of dispersers, as well as dispersal impediments associated with Yosemite Valley (e.g., steep slopes, sparse forest, heavily traveled roads, the Merced River).

The fisher population in this core has been intensively studied since 2007 as part of the Sierra Nevada Adaptive Management Project (SNAMP) and the Sugar Pine fisher study, which have provided a wealth of data on fishers and fisher habitat. R. Sweitzer (unpublished data) estimated the mean population size in Core 5 in recent years at ~87 (range 77-97) fishers. Recent and ongoing mechanical thinning and prescribed fire treatments have altered forest structure in significant portions of this core, coupled with SNAMP monitoring of fisher responses to habitat change.

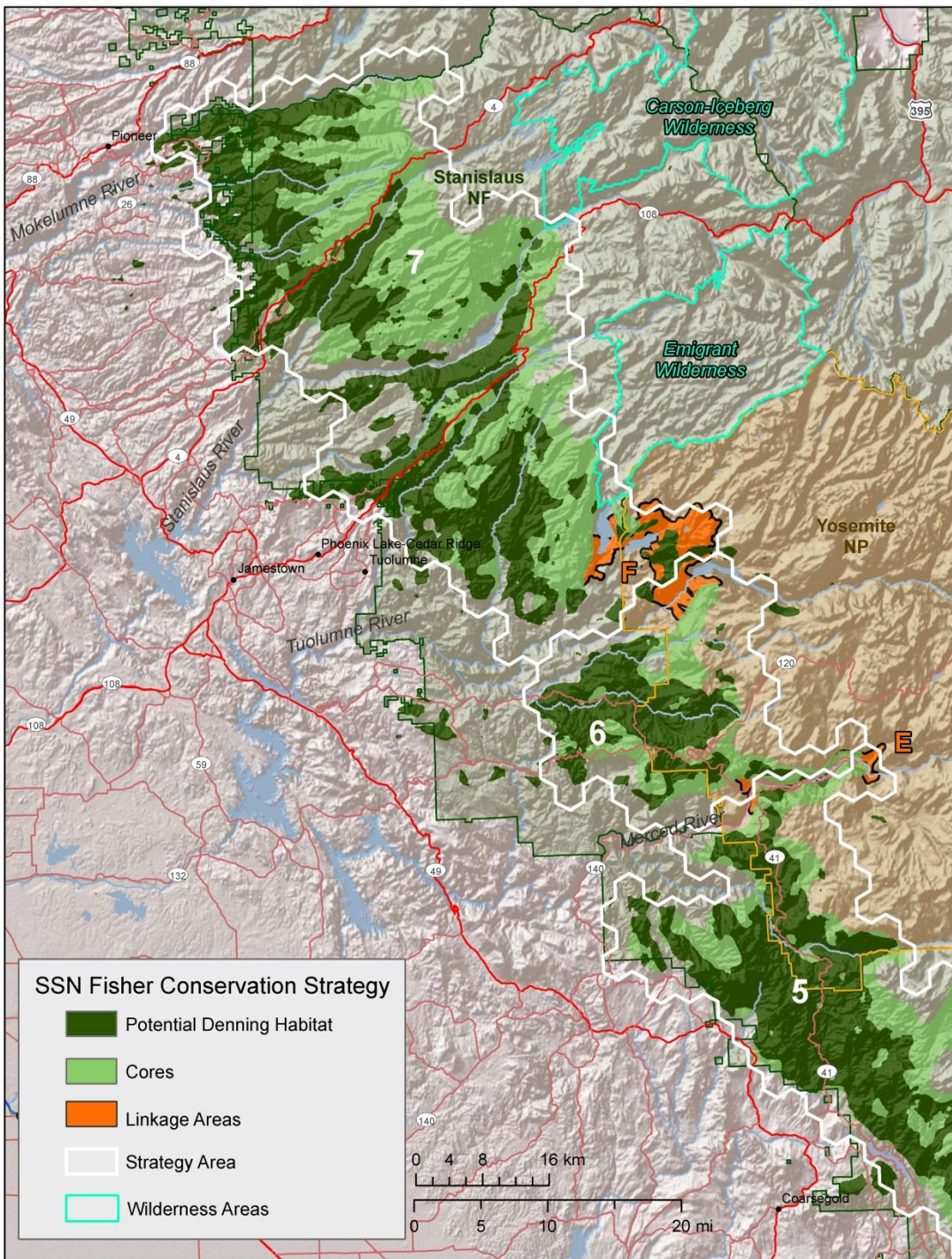
The easternmost portion of Core 5 and connecting habitats to Core 4 burned in the 2014 French Fire, directly across the San Joaquin River from the 2013 Aspen Fire. Effects of these fires on habitat value and inter-core dispersal potential are unknown and warrant study. Core 5 is also experiencing recent ponderosa and sugar pine mortality due to drought, disease, and insect attack, and oak mortality related to drought. This mortality is likely to continue and potentially increase under changing climate conditions.

Management in this core should reduce fisher mortality rates and maintain or improve potential for fishers to disperse north across Yosemite Valley to Core 6 and south across the San Joaquin River to Core 4. Improving habitat connectivity and reducing mortality factors (e.g., roadkill on Highway 41/Wawona Road, rodenticide poisoning) may facilitate northward population expansion. Vegetation management should minimize reduction or fragmentation of female home range potential (denning habitat) and restore more resilient forest conditions.

### 2.1.6 Core 6

Core 6, in western Yosemite National Park and the adjacent Stanislaus National Forest (Figure 5), is not currently occupied, although it was occupied historically (Grinnell et al. 1937, Chow 2009). Yosemite Valley separates it from occupied Core 5. Core 6 is the smallest of the identified cores and has moderate predicted habitat value (Table 1). Fishers are observed occasionally in this area (Chow 2009), but systematic monitoring studies have not detected fishers, and there is no evidence of an established, breeding population. Anecdotal observations of fishers in this core (Chow 2009) are likely males dispersing from Core 5 that fail to find mates in Core 6.





**Figure 5—Fisher Cores 6 and 7 showing modeled denning habitat and linkage areas.** Unlike Cores 1-5, Cores 6 and 7 are not currently occupied by breeding fisher populations. Linkage F was delineated based on modeled conditions after the 2013 Rim Fire, which burned much of the pre-fire linkage, but modeled denning habitat does not reflect 2013-2014 fires.

Although portions of this core support dense, mature forest stands, including scattered giant sequoia groves within the park, other portions are of low to moderate habitat quality, in part due to a complex disturbance and management history that has replaced significant areas of mature forest cover with early seral vegetation, shrublands, and plantations. The 105,200-ha (260,000-ac) Rim Fire burned the western and northern portions of this area in 2013, much of it in high-severity, stand-replacing fire.

Because this core currently does not support a breeding fisher population, there is an opportunity to use more intensive, extensive, or experimental management actions to restore more resilient and higher-value habitat conditions; however, this should be balanced against the goal of having fishers disperse into and establish a breeding population here within a few decades. Decreasing mortality factors in Core 5 and managing for habitat connectivity between Cores 5 and 6 (Linkage E) may facilitate the natural re-establishment of a breeding population in Core 6 via dispersal across Yosemite Valley. A robust monitoring program (Section 8) to detect fishers that disperse into Core 6 should inform when management should be adjusted to avoid adverse impacts, such as by imposing limited operating periods (LOP) in denning habitat (Section 4.5.4).

### 2.1.7 Core 7

Core 7 is a large, currently unoccupied area of potential habitat, mostly on the Stanislaus National Forest with a small portion in the northwest portion of Yosemite National Park (Figure 5). This core was almost certainly occupied by fishers during the early 20<sup>th</sup> century (Grinnell et al. 1937), and the FTT believes it could be occupied again in the future given appropriate management actions. In recent decades, this core has experienced large fires and intensive forest management in the form of harvest, post-fire salvage, and tree planting. The southern end of this core was burned by the 2013 Rim Fire, and a significant portion of the core was previously burned by stand-replacing fires in the large 1987 Stanislaus Complex, which converted many ponderosa pine forests to chaparral and patches of hardwoods and scattered pines.

Because Core 7 is not currently occupied by a breeding fisher population, and it likely will take several decades before natural re-establishment of a population, there is an opportunity for intensive management actions to restore more resilient and higher-value habitat conditions for fishers within a few decades, in anticipation of continued northward expansion of the population. A robust fisher monitoring program in Cores 6 and 7 should inform timing of management to avoid adverse impacts, such as imposing limited operating periods in denning habitat (Section 4.5.4).

## 2.2 Linkage Areas

The Assessment modeled fisher least-cost corridors (McRae and Kavanagh 2011) between fisher core areas (see Spencer et al. 2015 for methods). Least-cost corridors are intended to represent the least risky areas for fishers to disperse between core habitat areas, based on expert assumptions about fisher dispersal relative to vegetation, terrain, and other factors. This Conservation Strategy simplifies the modeled least-cost corridor outputs into more easily interpretable linkage polygons for planning and management purposes (Table 2, Figures 6-10)<sup>8</sup>. These linkage areas should be considered during project planning and

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<sup>8</sup> Linkage areas were delineated by buffering and smoothing modeled 25-km normalized least-cost corridors (see Spencer et al. 2015 for details) by 90 m, removing small “donut holes” in the model outputs, and eliminating any modeled dispersal habitat not directly connecting neighboring core areas.

analysis and imported into spatial decision-support systems, such as the Wildland Fire Decision Support System (WFDSS) used in managing wildland fire incidents. As with many aspects of this Strategy, linkages should be examined in the field and updated and refined as new or better information becomes available and as conditions change on the ground.

**Table 2—Key characteristics of fisher linkage areas.**

Linkage	Area in km <sup>2</sup> (mi <sup>2</sup> )	Min. distance in km <sup>2</sup> (mi <sup>2</sup> )	Vegetation classes <sup>a</sup> (% of linkage area)			
			Closed tree canopy	Sparse-open tree canopy	Shrubland	Other/open
A	32.2 (12.4)	3.9 (2.4)	13	55	27	5
B <sup>b</sup>	NA	NA	80	9	6	6
C	16.0 (6.2)	6.5 (4.0)	66	11	21	2
D	29.6 (11.4)	4.7 (2.9)	64	25	9	2
E	20.3 (7.8)	0.4 (0.2)	55	28	2	16
F	85.7 (33.1)	17.5 (10.9)	40	50	3	7

<sup>a</sup>Vegetation classes defined using EVEG physiognomic classes (as mapped in ~2001-2008 depending on location): Closed Tree Canopy includes forests with overlapping tree crowns (generally  $\geq 60\%$  tree canopy cover); Sparse-Open Tree Canopy includes forests and woodlands with  $< 60\%$  canopy cover; Shrubland includes shrubs generally  $> 0.5$  m tall and  $> 25\%$  cover, and trees generally  $< 25\%$  canopy cover; and Other/Open includes herbaceous, grassland, unvegetated, and other types with  $< 25\%$  tree and shrub cover.

<sup>b</sup>Linkage B is a split in otherwise contiguous core habitat to recognize the genetic subdivision at Mountain Home Demonstration State Forest (Tucker et al. 2014). Consequently, there is no linkage area polygon or distance across the linkage; vegetation classes there were calculated using a 1-km-wide buffer along the split.

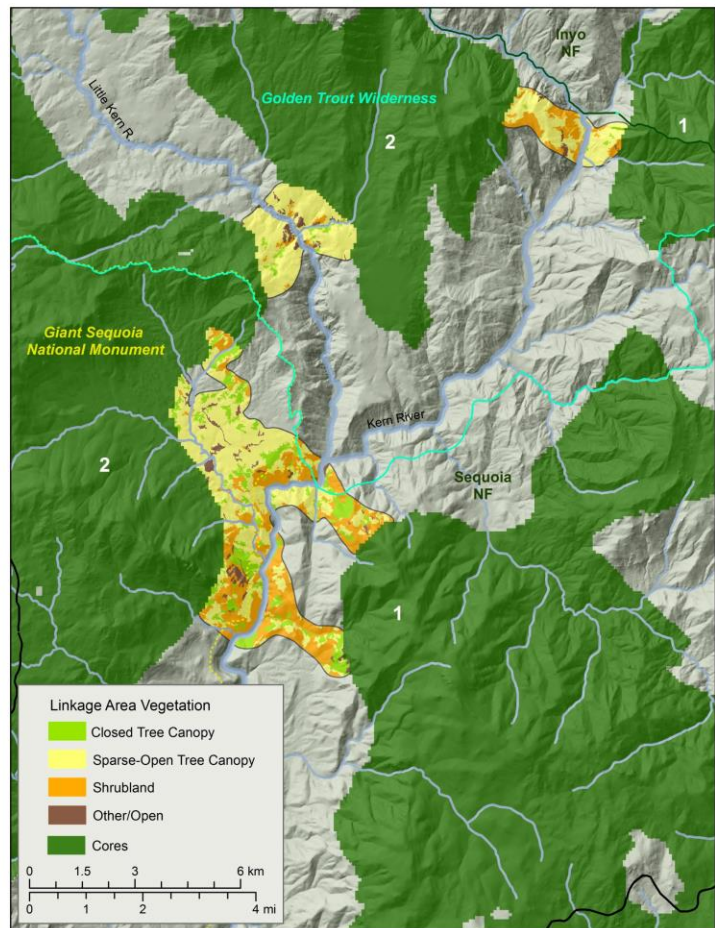
The following sections briefly describe specific conditions and management concerns in each linkage area. In general, management should retain and promote vegetation conditions favored by fishers and prevent or mitigate features that could impede fisher movements (e.g., new roads, reservoirs, openings), especially those that might span the full width of a linkage polygon. Open habitats, such as large meadows and sparsely vegetated areas, are unlikely to facilitate dispersal. Especially in areas lacking dense forest canopy, management should promote and retain coarse woody structures (snags and logs) and shrub patches to provide dispersing fishers with potential hiding and escape cover.

Because female dispersal is particularly important for expanding the fisher population into the currently unoccupied cores—and genetic evidence suggests females disperse primarily within dense-canopy forests with large trees (Tucker 2013)—Linkages E and F to the currently unoccupied cores should receive particular attention for retaining and promoting mature forest cover, where feasible. Riparian strips, rather than chaparral or other vegetation types, may provide more suitable dispersal habitat.



### 2.2.1 Linkage A

Linkage A is a generally east-west, multi-strand connection across the Kern River watershed between Cores 1 and 2. Several strands of the linkage cross the main stem of the Kern River at and just downstream of its junction with the Little Kern River; other strands cross the two rivers farther upstream via a stepping stone of core habitat (a portion of Core 2 in the Golden Trout Wilderness, Figure 6). The downstream strands are relatively long and open, such that fishers would need to navigate ~2-4 mi of relatively open forest and chaparral on very steep terrain. The upstream strands are shorter, cross gentler canyons, and consist mostly of sparse to open forest. Because these likely dispersal areas are in the Golden Trout Wilderness, and genetic results suggest that dispersal may be adequate between Cores 1 and 2 (Tucker et al. 2014), few if any management changes are recommended. Wildfire is expected to maintain vegetation heterogeneity in this region.



**Figure 6—Linkage A showing vegetation classes.**

### 2.2.2 Linkage B

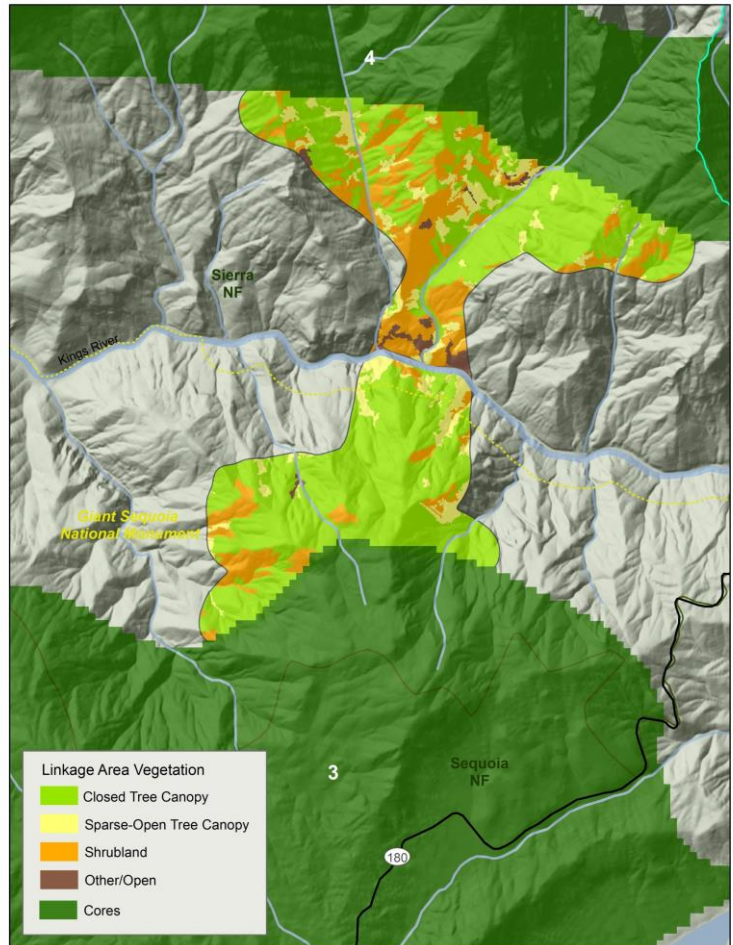
Linkage B represents the genetic subdivision identified by Tucker et al. (2014) near the Mountain Home Demonstration State Forest, for which Bear Creek in the Tule River watershed was used as the geographic break (Figure 3). Because there are no obvious dispersal impediments in this area, and the genetic discontinuity may represent a historical legacy of population contraction and expansion (J. Tucker, personal communication), no linkage area polygon has been delineated, and no specific restoration actions are recommended. Management in and near the Mountain Home Demonstration State Forest should maintain natural, mature forest conditions and avoid creating major breaks in forest cover.

### 2.2.3 Linkage C

Linkage C crosses Kings River Canyon between Cores 2 and 3 (Figure 7). Kings Canyon appears to be a significant dispersal impediment along most of its length due to steep, mostly unforested slopes, which is evident in fisher landscape genetic patterns (Tucker et al. 2012, 2014).

Vegetation in the linkage area is mostly forested on north-facing slopes but significantly more open on south-facing slopes, which are covered with chaparral and open vegetation communities at lower elevation, trending to more forested conditions higher up. Narrow riparian strips along tributary creeks may offer the best dispersal routes across the canyon (e.g., Rough Creek, Converse Creek), or fishers may cross farther upstream where there is more continuous forest cover and smaller canyons.

The most likely crossings and impediments to fisher dispersal should be evaluated in the field. Managers should investigate whether restoration actions may increase tree, shrub, or log cover in key locations. Management should also maintain fisher denning habitat in the cores on both sides of the canyon (e.g., around Converse Mountain/Converse Basin to the south and Spanish Mountain/Rodgers Ridge to the north).

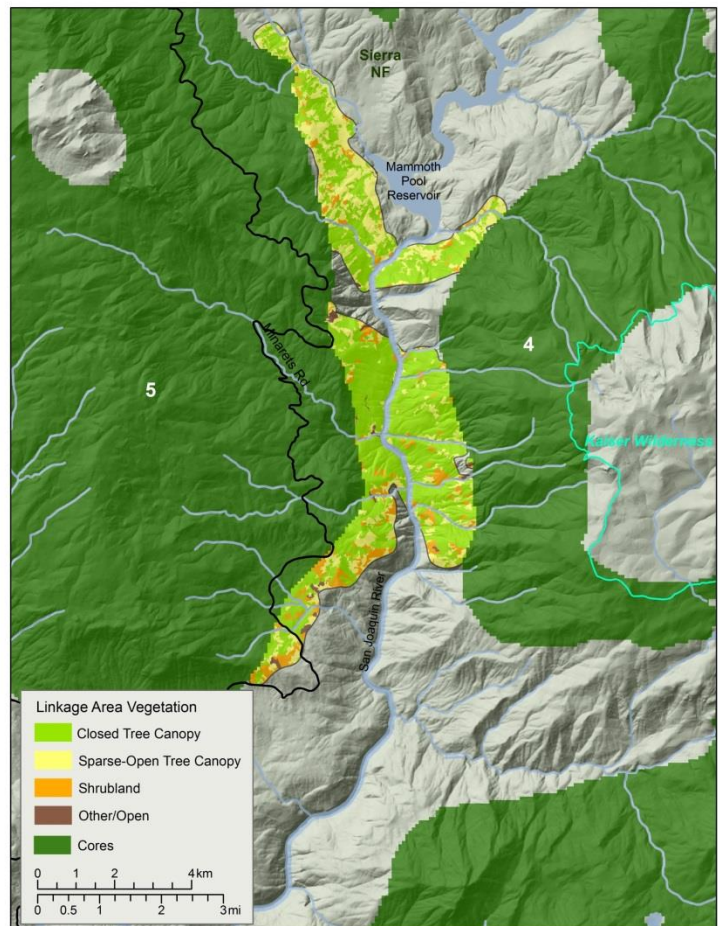


**Figure 7—Linkage C showing vegetation classes.**

### 2.2.4 Linkage D

Linkage D connects Cores 4 and 5 across the San Joaquin River (Figure 8). Connectivity models suggest the most likely crossing of the river is at or below the Mammoth Pool dam, which is consistent with repeated crossings there by one radio-collared male (R. Sweitzer, unpublished data). The 2013 Aspen Fire burned much of the potential dispersal habitat on the east side of the San Joaquin River, and the 2014 French Fire burned the west side. High-severity burn areas were patchy in both fires, probably reducing but perhaps not totally disrupting dispersal potential between the cores. The linkage should be re-evaluated when vegetation burn severity data are available for the French Fire, about 1 year post-fire.

How the combination of the two recent fires and post-fire management actions (e.g., salvage logging) may affect functionality of Linkage D should be studied with a combination of post-fire habitat modeling, field assessment, and radio-tracking of fishers in the vicinity. Post-fire management should avoid removing fisher habitat elements within the linkage area and should favor structural complexity of recovering forest cover. Promote high quality fisher habitat (especially denning habitat) within and adjacent to burned areas on both sides of the linkage.

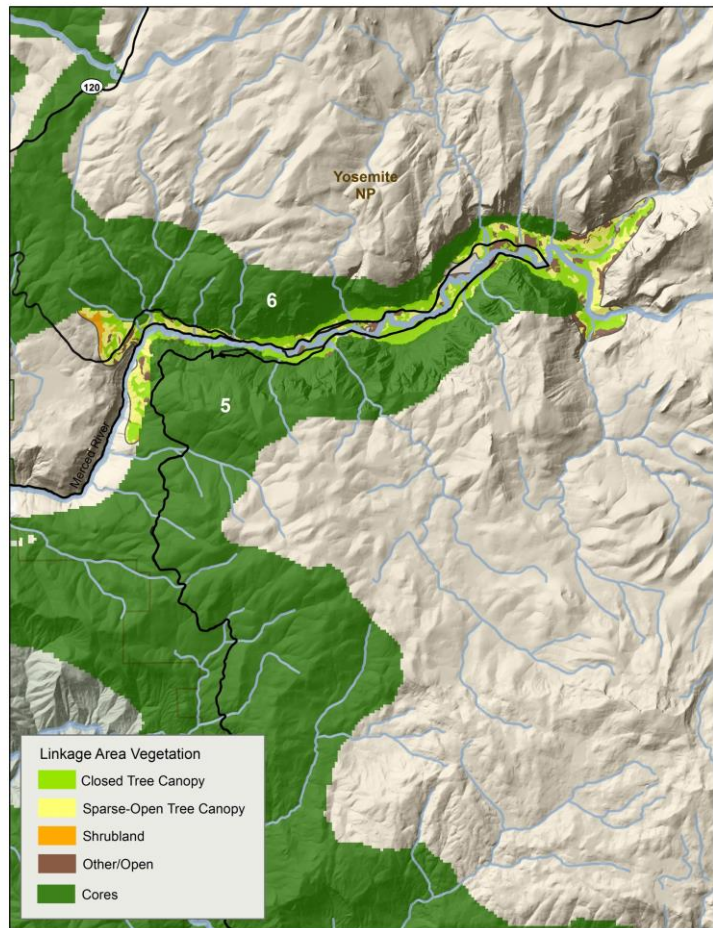


**Figure 8—Linkage D showing ~2008 vegetation classes.** Vegetation classes do not reflect changes due to 2013-2014 fires.



### 2.2.5 Linkage E

Linkage E connects occupied Core 5 and unoccupied Core 6 across Yosemite Valley and the Merced River (Figure 9). Yosemite Valley is a mosaic of forests of varying density and meadows, with very steep granite slopes and cliffs along much of its length, heavy traffic on Wawona Road, and heavy recreational use by humans. Core habitat areas on either side of Yosemite Valley have been affected by numerous recent fires, including the 2014 Meadow Fire. Loss of forest canopy may temporarily constrain linkage function. Connectivity models and field inspection suggest the most likely fisher crossing would be the lower reaches of Yosemite Valley, just east of the Wawona Tunnel overlook in Yosemite National Park. Alternatively, fishers might move along various tributary streams entering the Merced River downstream of the park and move upstream to cross the valley. It is also possible that fishers, especially males, would cross the Merced upstream above Yosemite Valley, but forest cover is sparser at higher elevations.

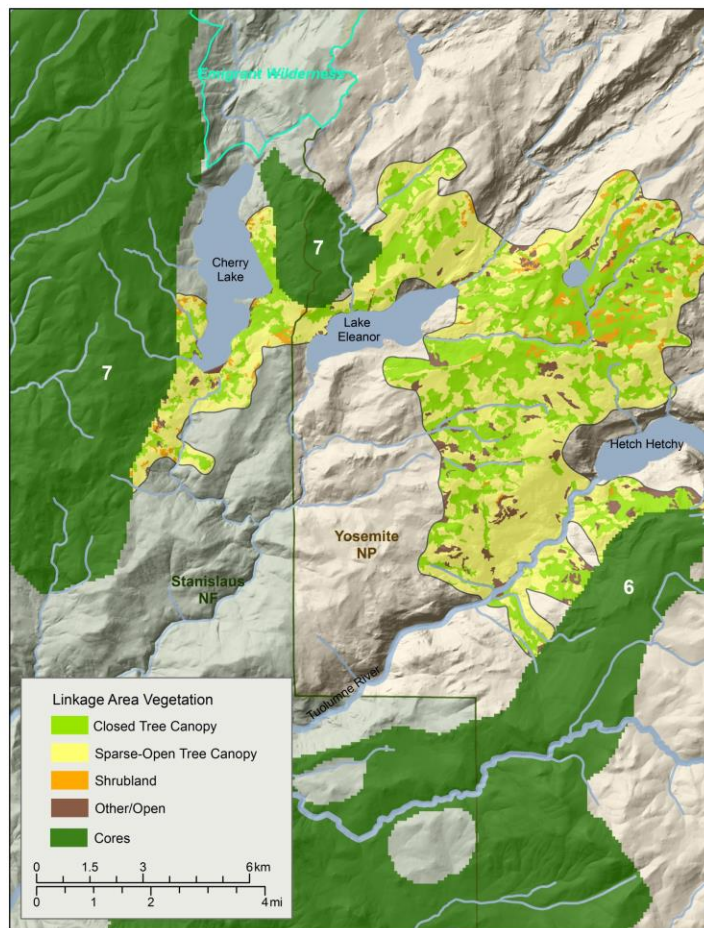


**Figure 9—Linkage E showing vegetation classes.**

Management should favor retention of forest cover across lower Yosemite Valley and reduce risks of severe fire in the western portion of the park and adjacent portions of Sierra National Forest. Overstory cover should be maintained in all significant drainages with culverts under Wawona Road. Though not all the culverts can be used by fishers today, riparian areas should be protected and culverts modified to facilitate fisher movement. Agencies should explore opportunities for additional crossing improvements along the road, including retrofitting existing culverts with above-water shelving, installing new undercrossing structures, or constructing a vegetated overcrossing to facilitate movement of fishers and larger mammals. Recent road-crossing improvements in the park should continue to be monitored for wildlife use, and further improvements and installations made if warranted. Monitoring of vehicle strikes and use of road-crossing structures by fishers and other wildlife should continue in this area.

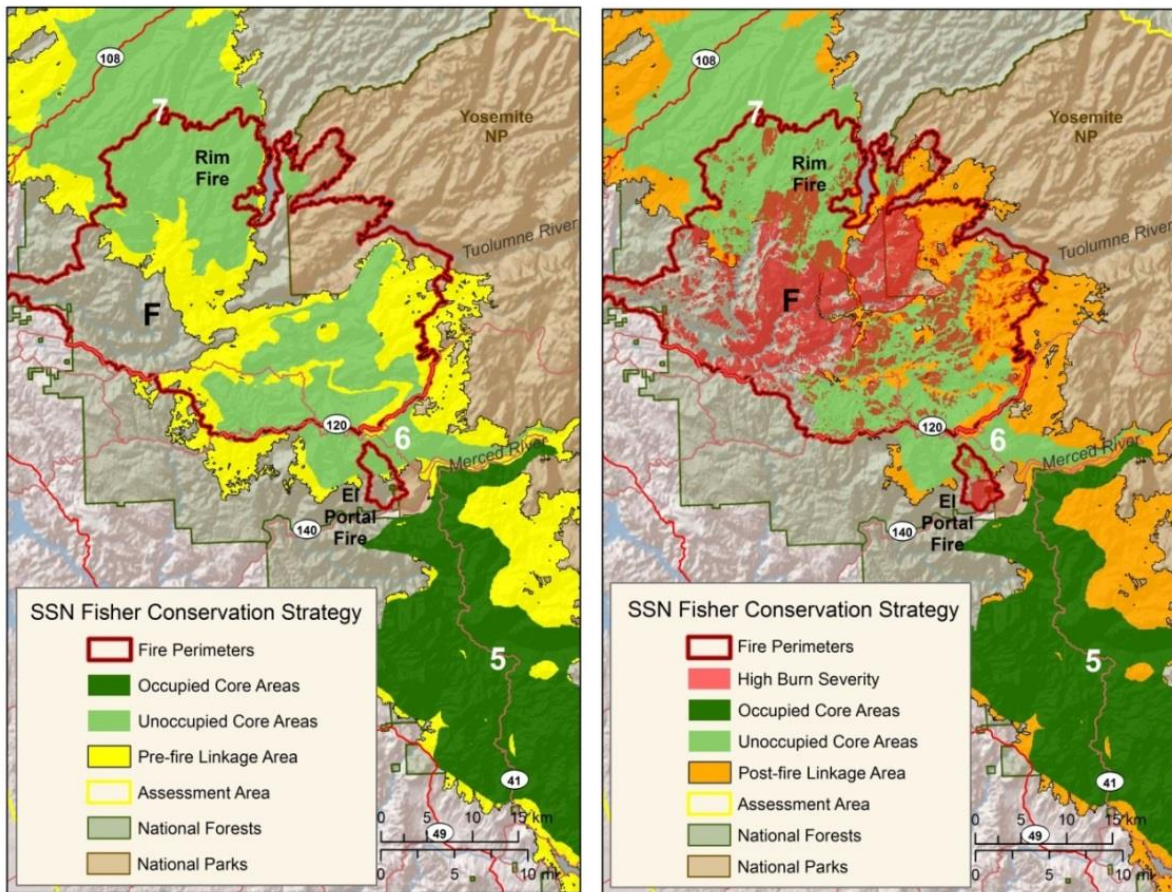
### 2.2.6 Linkage F

Linkage F connects unoccupied Cores 6 and 7 on the Stanislaus National Forest and Yosemite National Park (Figure 10). The 2013 Rim Fire burned at high severity across much of what was previously modeled as the most likely connecting habitat (Spencer et al. 2015), shifting the modeled post-fire least-cost corridor significantly eastward (up slope) from the modeled pre-fire corridor (Figure 11). Vegetation in the post-fire linkage area is a mosaic of conifer forest of varying density, with large areas of relatively open forest, especially on south facing slopes and ridges. Management should retain and promote fisher habitat elements within both the pre- and post-fire linkage areas, by promoting forest canopy recovery, hardwoods, or shrubs, depending on site conditions. Yosemite National Park should consult with ecologists to determine when and where use of wildland fire or prescribed fire is advised to promote forest regrowth in high severity patches. Salvage logging on Forest Service lands should retain the largest diameter snags and clusters of trees within salvage units. Restoration schemes should promote future spatial heterogeneity using diverse and fire-resilient species mix and wildlife habitat values. A carnivore connectivity plan is underway as part of the reforestation effort.



**Figure 10—Linkage F showing vegetation classes.** Modeled core habitat areas do not reflect effects of 2013 fires.





**Figure 11—Modeled effects of the 2013 Rim Fire on potential dispersal habitat between fisher Cores 6 and 7 (Linkage F).** The pre-fire least-cost corridor (left, yellow) was affected by large areas of stand-replacing fire (right, red), shifting the predicted corridor eastward (right, orange) to higher-elevation forests that did not burn at high severity. (Source: USFS Pacific Southwest Region 2014, Vegetation Burn Severity, 1984 to 2013, for the 2013 fire, <http://www.fs.usda.gov/detail/r5/landmanagement/gis/?cid=STELPRDB5327833>; USFS 2014, RAVG data bundle for the 2014 fire (CA3726811933420140728) <http://www.fs.fed.us/postfirevegcondition>).

## 3 Providing Habitat for Female Fishers

Female fishers have the most stringent habitat requirements and they raise their young alone; therefore, maintaining and increasing carrying capacity for breeding females is essential to sustaining and recovering the fisher population. This section describes a management grid system designed to help maintain a sufficient number and distribution of breeding female fishers in each core area, with the assumption that this will also maintain sufficient habitat for males. The grid system and associated habitat metrics can help land managers site, phase, and evaluate effects of fisher conservation measures on fisher habitat at coarse scales (>1,000 ac). It primarily serves as a monitoring tool to evaluate changes in the quality, quantity, and distribution of suitable habitat for breeding female fishers in response to vegetation changes occurring over years to decades.

### 3.1 Management Grid System

To create the grid and delineate the fisher Strategy Area (that area within which fisher conservation measures and recommendations apply), hexagonal grid cells about the size of an average female breeding home range or territory (10 km<sup>2</sup>, ~4 mi<sup>2</sup>)<sup>9</sup> were overlaid on the fisher Assessment Area using HexSim (Schumaker 2013). Cells intersecting modeled fisher core and linkage habitats are considered part of the fisher Strategy Area. This initial Strategy Area was slightly expanded by adding cells within 5 km (3 mi) of core and linkage areas that have potential to support breeding female fishers, based on the statistical analyses described in Section 3.1.1 below. The resulting Strategy Area (Figure 12) consists of 1,012 hexagonal cells that include all areas considered likely to contribute substantially to sustaining the fisher population over the next 15-30 years. The boundary of the Strategy Area should be adjusted in the future based on shifts in habitat distribution due to climate change and other factors.

#### 3.1.1 Calculating Female Home Range Potential and Carrying Capacity

The management grid system uses a statistically derived female home range “template” equation to serve as a metric for scoring and tracking habitat values at the home range scale and cumulatively across the landscape as a whole. The approach is based on a method first applied by Thompson et al. (2011) to fisher home ranges on Sierra National Forest in Core 4. A principal component analysis (PCA) of vegetation composition and structure was performed on 83 breeding-age female home ranges (most of which were verified as successfully reproducing) obtained from three radio-telemetry studies in the Assessment Area<sup>10</sup>. Variables included in the PCA (Table 3) are readily available from standard spatial datasets (EVEG and GNN [gradient nearest neighbor]), can be inputs to or outputs from Forest Vegetation

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<sup>9</sup> Cell size was based on an analysis of female home ranges and home range *core-use areas* using fisher telemetry data from Sierra National Forest. Core-use areas were defined using fixed-kernel isopleths that minimized overlap between neighboring female home ranges and therefore approximate female breeding territory density, or carrying capacity, on the landscape (see Spencer et al. 2015 for details). The size was rounded up from ~8 km<sup>2</sup> to 10 km<sup>2</sup> to account for variation in habitat quality and various other estimates of fisher carrying capacity in the Strategy Area (Spencer et al. 2011). Cells are not meant to represent actual home ranges, and their precise size and location are not critical, so long as they approximate the average area needed to support a female and her dependent kits.

<sup>10</sup> The Sierra Nevada Adaptive Management Program (SNAMP) Fisher Study (54 home ranges in Core 5), Kings River Fisher Project (22 home ranges in Core 4), and Southern Sierra Nevada Marten and Fisher Study (Zielinski et al. 2004a, 7 home ranges in Core 2). See Appendix A-1.1 for details.



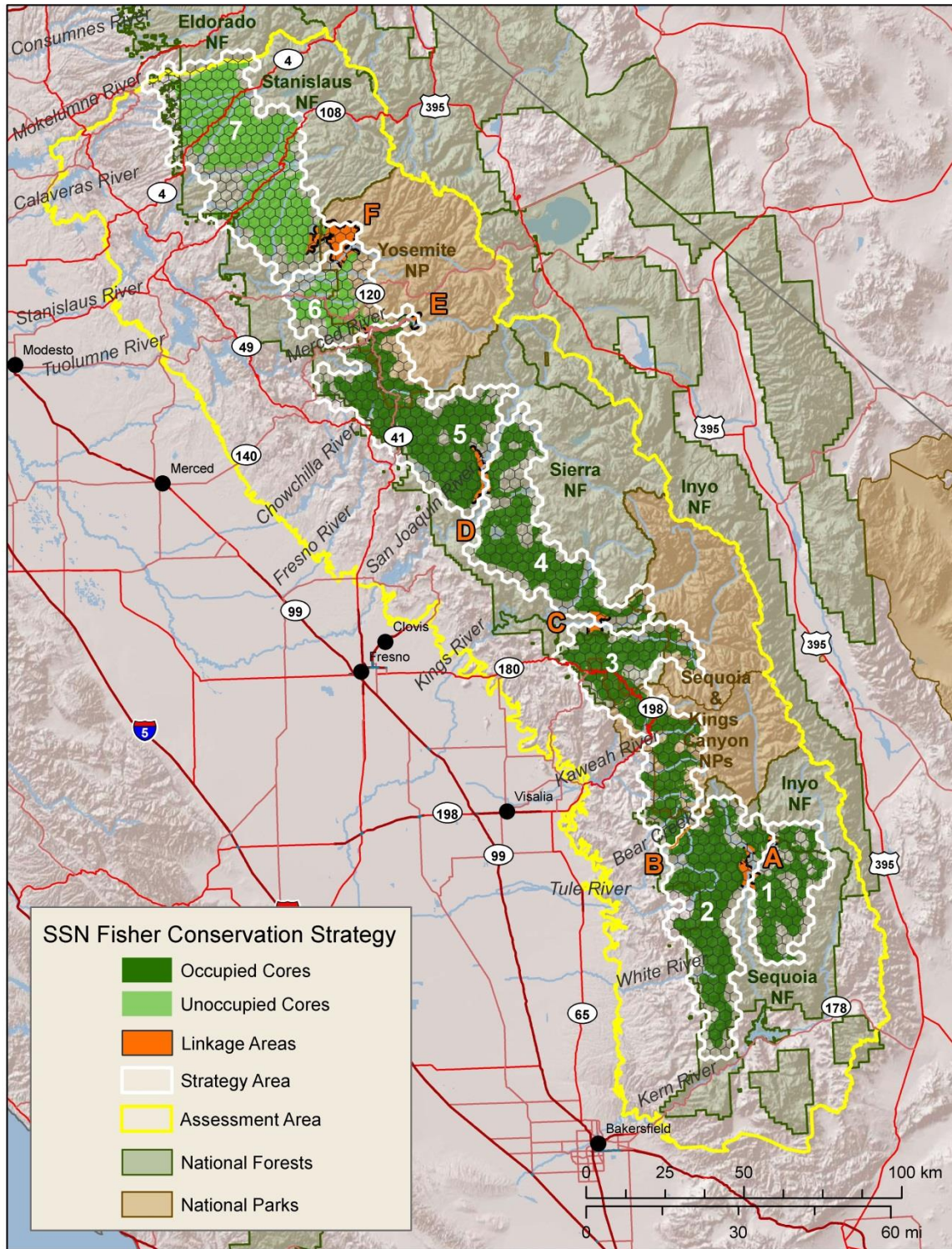


Figure 12—Grid of breeding territory-sized (10 km<sup>2</sup>, ~4 mi<sup>2</sup>) hexagonal cells constituting the fisher Strategy Area. Fisher core areas are numbered and inter-core linkage areas are lettered.



Simulator (FVS) with appropriate conversions<sup>11</sup>, are likely to be directly altered by vegetation management actions, and are known to be important to or correlated with fisher habitat value. Some variables were not normally distributed, and so were transformed by various techniques prior to use in the PCA (Table 3). (See Appendix A-1.2 for detailed methods.)

**Table 3—Variables used in the female home range PCA and to score hexagonal grid cells.** Most variables were transformed by various techniques to be more normally distributed.

<b>Variable</b>	<b>Description</b>	<b>Source</b>	<b>Transformation</b>
BA_MN	Mean basal area (m <sup>2</sup> /ha) of live trees $\geq 2.5$ cm (1 in) dbh	GNN	None required
DDI	Diameter diversity index (mean), measure of structural diversity of a forest stand, based on tree densities in different dbh classes	GNN	(DDI) <sup>3</sup>
PLAND	Proportion in CWHR high reproductive habitat, calculated with FRAGSTATS	EVEG	(PLAND) <sup>3</sup>
PLADJ	Percentage of adjacent pixels of CWHR high reproductive habitat divided by the total number of pixel adjacencies; a measure of CWHR high reproductive habitat aggregation, calculated with FRAGSTATS	EVEG	(PLADJ) <sup>13</sup>
SNAG_DENS	Density (mean) of snags $\geq 25$ cm (10 in) dbh and $\geq 2$ m (6.5 ft) tall (trees/ha)	GNN	None required
QUKE_BA	Mean basal area (m <sup>2</sup> /ha) of black oak	GNN	$\sqrt{(\text{QUKE\_BA})}$
TTCFA_LT40	Proportion with tree canopy cover classes <40%	EVEG	Log(TTCFA_LT40)
TTCFA_GE70	Proportion with tree canopy cover classes $\geq 70\%$	EVEG	(TTCFA_GE70) <sup>1.5</sup>

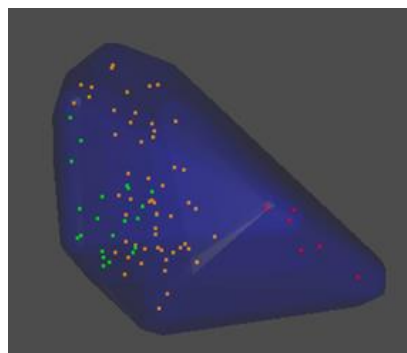
<sup>11</sup> Estimates of variables from different scales and sources may vary, requiring cross-walk tables or conversion equations to make them comparable. For example, canopy cover estimates derived using FVS and plot data are biased low compared to canopy cover estimates in EVEG based on aerial or satellite imagery (Fiala et al. 2006; Appendix A-4).

Once the PCA equation was developed from female home range characteristics, it was used to evaluate each hexagonal cell in the Strategy Area for its suitability to support a female home range (or breeding territory). A three-dimensional shape (a buffered convex hull) enclosing all home ranges was created in PCA space to define suitability using the first three principal components (which accounted for 94.5% of variance in home range conditions;

Appendix A-1.2). Cells with PCA scores inside the hull are considered *suitable* and those outside *unsuitable*, at least for analytical and accounting purposes<sup>12</sup>. Statistically, this assumes that the range of conditions within the existing sample of female home ranges represents the range of suitable conditions in the Assessment Area, and that conditions outside this range are unsuitable. Biologically, this approach also assumes that female fishers establish home ranges in those areas most suitable for survival and reproduction, and thus that their home ranges provide all their life requisites. Consequently, this approach assumes that a cell similar in composition and structure to actual female home ranges will also contain sufficient foraging, resting, and denning habitats, thus integrating measures of these different habitat types into a single metric (the PCA score or “template”).

Despite some uncertainties introduced by the limited spatial sample of home ranges used to create the PCA hull (see text box), it represents our best empirical summary of where female fishers are surviving and reproducing under currently available conditions. As forest conditions continue to

**Caveats:** (1) The PCA hull encompasses a wide range of habitat conditions and probably female home range habitat value; (2) the home ranges used to create the model are from three study areas in three of the seven fisher core areas and may not represent the full range of conditions fishers use in the Strategy Area; and (3) the home ranges are mostly within fire-suppressed forests, and therefore may not represent historical or optimal conditions for fishers. Home ranges on the Sequoia NF have significantly higher tree basal area and black oak basal area, more dense-canopied forest, and more CWHR high reproductive value habitat than those from Sierra NF. The seven Sequoia NF home ranges consequently cluster near one edge of the PCA hull, which may represent superior habitat conditions compared to those near the opposite edge. Thus, it is possible that some statistical space outside the PCA hull actually represents suitable, high-quality habitat conditions, but that these conditions either don’t currently exist on the landscape (e.g., large areas of old-growth forest unaltered by logging and fire suppression) or they exist but have not been sampled by fisher telemetry studies. It is also probable that some statistical space inside the PCA hull represents marginal habitat conditions for fishers, but that they do not have better conditions to select from.



Screen shot of PCA hull showing clustering of KRFP (green), SNAMP (orange), and Sequoia NF (red) home ranges in statistical space. Note the gap between red and other home ranges, which is likely suitable for fishers but not sampled.

<sup>12</sup> The *suitable* vs *unsuitable* terminology is to reflect statistical characterization of whether an area with a particular score is representative of areas used or not by breeding females. It is for tracking and accounting a proxy of fisher carrying capacity at coarse, landscape scales. As such, it should not be construed as an absolute prediction of occupancy by fishers.

change due to fires, management, succession, climate change, and other factors, adjustments to the PCA may be warranted. It is essential that the monitoring plan (Section 8) be designed to assess and refine the assumptions and predictions of the PCA hull to ensure it accurately portrays fisher habitat value as part of the adaptive management program.

Although cells with PCA scores falling outside the hull are considered *currently unsuitable*, some of them are likely to become suitable in the future due to forest growth and management actions (*potentially suitable* cells), whereas others have a very low likelihood of ever becoming suitable due to low site productivity (e.g., physical factors that limit their potential to support sufficient forest cover or large trees; *low potential* cells). Table 4 summarizes the number and proportion of currently suitable, potentially suitable, and low potential cells in each core area based on an analysis detailed in Appendix A<sup>13</sup>. Figure 13 maps the current distribution of these cell types, and Figures 14-16 show higher resolution views in the southern, middle, and northern portions of the Strategy Area. The distinction between potentially suitable and low potential cells is important for developing conservation targets for the number of suitable cells that are possible or desirable in each core area in the future (Section 4.1). The total of currently suitable and potentially suitable cells represents a rough estimate of the maximum future carrying capacity of breeding females in the Strategy Area, but without accounting for vegetation dynamics (see Section 4.1).

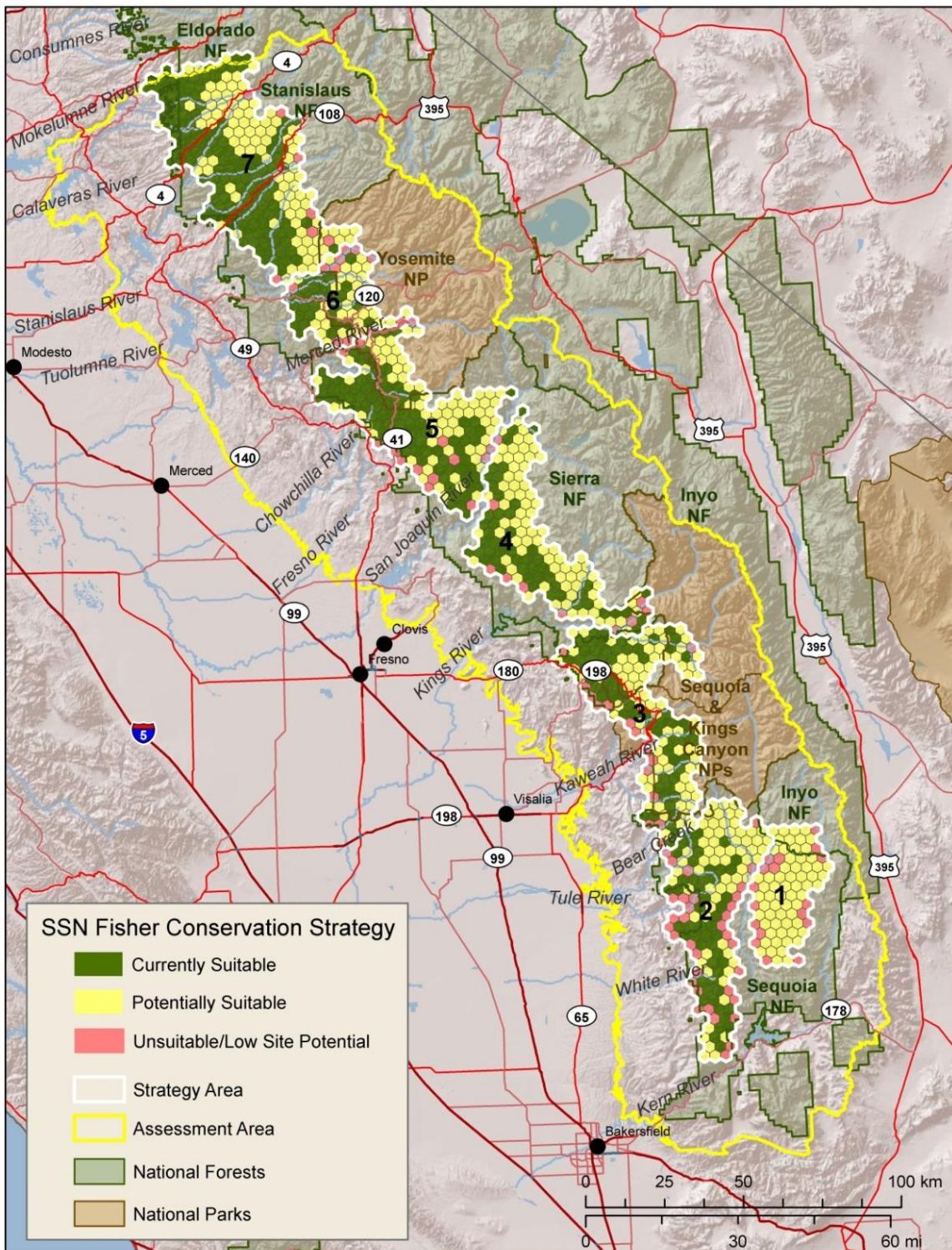
**Note:** Numbers and maps of suitable cells reflect conditions prior to 2013 and do not account for vegetation changes due to recent large fires, such as the Rim Fire and French Fire. Numbers will be updated when updated vegetation layers are available.

**Table 4—Current number and percent of currently suitable, potentially suitable in the future, and low potential hexagon grid cells in each fisher core area** based on the female home range template analysis. Cores 1-5 are currently occupied by breeding females, and Cores 6-7 are not.

Core	N total cells	N currently suitable	% currently suitable	N low potential	% low potential	N potentially suitable	% potentially suitable
1 <sup>a</sup>	80	0	0%	17	21%	63	79%
2	151	51	34%	34	23%	66	44%
3	159	64	40%	15	9%	80	50%
4	142	53	37%	10	7%	79	56%
5	173	88	51%	14	8%	71	41%
Occupied subtotal	705	256	36%	90	13%	359	51%
6	73	29	40%	10	14%	34	47%
7	234	130	56%	7	3%	97	41%
Unoccupied subtotal	307	159	52%	17	6%	131	43%
Total	1012	415	41%	107	11%	490	48%

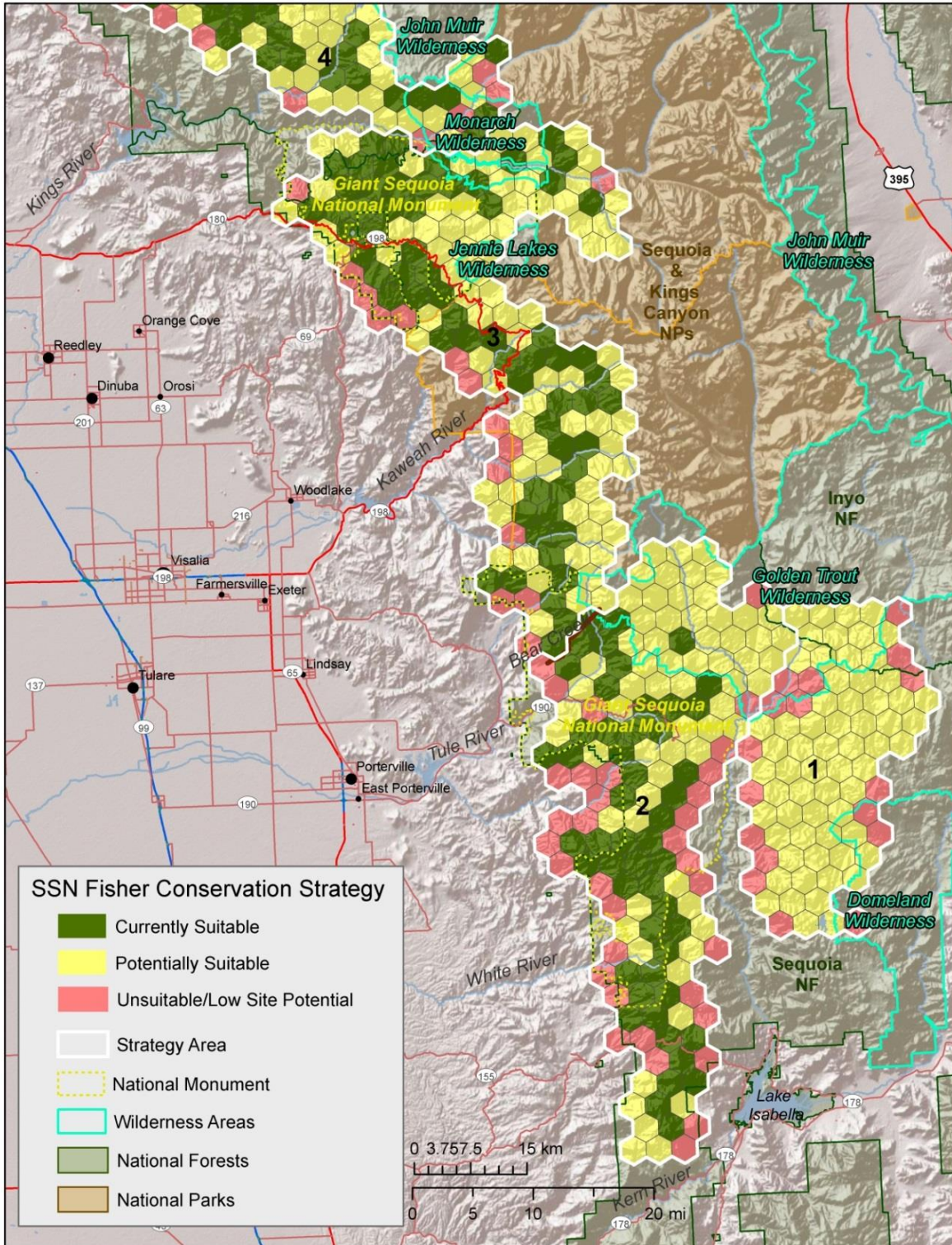
<sup>a</sup> Core 1 is known to be occupied even though the analysis shows no suitable cells there, probably due to unique environmental conditions compared to other cores. A separate scoring equation should be developed for Core 1.

<sup>13</sup> As detailed in Appendix A-1.4, 107 of the 1,012 cells in the Strategy Area were found highly unlikely to ever become suitable based on a time-series analysis of habitat value changes from 1990 to 2012 and five GIS data layers identifying low site potential. The analysis also calculates the probabilities and rates at which cells may switch between suitable and unsuitable states over time as a function of disturbances and forest growth and succession.



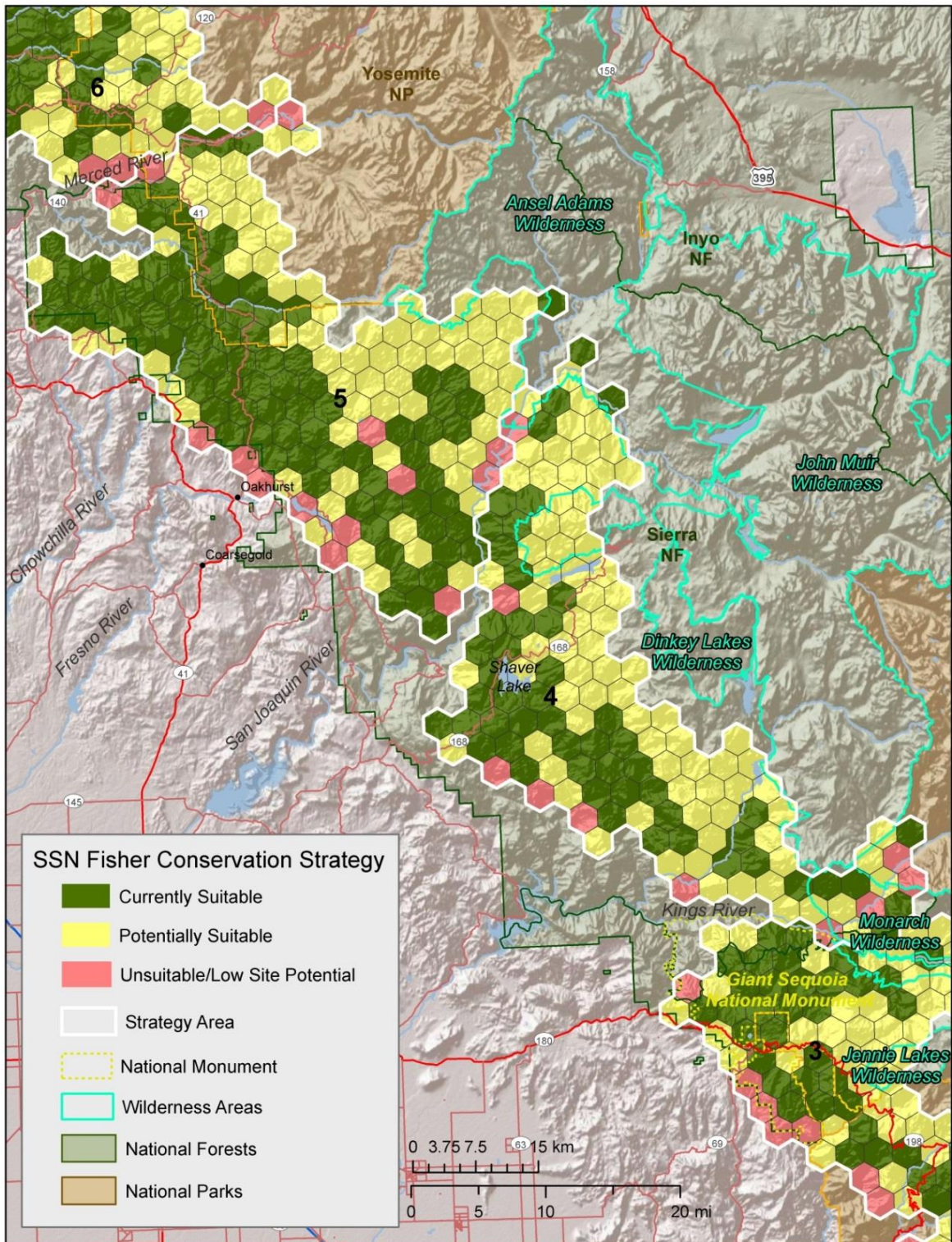
**Figure 13—The management grid system showing cells that are predicted to be currently suitable, currently unsuitable but potentially suitable in the future, and with low potential to ever support a breeding female fisher. Note that the lack of predicted suitable cells in Core 1 appears to result from poor statistical extrapolation from available data, which is to be rectified in the future.**





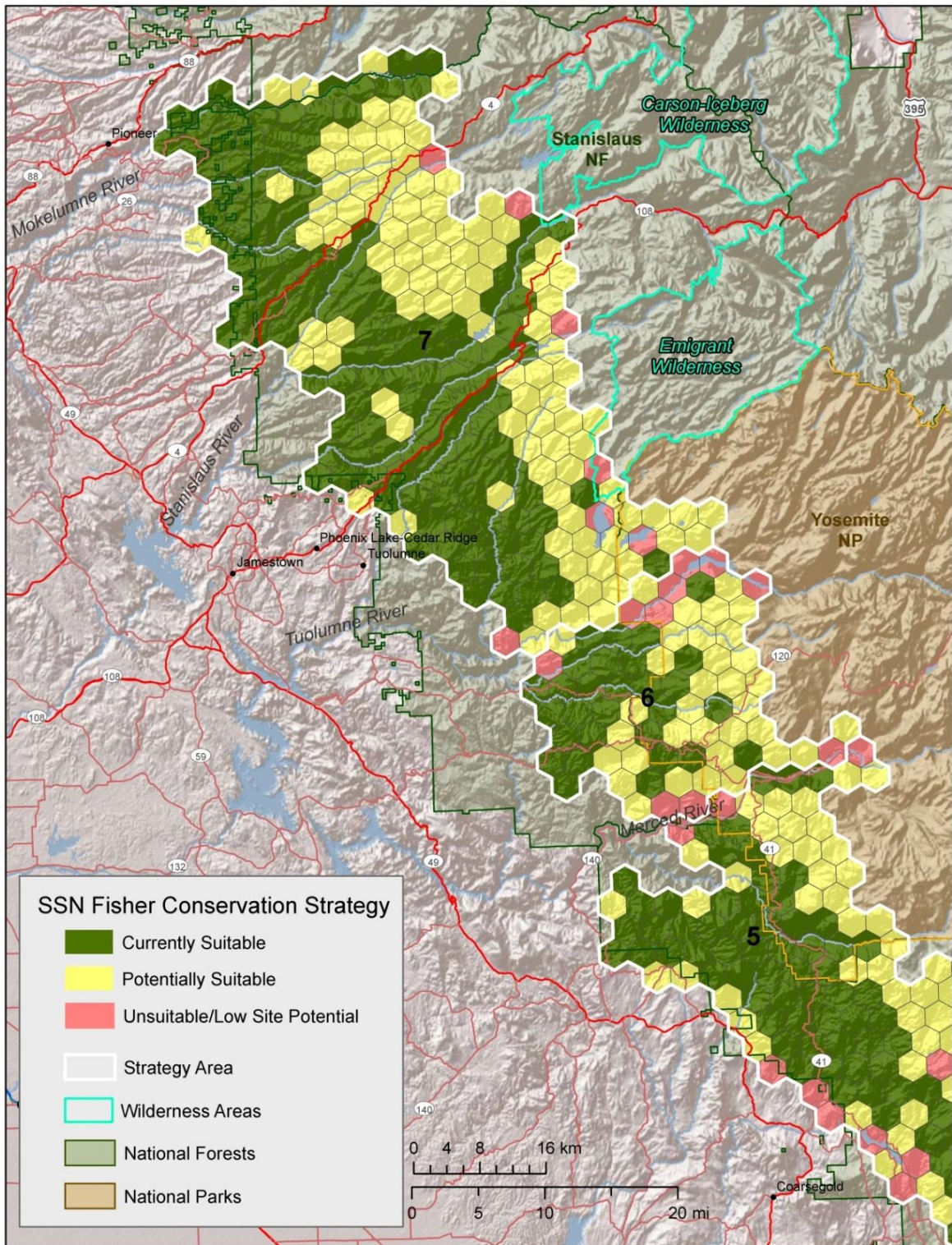
**Figure 14—Currently suitable, future potential suitable, and low potential to ever be suitable grid cells in the southern portion of the Strategy Area.** Note that the lack of predicted suitable cells in Core 1 appears to result from poor statistical extrapolation from available data, which is to be rectified in the future.





**Figure 15—Currently suitable, future potential suitable, and low potential to ever be suitable grid cells in the middle portion of the Strategy Area. Cell suitability not yet updated to reflect potential impacts of the 2013 Aspen and 2014 French fires.**





**Figure 16—Currently suitable, future potential suitable, and low potential to ever be suitable grid cells in the northern portion of the Strategy Area. Cell suitability not yet updated to reflect potential impacts of the 2013 Rim Fire.**

Note that there are no predicted suitable cells in Core 1, although Core 1 is occupied by fishers—albeit at the lowest occupancy rates measured in the southern Sierra Nevada (Zielinski et al. 2012). This is probably due to unique environmental conditions on the Kern Plateau compared to cores on the west slope of the Sierra Nevada (Spencer et al. 2015) such that conditions in the 83 home ranges used to create the PCA hull may not represent suitable conditions on the Kern Plateau. *A priority next step should be to prepare a separate model of habitat suitability for Core 1 for establishing and tracking conservation targets there. Ideally, a fisher telemetry study estimating home ranges and habitat selection of ~10-15 females should be used to develop a specific Core 1 habitat model, assessment tool, and conservation targets, although in the interim a less ideal model could be developed using existing fisher detection data and expert opinion. In the meantime, recognize that the number of currently suitable cells reported in this Conservation Strategy underestimate carrying capacity in Core 1 by an unknown amount<sup>14</sup>.*

### 3.1.2 Using Female Home Range Potential for Planning and Monitoring

The management grid and home range template equation can be used both to (1) help guide siting, prioritization, and phasing of conservation measures, including fuel management projects, and (2) monitor the cumulative effects of vegetation succession, management, fires, and other processes on fisher carrying capacity and habitat distribution over time. The PCA hull equation can be used as one tool to evaluate and refine vegetation treatments by applying it within a project footprint using vegetation data representing conditions before and after a planned treatment (so long as the project is at roughly the size of a fisher home range, or ~1,000-10,000 ac). The equation can also be applied periodically to all management grid cells to track the cumulative number of suitable cells within each core area and over the landscape as a whole. As demonstrated in Section 4, the template can also be coupled with metrics of habitat resiliency, such as integrated flame length or probability of crown fires under various weather conditions, to track progress toward resiliency goals.

For planned projects, a digital habitat suitability “slider tool”<sup>15</sup> based on the PCA template equation can be used to roughly assess how manipulating individual variables like basal area, canopy cover, or snag density may affect female home range habitat suitability (Figure 17). An analyst can use this statistical feedback, in combination with other, finer-scale assessments<sup>16</sup>, to help refine a project prescription before implementation, with a goal of maximizing fisher habitat benefits (potentially changing a cell from unsuitable to suitable) or minimizing adverse effects (including changing a cell from suitable to unsuitable). *A next priority should be to develop a similar slider tool that predicts changes in flame lengths, probability of crown fire, or other appropriate metrics of habitat resiliency as a result of changing habitat conditions.*

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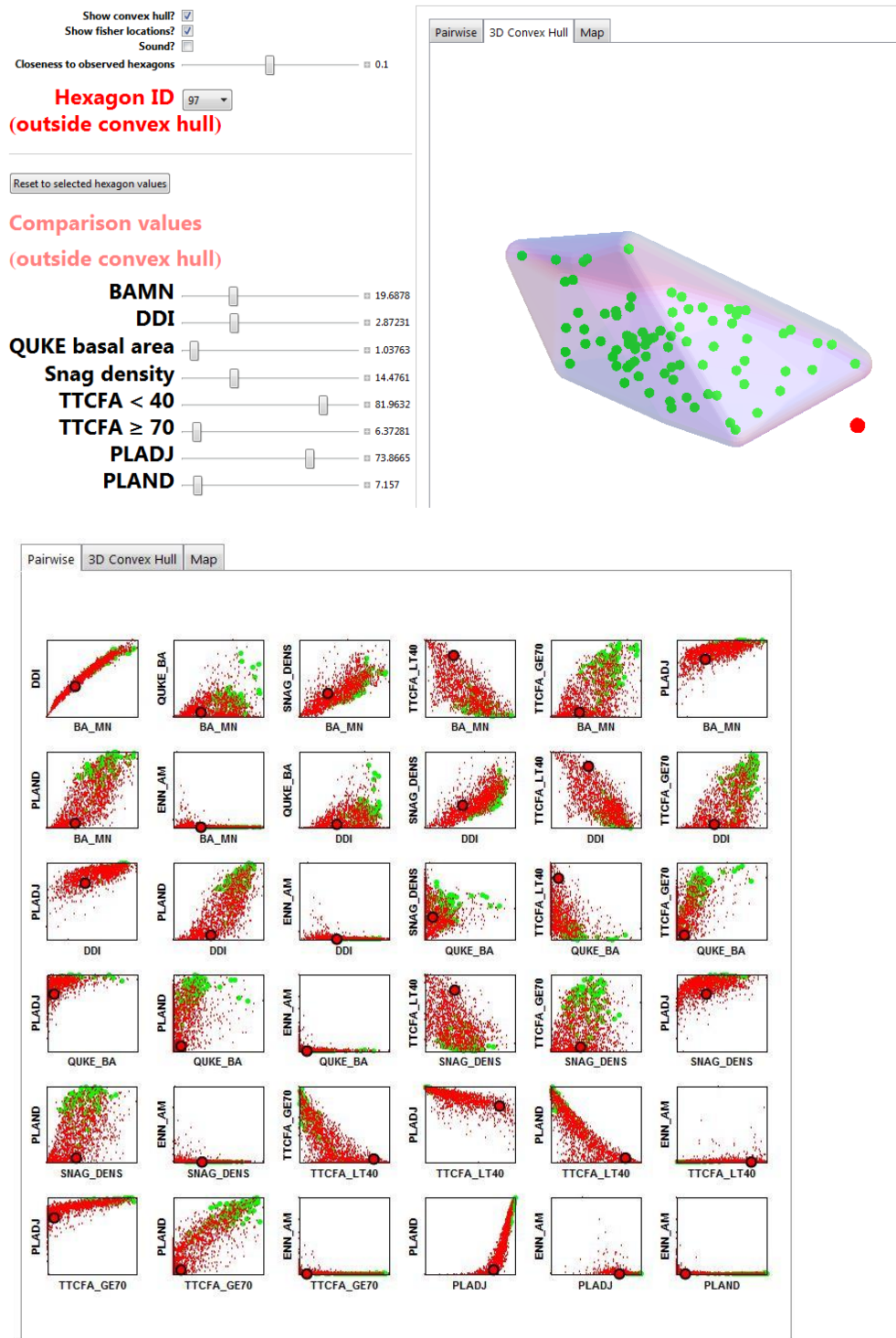
<sup>14</sup> This issue of apparent under-estimation of habitat potential appears to be largely confined to Core 1, as there are good statistical fits between the PCA predictions, other habitat model predictions, fisher detection data, denning locations, and fisher home range distribution in other fisher cores (Appendix A-1.3). The unique environmental conditions and lack of intensive fisher study on the Kern Plateau apparently result in poor statistical extrapolation to Core 1.

<sup>15</sup> The Suitability Slider Tool was created by J. Baldwin and uses Wolfram CDF Player (freeware) to operate.

<sup>16</sup> Because the PCA equation was developed at the home range scale and applied to entire grid cells in the slider tool, there can be a spatial mismatch when using it to evaluate specific project polygons, which will vary in size and may be contained within a single cell or span multiple cells. This dictates that the tool be used with caution, in concert with other metrics, when applied to evaluating individual projects.



# Southern Sierra Nevada Fisher Conservation Strategy



**Figure 17—Screenshots illustrating the fisher habitat “slider tool.”** Upper left: the variable slider control panel with eight variables that a user can manipulate to investigate effects on habitat value. Upper right: the PCA convex hull showing 83 home range scores inside the hull (green) and the location of a selected cell outside the hull (pink). Lower panel: scatterplots for each pair of variables showing the 1,012 cells (red), 83 fisher home ranges (green), and selected cell (black circle). The scatterplots are used to constrain variable settings within the slider tool to prevent the user from selecting unrealistic combinations of variable values, such as simultaneously maximizing dense canopy and open canopy.

### 3.2 Using Female Home Range Composition to Inform Desired Landscape-scale Conditions

Although the PCA equation is useful for distinguishing suitable from unsuitable habitat areas at the home-range scale, it is difficult to translate this abstract multivariate concept into meaningful descriptions of desired conditions for management purposes. Therefore, to inform desired conditions for maintaining female reproductive habitat on the landscape (Section 4.3), we performed a variety of other statistical analyses comparing the composition of the 83 female home ranges used to develop the PCA to available habitat conditions in the Assessment Area as well as to modeled denning habitat and CWHR high-value fisher reproductive habitat (Appendix A-2). Although the analyses were all very consistent in identifying what conditions females select on the landscape to establish home ranges and denning sites, it is uncertain whether these truly represent desired conditions, given that most female home ranges are in areas that historically experienced logging followed by fire suppression. This uncertainty is considered in establishing desired conditions and conservation measures in Section 4.

Measures of canopy cover used in these analyses and desired conditions are based on vertical tree canopy projections from above (EVEG classes) and not on FVS-derived metrics, which generally underestimate canopy cover, especially at higher values (e.g., Fiala et al. 2006 and Appendix A-4). FVS-derived canopy cover values lower than the EVEG-based desired conditions do not necessarily indicate that desired conditions are not being met. To determine if desired conditions are being met requires developing appropriate equations or cross-walk tables to convert FVS-derived canopy cover estimates to be consistent with these EVEG classes.

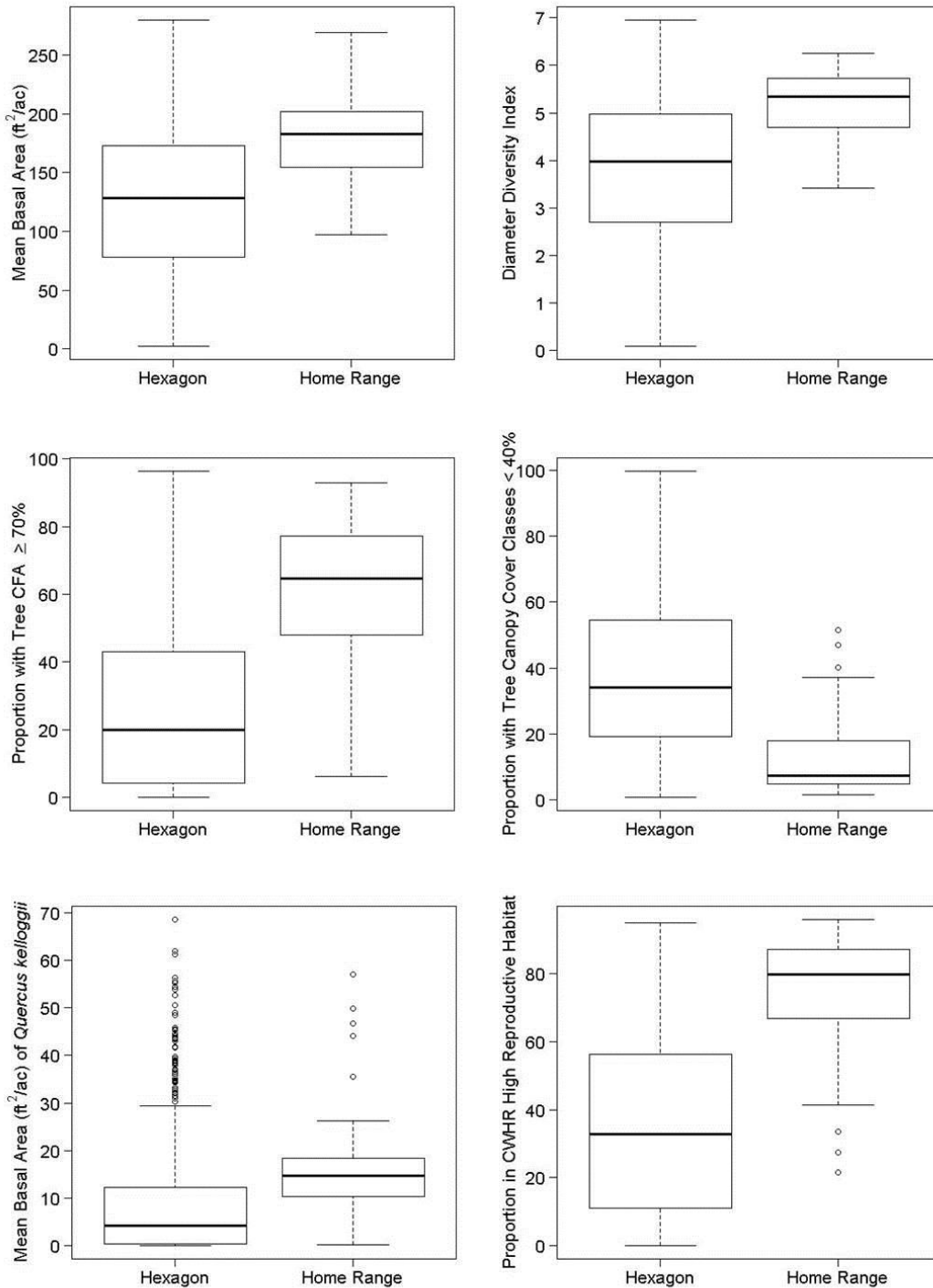
Figure 18 compares the composition of female home ranges to available conditions in the Strategy Area for select variables. It illustrates that, compared to available conditions, female fishers site their home ranges in areas with high basal area of trees, high diversity of tree stem diameters, abundant dense (>70%) canopy cover<sup>17</sup>, low proportion of open (<40%) canopy cover, moderate basal area of black oaks, and abundant CWHR high-value fisher reproductive habitat.

Habitat variables used in the PCA were also entered into a Classification and Regression Tree (CART) analysis, which derives a simple set of *if-then* logical conditions classifying whether habitat is suitable or not to support a female home range by comparing the composition of the 83 home ranges to randomly selected unsuitable cells (excluding Core 1 for reasons described above and excluding cells classed as having low site potential; Appendix A-2.2). The CART analysis demonstrates that female fisher home ranges can be accurately distinguished from random locations as having >60% of their area in CWHR high-value fisher reproductive habitat (variable PLAND)<sup>18</sup> and >2.8 ft<sup>2</sup>/ac BA of black oak.

<sup>17</sup> Appendix A-2.1 provides additional details of the canopy cover selection analysis used to define open vs dense canopy for use in fisher habitat suitability analyses and establishing desired conditions.

<sup>18</sup> CWHR classes comprising fisher high value reproductive habitat (variable PLAND in our analyses) are vegetation types Douglas Fir, Eastside Pine, Jeffrey Pine, Lodgepole Pine, Montane Hardwood-Conifer, Montane Hardwood, Montane Riparian, Ponderosa Pine, Red Fir, Subalpine Conifer, Sierran Mixed Conifer, or White Fir in size and density classes 4D, 5M, 5D, or 6, where Class 4 has mean dbh of 11-24 in, 5 is dbh >24 in; density class M has canopy cover 40-59% and D canopy cover >60%; and Class 6 has size Class 5 trees over a distinct layer of Class 4 trees and canopy cover >60%.





**Figure 18—Statistical boxplots comparing characteristics of female home ranges to available cells in the Strategy Area for select variables.** Bold horizontal lines are the means; boxes are the middle two quartiles; whiskers are 95% confidence intervals; and points are outliers. See Table 3 for variable descriptions.

The strong predictive value of PLAND as a landscape-scale variable might seem to suggest that CWHR classes 4D, 5M, 5D, and 6 all contribute positively to habitat value. However, class 5M has lower canopy cover (40-59%) than research has consistently suggested is suitable for fisher habitat, including for resting, denning, foraging, and female dispersal (Zielinski et al. 2004b, 2006; Purcell et al. 2009, Truex and Zielinski 2013, Tucker 2013, Spencer et al. 2015). We therefore performed additional use-availability analyses using t-tests and selection indices (Jacob's and Manly) to determine whether fishers are selecting for or against the various size/density classes in CWHR high reproductive habitat (see Appendix A-2.3 for details). The analyses consistently showed that female fishers are significantly selecting *against* class 5M (large trees, 40-59% canopy) and *for* classes 4D and 5D (moderate-large trees,  $\geq 60\%$  canopy). This finding is also consistent with the finding that modeled denning habitat covers the majority of acreage within female home ranges (mean =  $85\% \pm 22\%$  SD, N = 83) and that dens are very strongly associated with CWHR classes having  $\geq 60\%$  canopy cover (Spencer and Rustigian-Romsos 2012). Taken together with previous assessments of fisher habitat requirements, the finding that fishers require a significant proportion of the landscape to be  $\geq 60\%$  canopy cover is strongly supported. Moreover, female fishers preferentially select habitat with  $\geq 70\%$  canopy cover (Figure 18). We reiterate that these canopy cover estimates from EVEG are generally higher than those estimated using FVS (Fiala et al. 2006 and Appendix A-4).

Fishers live in forests shaped by logging, grazing, fire suppression, and other management actions—as well as climate change—which have altered habitat conditions. Sierra Nevada forests now support fewer large trees and more small trees, less pine and oak and more firs and cedars, higher overall tree stem densities, and larger, more continuous areas of dense forest canopy than a century or more ago (Section 4.2). These conditions may reduce forest resiliency to fires, drought, insect outbreaks, climate change, and other factors. The goal to maintain or increase suitable fisher habitat must therefore be compatible with the equally important goal to increase habitat resiliency. *We recommend additional study of habitat conditions that are sufficiently resilient and also suitable to support breeding female fishers. Results of such analyses could be used to refine the desired conditions described in Section 4.3 and conservation measures described in Section 4.5.*

## 4 Habitat Conservation and Enhancement

Active habitat management is needed to achieve multiple fisher conservation goals and objectives as defined in Section 1, including increasing the size and distribution of the population, reducing mortality rates, increasing habitat resiliency, and maintaining genetic diversity. This section provides guidance for designing, siting, and analyzing habitat management projects to meet fisher conservation objectives.

### 4.1 Conservation Targets

The Strategy's biological goal of maintaining or increasing fisher population size and distribution requires that (1) the amount of suitable home range habitat be relatively stable or increasing, and (2) currently unoccupied but suitable habitat becomes occupied in the future. Using cell score as a proxy for home range habitat suitability, this requires (1) maintaining or increasing the number of suitable cells in each core area, (2) increasing the proportion of suitable cells that are occupied by females (especially in unoccupied Cores 6 and 7), and (3) increasing the long-term resiliency of cells to reduce potential of habitat losses to large disturbances.

#### 4.1.1 Enumerating Conservation Targets

To establish realistic *conservation targets* for the desired number of suitable cells on the landscape, it is important to consider how many suitable cells are *possible* in the future, given biophysical constraints on the land's capacity to support fisher habitat (dense-canopied, large-tree forests) and taking into account the dynamic nature of the ecosystem—with fires, management, succession and other processes changing the habitat mosaic over time. Establishing targets for the number of fisher-occupied cells (*population targets*) requires understanding the probabilities and rates at which the population may expand into currently unoccupied areas.

Conservation targets are established over a roughly 30-year time horizon, beyond which uncertainties about climate and vegetation change magnify<sup>19</sup>. We assessed the first objective (increasing potential amount of suitable home range habitat over 30 years) using a dynamic time-series analysis of changes in vegetation conditions and home range habitat value over the past 2-3 decades, and assumed that the overall effects on habitat quality of disturbance processes observed during this period remain roughly constant for the next 3 decades (Appendix A-3).

For the second objective (expanding the fisher population to fully occupy suitable habitat in Cores 6 and 7), we used expert opinion to establish a goal of complete occupancy of suitable habitat in Cores 6 and 7 by the year 2040. Although this may be optimistic, especially in light of the 2013 Rim Fire effects on fisher core and linkage habitat, it is consistent with evidence that the population reached its current northern extent by expanding north from near the Kings River across Cores 4 and 5 during the past 2-3

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<sup>19</sup> Climate change is undoubtedly one factor affecting the trends observed in the analyses described in this section, but it is extremely difficult to parse out effects of climate change from those of other processes (e.g., recovery from past and present management actions). If climate change effects are accelerating, future projections for the potential number of suitable cells would change to an unknown degree. The Strategy therefore focuses on near-term habitat conditions with intent to more explicitly address climate change during adaptive management.

decades (Tucker et al. 2014, Spencer et al. 2015)—roughly the same distance as needed to expand across Cores 6 and 7.

Although these future projections of vegetation change and population expansion are uncertain, they serve as a defensible foundation for establishing realistic conservation targets for fisher home range carrying capacity and population size. These estimates and targets should be further investigated and refined with additional data and modeling (e.g., using the spatially explicit population model HEXSIM) and subject to the robust adaptive monitoring program described in Section 8. Progress toward these targets should be assessed regularly (every 5 years) as part of the monitoring program (Section 8).

Table 5 estimates the number of suitable home range grid cells within each core area in 2010 and 2040 based on a time-series analysis of changes in cell scores from 1990-2012, using a version of the female fisher PCA equation and GNN vegetation data obtained for the years 1990, 2000, and 2012 (Appendix A-3.1). These data allowed us to calculate transition probabilities between 6 different cell suitability classes (from 0 = suitable to 5 = highly unsuitable) at roughly decadal time steps using a Markov chain analysis (Appendix A-3.2). The analysis takes into consideration that not all cells in the Strategy Area have the potential to become suitable in the future due to biophysical constraints (e.g., shallow soils, low site productivity), and it accounts for habitat dynamics (losses due to disturbances and gains due to vegetation growth and succession). Among other things, the results demonstrate the rate at which cells can recover to suitable habitat condition following disturbances, such as severe fire or timber harvest (Appendix A-3.3). The analyses detailed in Appendix A-3 show that forest growth (sometimes transitioning cells from unsuitable to suitable) has in recent decades more than compensated for disturbances like severe fire (which sometimes transition cells from suitable to unsuitable), resulting in a net increase of 39 suitable cells from 1990-2012. The analysis predicts that, if the effects of disturbance and succession on habitat value observed during 1990-2012 continue at roughly the same rates until 2040, we can expect an additional increase of ~30 suitable cells in the Strategy Area by the year 2040 (from 415 to 445, Table 5)<sup>20</sup>.

**Note:** Conservation targets currently reflect conditions prior to 2013 and do not account for habitat changes due to recent large fires, such as the Rim Fire and French Fire. Numbers will be updated when updated vegetation layers are available.

The future projections in Table 5 represent this potential increase as a “baseline” for establishing conservation targets that reflects a “status quo” assumption about rates of vegetation disturbances due to both controllable (e.g., management actions) and uncontrollable events (e.g., droughts, wildfires). *If future management actions are actually more successful at restoring habitat value and resiliency than past actions, these estimates could be surpassed; if, on the other hand, the coming decades experience more severe disturbance due to climate change, drought, insect outbreaks, and large severe fires, the estimates may not be met.*

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<sup>20</sup> The FTT is pursuing development of core-specific models and targets for Core 1, where current models apparently underrepresent habitat value and home range capacity, probably due to significant differences in ecological conditions on the Kern Plateau compared to the west-slope cores. More intensive sampling of fisher occupancy in Core 1 during 2014 by the regional monitoring program will soon be available to support this effort (J. Tucker, personal communication). In the meantime, all predictions for Core 1 should be considered unreliable.



**Table 5—Predicted number of suitable home range cells in each fisher core area in 2010 and 2040.**

Core 1 has no predicted potential to support breeding females according to currently available data, despite known presence of female fishers; this will be rectified during implementation with a specific approach for Core 1. Estimates for Cores 4-7 do not yet reflect vegetation changes due to large, severe fires during 2013-2014.

Core	Total cells	Low potential cells	2010 suitable cells	2040 suitable cells	Net expected increase
1	80	17	0	0	0
2	151	34	51	55	4
3	159	15	64	69	5
4	142	10	53	57	4
5	173	14	88	94	6
Occupied subtotal	705	90	256	275	19
6	73	10	29	31	2
7	234	7	130	139	9
Unoccupied subtotal	307	17	159	170	11
Total	1,012	107	415	445	30

<sup>a</sup>Core 1 is known to be occupied even though the analysis shows no suitable cells there, probably due to unique environmental conditions compared to other cores. A separate scoring equation should be developed for Core 1.

Based on this analysis and the assumption that Cores 6 and 7 can be fully occupied by a breeding fisher population in the coming decades, the Strategy establishes the following conservation targets for the year 2040:

- Habitat targets.** Increase the total number of suitable home range cells in the Strategy Area, and in each core area, by at least the numbers shown in Table 5 (except for Core 1, for which a separate, higher, estimate is to be developed and added to Table 5).
- Population targets.** Increase fisher occupancy and total female population size in the Strategy Area, and in each core area, to at least the numbers shown in Table 6 (except for Core 1, for which a separate, higher, estimate is to be developed and added to Table 6).
- Resiliency targets.** Increase to a designated target level [*to be determined based on further analyses; see text box*] the proportion of suitable cells considered resilient based on appropriate metrics, such as modeled fire risks (e.g., based on expected flame lengths or proportion crown fire modeled under appropriate fire weather conditions), stand density index, or modeled insect mortality risks.

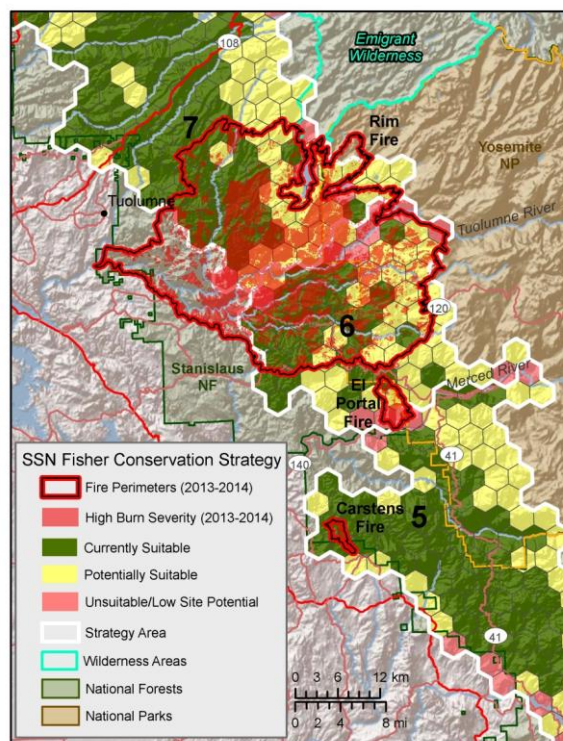
**Note:** Quantitative metrics of fisher habitat resiliency are currently being developed based on analyses of existing data and ecological models that predict degree of risk (or, conversely, resiliency) to fisher habitat quality from fire, drought, insects, diseases, or other disturbances. The results will be used to establish fisher habitat resiliency targets that can be tracked using the management grid system.

**Table 6—Potential female population size in each core area in 2010 and 2040, assuming population expansion to fully occupy Cores 6 and 7 by 2040.** Core 1 has no predicted potential to support breeding females according to currently available data, despite known presence of female fishers; this will be rectified during implementation with a specific approach for Core 1. Estimates for Cores 4-7 do not yet reflect vegetation changes due to large, severe fires during 2013-2014.

Core	2010 potential female population	2040 potential female population	Net increase	% increase
1	0	0	0	0%
2	51	55	4	8%
3	64	69	5	8%
4	53	57	4	8%
5	88	94	6	7%
Occupied subtotal	256	275	19	7%
6	0	31	31	NA
7	0	139	139	NA
Unoccupied subtotal	0	170	170	NA
Total	256	445	189	74%

<sup>a</sup>Core 1 is known to be occupied even though the analysis shows no suitable cells there, probably due to unique environmental conditions compared to other cores. A separate scoring equation should be developed for Core 1.

The template tracking system, in concert with fisher occupancy monitoring, can be used to track progress toward these conservation targets on a roughly 5-year schedule (Section 8). The Strategy acknowledges that meeting these targets by the year 2040 cannot be guaranteed due to factors beyond management control, such as large crown fires during severe weather conditions. The 2013 Rim Fire, for example, burned 29 cells at high severity over  $\geq 50\%$  of their area (Figure 19). Although changes in the cell PCA scores cannot be calculated until the vegetation data are updated, the Rim Fire probably shifted  $\sim 14$  or more cells from suitable in 2010 to unsuitable in 2015. It also shifted the modeled linkage area upslope to the east into areas that burned at lower severity or not at all (Spencer et al. 2015). Based on rates of recovery observed in the GNN time-series analysis (Appendix A-3.3), we suspect recovery to functional habitat quality to take decades. In the event of large, unforeseen impacts to fisher habitat, the schedule for achieving conservation targets should be re-evaluated, and the monitoring program adjusted as needed (Section 8).



**Figure 19—The 2013 Rim Fire burned portions of Cores 6 and 7 at high severity and probably made  $\sim 14$  cells that were suitable in 2010 unsuitable in 2015 and reduced dispersal potential between cores.**

Northward population expansion into Cores 6 and 7 has greater potential to increase total population size than habitat improvement alone. Currently, about 41% of land within the Strategy Area is suitable to support female fisher home ranges (46% of land not constrained by low site potential, Table 4), and only 62% of that suitable habitat is in cores currently supporting a reproducing fisher population. The ultimate objective is to increase this to  $\geq 44\%$  suitable habitat (445 of 1,012 total cells)—or  $\geq 49\%$  of land not constrained by low site potential (445 of 905 cells)—but with nearly 100% of that suitable habitat occupied by fishers (Table 6). If conservation actions can both meet the habitat suitability targets and facilitate population expansion across Cores 6 and 7, this could increase total female fisher carrying capacity by  $\sim 74\%$ , from a current estimate of  $\sim 256$  to a possible future size  $\geq 445$  (Table 6).

#### 4.1.2 Mapping Target Cells

Fisher *target habitat* is represented as *target cells* in the fisher management grid system. The preceding section established the desired *number* of target cells in each core area, but their *locations* cannot all be mapped until appropriate resiliency targets and maps are also created (see Section 4.1). Ideally, target cells should be mapped using both fisher suitability status (Figures 13-16) and resiliency status (to be determined), so that management can be planned and prioritized to most effectively and efficiently meet both fisher habitat and forest resiliency goals. Mapping and prioritizing of target cells should also consider spatial configuration issues, such as proximity to linkage areas and patterns of contiguity or fragmentation of currently suitable habitat cells.

Once mapped, locations of target cells may change over time, e.g., following large, severe wildfires. Given the dynamic nature of this system, shifting target locations over time is acceptable, so long as the target numbers are maintained and habitat core and linkage areas are not significantly fragmented or severed.

Section 4.4 provides guidance for prioritizing where management actions can best help achieve these conservation targets by protecting suitable cells, promoting transitions from nearly suitable to suitable conditions, and strategically reducing hazardous fuel conditions in areas of highest fire risk. Specific management actions to help achieve the targets are described in detail in Sections 4.5 and 5.3.

## 4.2 Current Conditions

This section briefly summarizes landscape-scale habitat conditions in the Strategy Area, primarily as they pertain to achieving Objective 3.1: restoring fisher habitat resiliency and fire as an ecological process. The Fisher Conservation Assessment provides detailed descriptions of current fisher habitat conditions, core and linkage areas, and ecological conditions and processes in the Assessment Area.

Current fisher habitat conditions vary substantially across the Strategy Area and among the habitat core and linkage areas described in Section 2. Over much of the region, however, the fisher's mixed-conifer forest habitat is outside the natural range of variation (NRV) due to previous management actions and climate change (Safford et al. 2012, Mallek et al. 2013, Safford and van de Water 2013). This may elevate the risk of forest loss and fragmentation by large, severe fires and other disturbances (Miller et al. 2009, Churchill et al. 2013) and consequently, at least the temporary loss and fragmentation of fisher habitat (Scheller et al. 2011, Spencer et al. 2015).

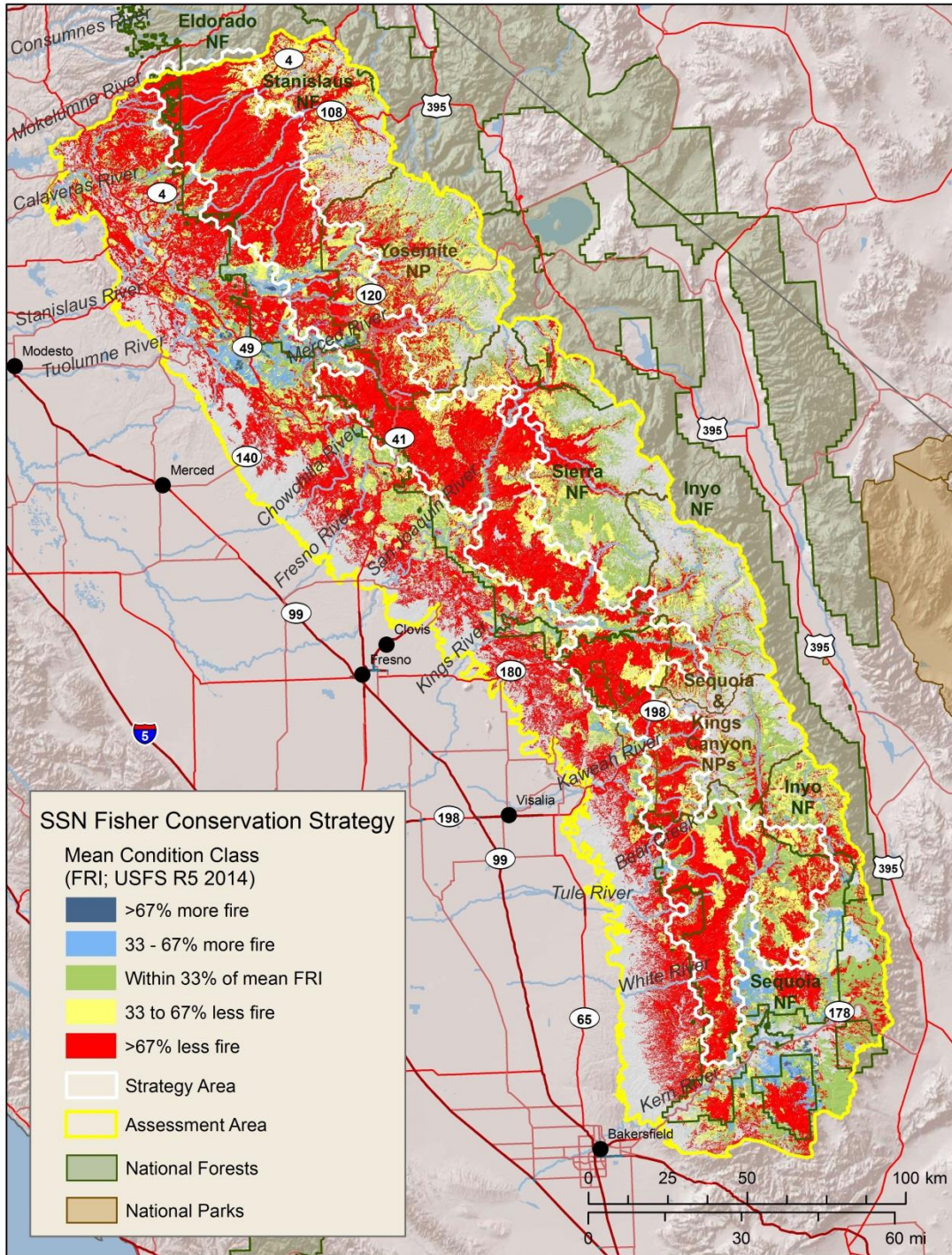
Figure 20 shows the current fire condition class, or fire return interval departure (FRID), in the fisher Assessment Area. This is a measure of the extent to which contemporary fires (1908-2012) are burning at frequencies similar to the frequencies prior to Euro-American settlement (Safford and van de Water 2013). Most of the Strategy Area has experienced substantially less fire over the past century than historically, due primarily to modern fire suppression. A consequence of fire suppression is that, for the most part, the fires having the greatest influence on the landscape are those that escape initial attack. Such fires can burn very large areas at high severity, especially during severe fire weather conditions, as observed in the 2013 Rim Fire (Lydersen et al. 2014). This departure from the natural fire regime is exacerbated by a changing climate, putting these forests at increased risk of loss due to severe, stand-replacing fires, droughts, and insect and disease outbreaks (Lenihan et al. 2003, 2008; Westerling and Bryant 2006, 2008; Westerling et al. 2011).

Historically, the yellow pine and mixed-conifer forest types were characterized by higher densities of large trees and lower densities of small trees than today, with about the same overall basal area but fewer trees per acre (Dolanc et al. 2014). Trees 24-36 in dbh, and especially trees >36 in dbh, have declined in abundance, and trees <24 in dbh have increased (Verner et al. 1992, North et al. 2007, Fellows and Goulden 2008, Lutz et al. 2009, Scholl and Taylor 2011, Dolanc et al. 2014, McIntyre et al. 2015, Stephens et al. 2015). Although the exact size threshold above which larger trees are in deficit varies among places, trees >36 in dbh are in deficit throughout the Sierra Nevada (Dolanc et al. 2014).

Forest stands at fine (stand and sub-stand) scales are also more homogeneous, with less patchy patterns of tree size and density (Agee 1993, Barbour et al. 1993, 2007; SNEP 1996, Sugihara et al. 2006), increased tree clump size (Lydersen et al. 2013), and decreased proportion in canopy gaps (Lydersen et al. 2013) than they were historically. Forest composition has also shifted, with declines in abundance of shade-intolerant pines and increases in shade-tolerant species like firs and cedars (Barbour et al. 2002, Guarin and Taylor 2005, Dolanc et al. 2014, McIntyre et al. 2015, Stephens et al. 2015). This elevates the risk of crown fires, as firs often retain both live and dead branches down to the ground, creating ladder fuels.

Recent studies have documented high mortality rates of trees throughout the Sierra Nevada (van Mantgem et al. 2009), including higher than expected and accelerating rates of loss of the largest size classes (e.g., >36 in dbh, Smith et al. 2005, Lutz et al. 2009, Fellows and Goulden 2012, McIntyre et al. 2015). This threatens to reduce the availability of the large trees fishers require for resting and denning structures. The increasing mortality of large trees is suspected to reflect effects of climate change, drought, and water stress (Fellows and Goulden 2008, Lutz et al. 2009, McIntyre et al. 2015) in interaction with multiple other factors, including pathogens, insects, and air pollution (Guarin and Taylor 2005, Smith et al. 2005, Das et al. 2011, McIntyre et al. 2015). In particular, there has been a recent dramatic increase in loss of large trees due to bark beetles, which are currently considered one of the principal agents of tree mortality in the Sierra Nevada (Fettig 2012).





**Figure 20—Fire return interval condition class in the Assessment Area.** Most forests within the Strategy Area (white border) have experienced significantly less fire during the period 1908-2012 than during pre-EuroAmerican settlement, thus elevating fuel loads and risks of severe fires (Safford et al. 2014: <http://www.fs.usda.gov/main/r5/landmanagement/gis>).

Increased tree density plays a role in elevating tree mortality (Guarin and Taylor 2005, Smith et al. 2005, Zhang et al. 2006, Das et al. 2011), but competition is not always the driving force in mortality processes (Das et al. 2011), which depends largely on site conditions. For example, North et al. (2009) emphasize that groups of intermediate and large trees are not necessarily moisture-stressed by within-group competition, because they have deep roots that can access reliable ground water sources, such as fissures in bedrock (Arkley 1981, Hubbert et al. 2001, Hurteau et al. 2007, Plamboeck et al. 2008). Furthermore, reconstructions of historical conditions in Sierran forests with active fire regimes have consistently found large trees in groups. Thus, depending on location and ecological traits, tree density alone is not necessarily sufficient rationale to support the removal of larger trees to reduce competition (M. North, personal communication). Nevertheless, stand density (number of trees per acre) is strongly implicated in reduced vigor and mortality due to insects, water stress, and other factors, and reducing tree density using principles in GTR 220 (North et al. 2009) is considered one of the most effective approaches to reducing tree mortality in fire suppressed forests (review in Fettig 2012).

### 4.3 Desired Conditions

To meet the conservation targets established in Section 4.1, habitat management should create or maintain the following desired vegetation conditions within the Strategy Area<sup>21</sup>. The focus is on providing habitat conditions that can support breeding female fishers now and in the future while improving habitat resiliency to extreme disturbance events. Fire resiliency is increased most significantly by reducing surface and ladder fuels (North et al. 2009 ); resiliency to climate change, drought, and other stressors may be increased by providing naturally heterogeneous habitat conditions that reflect physical (e.g., topographic, edaphic, and climatic) influences on vegetation condition, fire behavior, and other ecological processes (GTR 220/237).

#### 4.3.1 Entire Strategy Area

The following conditions are desirable anywhere within the Strategy Area, even in portions not specifically targeted for restoring or maintaining female fisher habitat (Section 4.1).

- Vegetation occurs in a complex mosaic across the landscape and varies in ecologically appropriate ways with topography, soils, and microclimate—with, for example, denser forests on mesic slopes and in drainages and swales and more open conditions on xeric slopes and ridges (North et al. 2009).
- Fire operates as a key ecological process, within the NRV, in all vegetation communities. Fires create mosaics of varying forest composition and structure and help recruit important wildlife habitat elements, including large dead-wood structures and complex early seral habitats.
- Trees and other vegetation recover from disturbances via natural regeneration, growth, and dispersal processes and respond adaptively to changing climate and other conditions. Post-

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<sup>21</sup> These desired habitat conditions should be updated when more quantitative analyses of fisher habitat resiliency are completed. They currently reflect statistical analyses performed for this Conservation Strategy (Appendix A-2) and the Conservation Assessment (Spencer et al. 2015); recent literature on fisher habitat requirements (as summarized in the Conservation Assessment); recommendations by Freel (1991) and Heinemeyer and Jones (1994); and deliberations among biologists, silviculturists, and others involved in the Dinkey Collaborative Forest Landscape Restoration project.

disturbance management actions, such as tree planting and herbicide application, therefore become largely or wholly unnecessary<sup>22</sup>.

- Native wildlife species that contribute to the formation of cavities and tree deformities, such as woodpeckers and porcupines, occupy all appropriate habitats at natural population levels; and endemic pathogens that create decay, deformities (e.g., epicormic branching, mistletoe, witches brooms), and mortality in trees through natural ecological processes are present at natural levels.

#### 4.3.2 Habitat Conditions in Fisher Target Cells

The following conditions are desirable where restoring or maintaining female fisher home range habitat is a conservation priority—i.e., in *target cells* as defined in Section 4.1. Recognizing ecosystem dynamics (e.g., forest growth and natural disturbance processes), these conditions are not expected to be met everywhere simultaneously.

##### **Fisher reproductive habitat**

- At least 60% of each target cell is in CWHR fisher high reproductive habitat value (CWHR classes 5M, 4D, 5D, and 6).

##### **Tree canopy cover<sup>23</sup>**

- At the home range scale, >50% of a target cell supports tree canopy cover  $\geq 70\%$  (as measured by EVEG), with dense stands patchily distributed in mosaic with patches of more open (<40% cover) and moderate (40-69%) canopy forest to provide habitat heterogeneity.
- At finer scales, dense canopy stands are punctuated by small gaps (~0.1-2.0 ac each with an overall average of ~0.25 ac) to increase forest structural diversity (Knapp et al. 2012, Lydersen et al. 2013, Safford 2013).

##### **Basal area**

- Within each fisher target cell, basal area of mixed-conifer forest averages  $\geq 150 \text{ ft}^2/\text{ac}$ , ranging from  $\sim 100 \text{ ft}^2/\text{ac}$  to  $>400 \text{ ft}^2/\text{ac}$  at finer scales, depending on site conditions.
- Basal area of black oaks increases where site conditions allow<sup>24</sup>. Black oaks are well-distributed within mixed-conifer and conifer-hardwood stands and are growing and reproducing vigorously.

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<sup>22</sup> We recognize that achieving this desired condition of a self-sustaining ecosystem with no need for human intervention may be difficult or unrealistic to attain in some locations due to currently altered ecological conditions and climate change, which may disrupt ecological succession and habitat recovery processes following large disturbances. Nevertheless, a resilient forest that requires little management intervention is the desired landscape condition.

<sup>23</sup> Measures of canopy cover used herein are based on vertical canopy projections from above (EVEG classes) and not on FVS-derived metrics, which generally underestimate canopy cover, especially at higher values (e.g., Fiala et al. 2006 and Appendix A). Canopy cover values not based on vertical projections of actual tree canopies should be adjusted with an appropriate conversion factor to determine if desired conditions are being met.

<sup>24</sup> We do not explicitly provide a desired basal area range for black oaks due to large variation in oak abundance in fisher home ranges, but in general most female home ranges have  $\sim 10\text{-}20 \text{ ft}^2/\text{ac}$  (Figure 18). Whether higher levels than this are even better for fishers is unknown, but statistical analyses suggest that fishers are not selecting for oak-dominated habitats (e.g., oak woodlands) but rather mixed conifer forest with some admixture of oaks.

### **Fisher habitat elements**

- Essential fisher habitat elements, including large living and dead trees (especially pines and oaks) and structures used by fishers for resting and denning (cavities, deformities), are common and well distributed. Endemic levels of wildlife species and pathogens that create decay, deformities (e.g., epicormic branching, mistletoe, and rust brooms), and mortality in trees through natural ecological processes are present within NRV.
- Snags occur in all size classes, but with many >35 in dbh or the largest possible depending on site conditions. At the landscape and stand scales, mixed-conifer forests have on average 5-40 large snags >20 in dbh per 10 acres, but densities vary tremendously at finer scales. Snags are clustered at the stand scale, with most dense clusters found near canyon bottoms and on mesic slopes. At the finer scale, snag densities range from 0-25 snags per acre.
- At the landscape scale, mixed-conifer forests support an average 3-5 tons of large (>20-in diameter) logs per acre (but favoring the largest logs available); at finer scales, log density varies widely across the landscape, with some patches of high abundance (>5 tons/acre) and others with lower densities (<1 tons/acre), with higher log densities concentrated in more mesic areas (drainages and north slopes) and in late-seral dense canopy stands.

### **Fisher habitat resiliency**

- Fuel conditions support mixed severity fire under 90<sup>th</sup> percentile weather conditions, with a majority of the area sustaining low and moderate severity fire. Conditional flame lengths (CFL) under 90<sup>th</sup> percentile weather conditions are mostly 0-6 ft (Fry et al. 2015), with some longer flames that result in patchy torching and tree mortality.
- Canopy cover is highly variable based on site potential and landscape position, with dense canopies ( $\geq 70\%$ ) dominating in relatively mesic areas—such as in canyons, swales, and on north and east slopes—and open canopies (<40%) dominating more xeric slopes and ridges (North et al. 2009, Lydersen and North 2012).
- At the stand scale (tens to hundreds of acres), the basal area of trees is highly variable, occurring in tree groups and gaps (North and Sherlock 2012). Drainage bottoms, swales, and northeast-facing slopes generally have greater tree densities and basal areas than other areas (North et al. 2009).

#### **4.3.3 Habitat Conditions in Linkage Areas**

- Fisher linkage areas support patchy vegetation, with some moderate to dense tree canopy cover where site conditions allow, such as along riparian corridors—and shrub cover where forest cover is inadequate—and have minimal impediments to fisher movements, such that fishers disperse frequently enough to maintain genetic diversity within and among subpopulations.
- Core habitat areas adjacent to linkages support high-value fisher home range and denning habitat to maximize potential of reproduction close to linkages and dispersal across linkages.
- Barriers or strong impediments to fisher movement do not completely sever any linkage.
- Risk of stand-replacing fires in linkage areas is reduced; fires starting in lower-elevation chaparral habitats are less likely to burn forested areas within linkages at high severity.



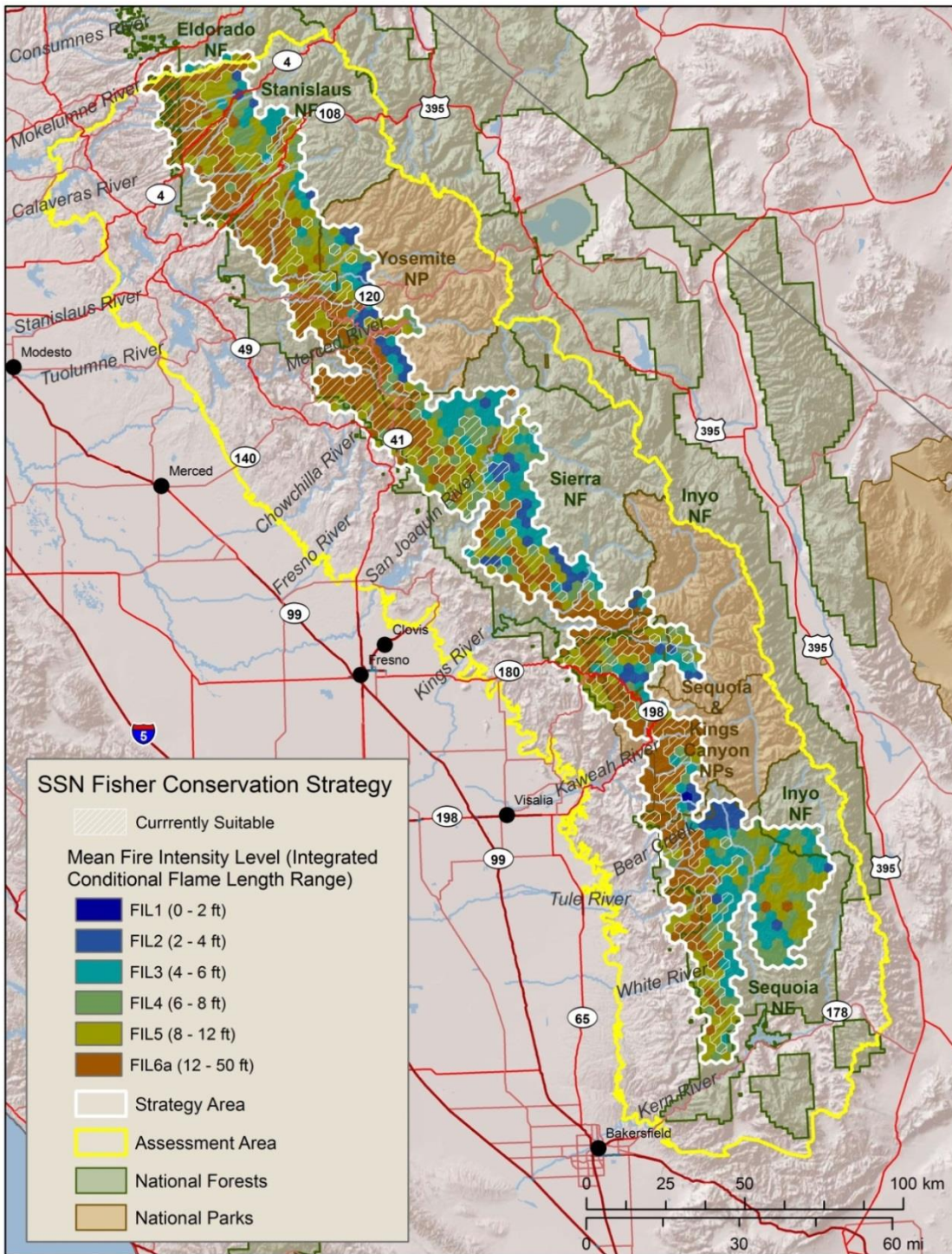
## 4.4 Assessing Conditions for Project Planning and Design

Decisions made during planning, design, and implementation of habitat management projects should be documented as part of the adaptive management record to inform future decisions. A project evaluation should be prepared by a qualified biologist to (1) assess fisher habitat and resiliency conditions at the landscape, home range, and stand scales, (2) compare them to desired conditions, and (3) recommend how best to achieve fisher conservation objectives. The multi-scale evaluation should also explain the rationale for project design features and decisions, and reasons for any deviations from recommendations or guidelines in this fisher Conservation Strategy.

For efficiency, projects should be planned at landscape (or fireshed) scales and be designed to facilitate a transition to where natural wildfire (or use of wildland fire) can manage significant portions of the landscape—at least where risks to human communities and other constraints on using fire are not too high. Planners should identify where on the landscape fire is likely to burn with desirable effects, within the natural range of variation, under moderate weather conditions—as well as where pretreatment with mechanical methods and/or prescribed fire are first necessary. Mechanical treatments alone are unlikely to restore resilient conditions due to numerous well-documented constraints; where feasible, they should be used to create “anchor points” from which prescribed fire and wildland fire can be predominant management tools (North et al. 2012).

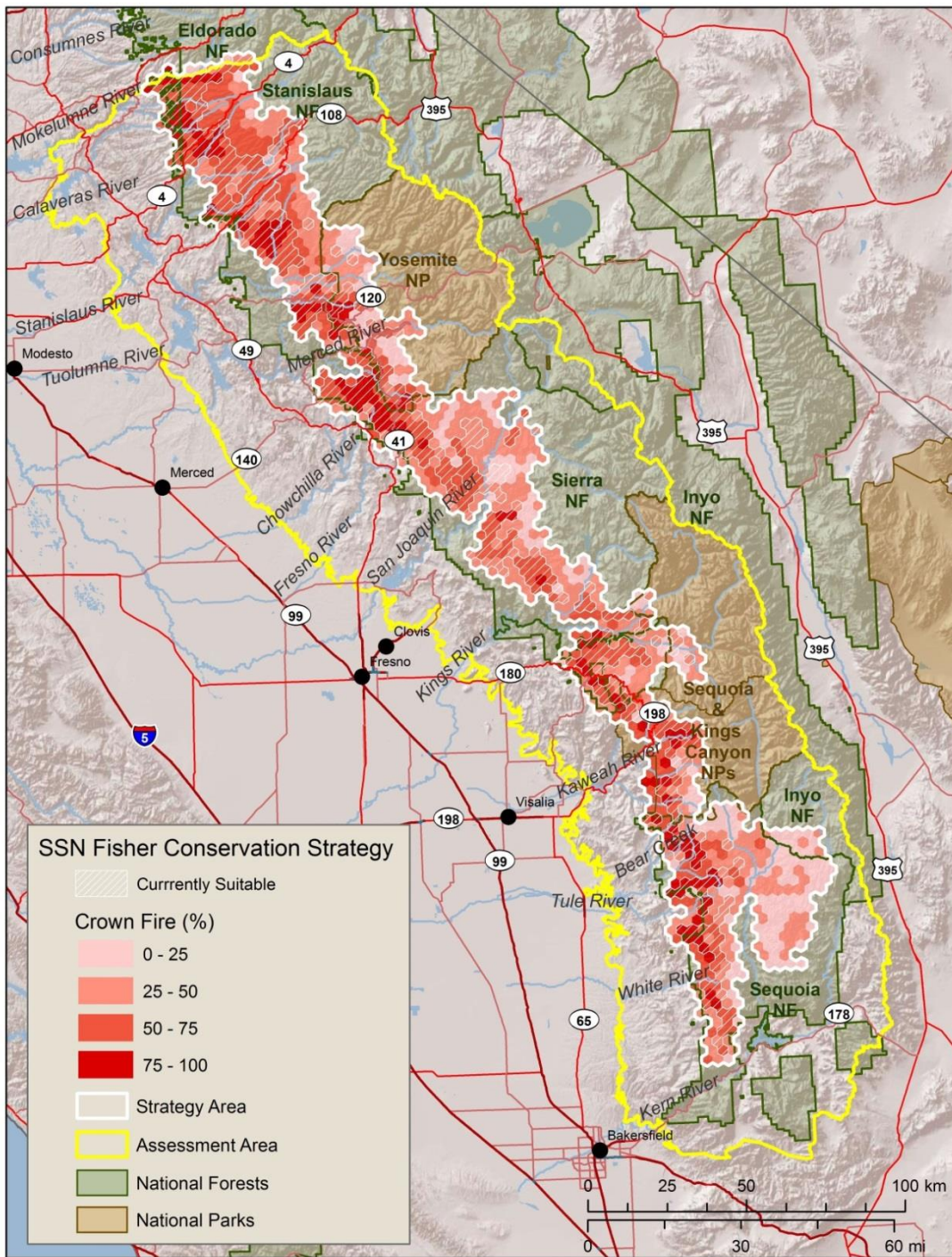
Project evaluation should begin with a landscape-scale assessment of general conditions, including fuel conditions and the current and targeted suitability status of female home range cells in and adjacent to the area of interest. This includes an evaluation of fire risk and hazard using data and tools—such as those provided by LANDFIRE or appropriate fire management or hazard zone maps and analyses—to identify areas of highest priority for reducing fire hazards to fisher habitat. Figures 21 and 22 illustrate two draft data layers that may be useful in prioritizing management actions to reduce risk of severe disturbance based on two metrics of fire risk: conditional flame length (Figure 21) modeled based on fuel conditions, terrain, weather patterns, and fire history; and fire type (crown vs other) modeled under severe (97%) fire weather conditions (Figure 22). *Additional models should be developed to help highlight areas where prescribed fire and use of wildland fire are priority management tools, for example, by considering degree of risks to fisher habitat elements under more moderate fire weather conditions.*

At the home range scale, the assessment should evaluate fisher habitat quality and resiliency within management grid cells using the metrics and tools introduced in Section 3 (PCA hull, habitat slider tool, flame length slider tool, etc.). Cells that are currently suitable to support female fishers should be maintained in that status to the degree possible while maintaining or improving habitat resiliency. Cells that are currently unsuitable but have potential suitability in the near term (<30 years) should be managed toward that condition while also maintaining or improving resiliency. To some degree, conditions selected by fishers (dense, multi-layered canopies, abundant dead woody structures) may increase risks of tree loss due to fires, droughts, and other disturbances, but restoration treatments should be designed to balance these concerns by reducing surface and ladder fuels and increasing habitat patchiness according to GTR 220/237 principles.



**Figure 21—Modeled fire intensity level (conditional flame length) summarized by home range cells.** Cells with high expected flame lengths in or adjacent to currently suitable cells and fisher linkage areas could be high priorities for vegetation treatment actions. The model does not reflect changes due to the 2013 Rim Fire. Source: Scott et al. (In Prep).





**Figure 22—Expected percent crown fire summarized by home range cells.** Cells with high expected proportions of crown fire ( $\geq 50\%$ ) modeled under 97% fire weather conditions. Cells in and adjacent to suitable fisher cells and linkage areas could be high priorities for vegetation treatments to reduce risks of crown fire. The model does not reflect changes due to the 2013 Rim Fire. Source: Scott et al. (In Prep).

## 4.5 Conservation Measures

This section presents fisher conservation measures, primarily as guidance for the placement, design, and implementation of vegetation management actions to promote the fisher conservation goals and objectives defined in Section 1.4. The section is not rigidly organized by the goals and objectives, because many conservation measures contribute to multiple objectives and all objectives require application of multiple measures.

These guidelines should be implemented within an adaptive management framework and refined as information accrues from monitoring (Section 8) and research (Section 9). This requires documenting project decisions and evaluating their outcomes for the adaptive management record. Project evaluation documents should describe adherence to or deviations from these guidelines (Section 4.4), and monitoring should test whether assumptions and predictions were correct or should be revised for future projects.

Mechanical vegetation treatments should be implemented in a multi-disciplinary framework. Marking crews could work with silviculturists and biologists familiar with fisher habitat to discuss these guidelines in the field and implement marking rules that translate the intent of the guidelines into effective on-ground actions that maximize benefits and minimize potential impacts to fishers and fisher habitat.

### 4.5.1 Maintain Well-distributed and Connected Fisher Habitat

To achieve Goals 1 and 2 and their constituent objectives of increasing the geographic extent of occupied habitat, increasing carrying capacity within core areas, and increasing dispersal potential between core areas (Objectives 1.1-2.1), conservation measures must maintain well-distributed and connected fisher habitat in the Strategy Area. In addition to tracking progress towards conservation targets for the *number* of suitable grid cells in each core area (Section 4.1), the management grid system can be used to help maintain adequate *dispersion and connectivity* among suitable cells within a core area and across linkage areas. This section provides guidelines to help achieve this by considering the spatial context of vegetation management relative to suitable and unsuitable cells and linkage areas so that treatments can be dispersed and phased to avoid habitat and population fragmentation.

These guidelines should be sensitivity tested and fine-tuned using the spatially explicit population model HEXSIM (which also uses female home range-size cells as a grid system, Schumaker 2015). Scenario testing can help optimize how management should be distributed and phased over time to best achieve fisher conservation targets.

#### **In fisher core areas**

Use the management grid system, habitat value slider tool, and multi-scale habitat assessment methods (Section 4.4) to achieve desired landscape- and home range-scale conditions described in Section 4.3.2 and to help keep grid cells in suitable condition to support breeding females, or to move potentially suitable cells into suitable condition. Disperse treatments in space and time to avoid fragmenting core areas or degrading dispersal probability between core areas.

- Avoid treating two or more adjacent cells in a manner that creates simultaneously unsuitable conditions in each.
- Avoid treating one or more cells adjacent to recently disturbed (e.g., severely burned) cells in a manner that reduces their suitability for more than 5 years.



### **In fisher linkage areas**

Manage vegetation in linkages to promote and protect forest cover—or alternative cover such as shrub patches and scattered trees that might be used by dispersing fishers.

- Avoid actions that could create an unsuitable grid cell within or adjacent to a linkage, and favor actions to protect linkage areas from severe disturbances.
- Where site conditions permit, maintain or increase tree canopy cover in delineated linkage areas, particularly in drainages, more mesic north-facing slopes, and riparian corridors.
- Protect forested portions of linkages from stand-replacing fire through vegetation management to reduce ground fuels and retain trees, and protective measures during wildfires (such as backfiring from top of slope at night). Consider strategic placement of treatments on either side of a linkage area to slow the spread of fire and provide firefighter access during a fire.
- Avoid creating openings (<30% tree or shrub cover) that completely sever any linkage, while strategically breaking up vegetation continuity as necessary to achieve desired fuel conditions.
- Based on site potential, retain and promote shrub cover clumps, downed logs and standing trees, either single or in small groups, within open areas (Freel 1991, Heinemeyer and Jones 1994).
- Prevent new barriers (e.g., water reservoirs) from being created in linkage areas.

### **In large post-disturbance areas**

When large areas are disturbed by severe fires, insect outbreaks, or other processes, fisher habitat value may be lost for variable lengths of time. Nevertheless, post-disturbance management should consider both the short-term and long-term value of early-seral habitats to fishers and other wildlife, including support of fisher prey and recruitment of habitat elements (e.g., snags). Best management practices may vary with whether or not the disturbance is within the desired range of variability (e.g., mean stand-replacing patch size is <10 ac and maximum patch size is generally < 250 ac; Collins and Stephens 2010, Miller et al. 2012, Safford 2013, Meyer 2015).

- When the effects of a disturbance are within the desired range of variability, standing dead or dying trees should be left on the landscape for their ecological benefits to fishers and other wildlife.
- When the effects of disturbance are outside the desired range of variability, a variety of post-disturbance management actions may be considered, but preference should be for retaining standing dead or dying trees to provide fisher habitat elements as the vegetation recovers.

#### **4.5.2 Improve Habitat Resiliency and Restore Fire as a Key Ecological Process**

Restoring fire as an ecological process within its natural range of variation is the preferred means to restore and sustain natural and resilient habitat conditions for fisher and other wildlife species (Roberts et al. 2015). However, current conditions and regulations may preclude allowing wildfires to play this natural role in many areas, at least until hazardous fuel conditions are pre-treated by mechanical means and prescribed fire to reduce the risks of unnaturally large and severe fires (North et al. 2012, 2015). The conservation measures described below are designed to facilitate the transition from current to desired

conditions so that wildfire can play its natural role in sustaining high quality and resilient fisher habitat over large areas, where feasible, in the future (Objective 3.1).

Ideally, large-scale, coordinated fire management plans (e.g., involving collaboration between the US Forest Service and National Park Service working across boundaries) should be prepared and implemented to maximize effective use of wildfire and prescribed fire (Moghaddas et al. 2010, Collins et al. 2011, Collins and Stephens 2012, North et al. 2012). Such plans should be prepared to cover multiple years over large areas where use of wildland fire or prescribed fire are the principal tools for management, anchored as needed by mechanical treatments in strategic locations (North et al. 2012). This approach should increase flexibility for using fire rather than mechanical treatments to restore more natural heterogeneity, ecological processes, and fisher habitat value.

Fire management plans should consider the following recommendations to maximize benefits to fishers:

- Plan prescribed fire under weather and fuel conditions that promote habitat resiliency and fisher habitat values, including burn prescriptions that promote mosaic fire effects within the natural range of variability. Tactics should recognize that fires during moderate fire weather conditions can benefit fisher habitat, but severe fire has the potential to remove canopy and important fisher habitat elements.
- Design prescribed fires to leave some unburned patches (tentatively, 10-25% of total area within the burn perimeter), especially in larger burn units, to provide heterogeneity and refugia for prey.
- Use methods described in Hood (2010) to reduce losses of large trees and potential denning structures during prescribed fires. Where feasible, this may include raking or targeted preparatory burning around high-value (e.g., large, structurally complex) trees and snags where surface fuel conditions increase the risk of loss to the fire. Known high-value areas and habitat elements should be available to the Incident Management Team before fire season.
- Perform prescribed fires when wind conditions will minimize smoke in denning habitat during denning season (see Section 4.5.4).
- When conditions allow, manage natural ignitions for ecological benefits. Work with air quality specialists and stakeholders (e.g., Southern Sierra Prescribed Fire Council) to address air quality issues and increase ability to use fire.

Although use of wildfires and prescribed fires is the preferred approach for transitioning to more resilient and natural habitat conditions, many factors currently limit the use of fire as a management tool, including risks to fisher kits, uncharacteristically heavy fuel loads and stand densities, risks to human structures, limited fuel management budgets, limited air quality windows for burning, and multiple-use mandates not fully compatible with fire (Stephens and Ruth 2005, North et al. 2012, 2015). Consequently, many stands need some form of mechanical treatment prior to use of wildland fire or prescribed fire. Although there are concerns that vegetation treatments may adversely affect fisher habitat and displace fishers from their home ranges, available evidence suggests that fishers generally tolerate the types and levels of treatments necessary to restore forests to more resilient conditions (Garner 2013, Truex and Zielinski 2013, Zielinski et al. 2013).

The following guidelines apply where mechanical treatments are planned in fisher habitat target areas:

- Design treatments to keep affected management grid cells in suitable fisher habitat condition *and* limit disturbance from mechanical treatments to <13% of the affected cells over a 5-year period (Zielinski et al. 2013b) or <25% over a 10-year period, unless treatments will not fragment fisher core or linkage areas and will better meet fisher conservation objectives. In areas at highest risk of severe fire in critical locations, up to 30% of the area may be treated over a 5-year period or up to 50% in a 10-year period, so long as the retention guidelines in Section 4.5.3 are adhered to and fisher core or linkage areas are not fragmented.
- Prioritize treatments where they maximize potential benefits (e.g., by affecting fire behavior in strategic locations, North et al. 2012) and minimize potential impacts on fisher habitat. For example, prioritize treatments on terrain with relatively warm microclimates (e.g., ridgetops, south and west slopes).
- Use treatments to create varying stand density and structure using topography and microsite conditions as guides for varying treatments (North et al. 2009). Design treatments to achieve the desired fisher habitat conditions provided in Section 4.3.
- Retain essential fisher habitat elements (Section 4.5.3) to the degree feasible in achieving resiliency objectives.

#### 4.5.3 Maintain and Increase Important Fisher Habitat Elements

The following conservation measures are recommended to help maintain and increase important fisher habitat elements (Objective 3.2) when mechanical vegetation treatments are used to help achieve fisher habitat objectives (Sections 4.5.1 and 4.5.2). Once a proposed vegetation treatment project has been sited using the landscape-scale and home range-scale guidelines described in Section 4.4, the project should be designed to maximize fisher habitat benefits based on a field assessment and biological analysis. The analysis should assess whether deviations from the guidelines will better meet fisher habitat goals based on site-specific conditions, and the reasons for deviations should be clearly justified by a biologist in project planning documents. As with all aspects of this Strategy, the guidelines should be refined with new information and changing conditions as part of the adaptive management process.

##### **Tree and snag retention guidelines**

Fishers select trees and snags for resting and denning that are among the largest available, especially in stands with dense, multi-storied forest canopies (Zielinski et al. 2004a, Purcell et al. 2009, Green unpublished data). As large trees, especially those >36 in dbh, are less abundant in Sierra Nevada mixed-conifer forests than they were historically (Taylor 2004, North et al. 2007, Lutz et al. 2009, Scholl and Taylor 2011, Stephens et al. 2015), they may be limiting to fishers. Moreover, stem densities are higher, and smaller trees (<24 in dbh) are more abundant than they were historically (Fellows and Goulden 2008, Dolanc et al. 2014, McIntyre et al. 2015, Stephens et al. 2015), which may contribute to reduced forest resiliency, heterogeneity, and recruitment of large-tree structures (Guarin and Taylor 2005, Fellows and Goulden 2008). Therefore, design conservation measures to increase the abundance and vigor of larger trees and reduce the abundance of smaller trees by (1) retaining most if not all large trees and snags when implementing mechanical treatments, especially those with structural deformities or decadence, and (2) judiciously removing smaller trees to promote recruitment and survival of the larger trees and increase habitat heterogeneity.

*Except where it threatens public safety or the ability to meet fisher habitat objectives based on site conditions, mechanical treatments should retain conifer trees and snags >30 in dbh, including pines >27 in dbh. These thresholds are based on size distributions of trees and snags used as resting or denning sites in the Strategy Area<sup>25</sup>. This guidance does not imply that it is necessary or desirable to remove most or all trees below these size thresholds, because treatments should contribute to fine-scale vertical and horizontal structural complexity and multi-age or multi-size cohorts, to the degree feasible.*

The multi-scale evaluation described in Section 4.4 should include an informal, fisher-centric, biological cost-benefit analysis to determine (1) when removing trees larger than these thresholds may contribute to resiliency goals and recruitment of future fisher habitat elements without significantly reducing short-term habitat value, and (2) whether all large trees and snags should be retained as habitat elements, or whether cutting some proportion of large structures may be warranted for public safety or to better meet long-term habitat goals. Examples of where cutting larger trees might be justified are in dense, homogenous stands with relatively low habitat value and high susceptibility to crown fires, insect outbreaks, or water stress (Guarin and Taylor 2005, Fellows and Goulden 2008, Safford 2013, Fry et al. 2014), especially those dominated by shade-tolerant, fire-intolerant species like white fir and incense cedar.

The Strategy recognizes that in some areas and site conditions, removing some trees larger than thresholds established in this section *may* better achieve long-term fisher conservation objectives by increasing survival, growth, and recruitment of larger trees. However, the science is unclear about whether removing larger trees may affect sustenance and recruitment of these important fisher habitat elements. Adaptive management, monitoring, and research (e.g., using before-after/control-impact study designs) should be used to revise these guidelines during Strategy implementation. In the meantime, these guidelines err on the side of protecting fisher habitat elements in the near term, while providing managers a means of justifying removal of some larger trees where it can be justified with strong, scientific rationale.

### **Stand structure guidelines**

Fishers also select or require specific habitat stand structural conditions, including dense, multi-storied canopies for resting and denning habitats, abundant dead-wood structures, and ground-level hiding and escape cover. The following guidelines should apply to the design of vegetation treatments to retain and promote suitable habitat structural conditions:

- Retain some overtopping and multi-storied canopy conditions, including some shade-tolerant understory trees (firs and cedars), especially in drainages, swales, and canyon bottoms and on north and east-facing slopes.
- Use multi-cohort management to the degree feasible to retain and promote a range of tree size and age classes to recruit future larger trees.
- Retain a patchy mosaic of shrubs and understory vegetation separated by more open areas to reduce fuels continuity, increase habitat heterogeneity, support fisher prey, and provide fishers with hiding cover—with a goal of 10-20% shrub cover at the home range scale (North et al. 2002, North et al. 2009, North and Sherlock 2012).

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<sup>25</sup> Based on the upper three quartiles (i.e., the largest 75%) of trees and snags used by resting fishers (Zielinski et al. 2004b, Purcell et al. 2009, Spencer et al. 2015, Green unpublished data).



- Retain on average 3-5 tons of large (>20-in diameter) logs per acre. Log density should vary across the landscape, with some patches of high abundance (5 tons/ac) and others with lower densities (<1 tons/ac). If large trees or snags must be felled, leave 3-5 tons per acre on the ground in the largest size classes where they do not pose a significant fuel or safety risk.
- Pile brush and retain some slash piles for fisher escape cover and prey habitat.

#### 4.5.4 Increase Fisher Reproduction and Kit Survival

Some management activities should be avoided or minimized in denning habitat during the season when kits or their mothers are most sensitive to disturbance (March-June). The following guidelines are intended to reduce the potential for harm to fisher kits that may result from human activities, including temporary abandonment by the mother or smoke accumulation in the den cavity, which may affect natal development. Moreover, mating occurs just after birthing, and disruption during the mating period could result in reduced reproduction the following year. Nevertheless, the Strategy recognizes that the potential harm to one or a few individuals from management actions in denning habitat and season should be balanced against the potential benefits to fishers by increasing long-term habitat quality and resiliency.

In general, the period March 1 to June 30 is of heightened concern for management actions in or near denning habitat, especially noisy activities or those involving felling of trees. The following dates for major fisher life-cycle events in the Strategy Area were considered in establishing Limited Operating Periods (LOP) during which actions listed in Table 7 should be avoided within the LOP footprint mapped in Figure 23, *unless a project-specific analysis determines that the potential benefits to fishers outweigh the potential harm:*

- Natal den establishment and parturition: March 17-April 14
- Male visits to dens and mating: March 29-May 6
- Kits moved to maternal den(s): April 4-June 24
- Rearing of mobile kits and use of maternal rest sites: mid or late June-October.

Projects proposed in the LOP footprint during March-June should be assessed by a biologist knowledgeable about fishers to determine whether potential benefits to fishers are likely to outweigh the risks, in which case the activities may be exempt from the LOP restrictions if they are carefully designed and implemented to mitigate risks. This benefit-risk evaluation should recognize uncertainties on both sides, and consider the scale, duration, expected noise levels, and vegetation impacts of the actions<sup>26</sup>.

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<sup>26</sup> More specific guidance for project-specific evaluations should be developed by a team of fisher experts, forest biologists, and other resource management experts as soon as possible to provide scientifically justified guidelines.

**Table 7—Limited operating period recommendations for specific activities in occupied cores within the LOP footprint.** Exemptions from these restrictions must be justified by a project-specific biological evaluation establishing that potential benefits to fisher habitat outweigh the potential for harm to fishers.

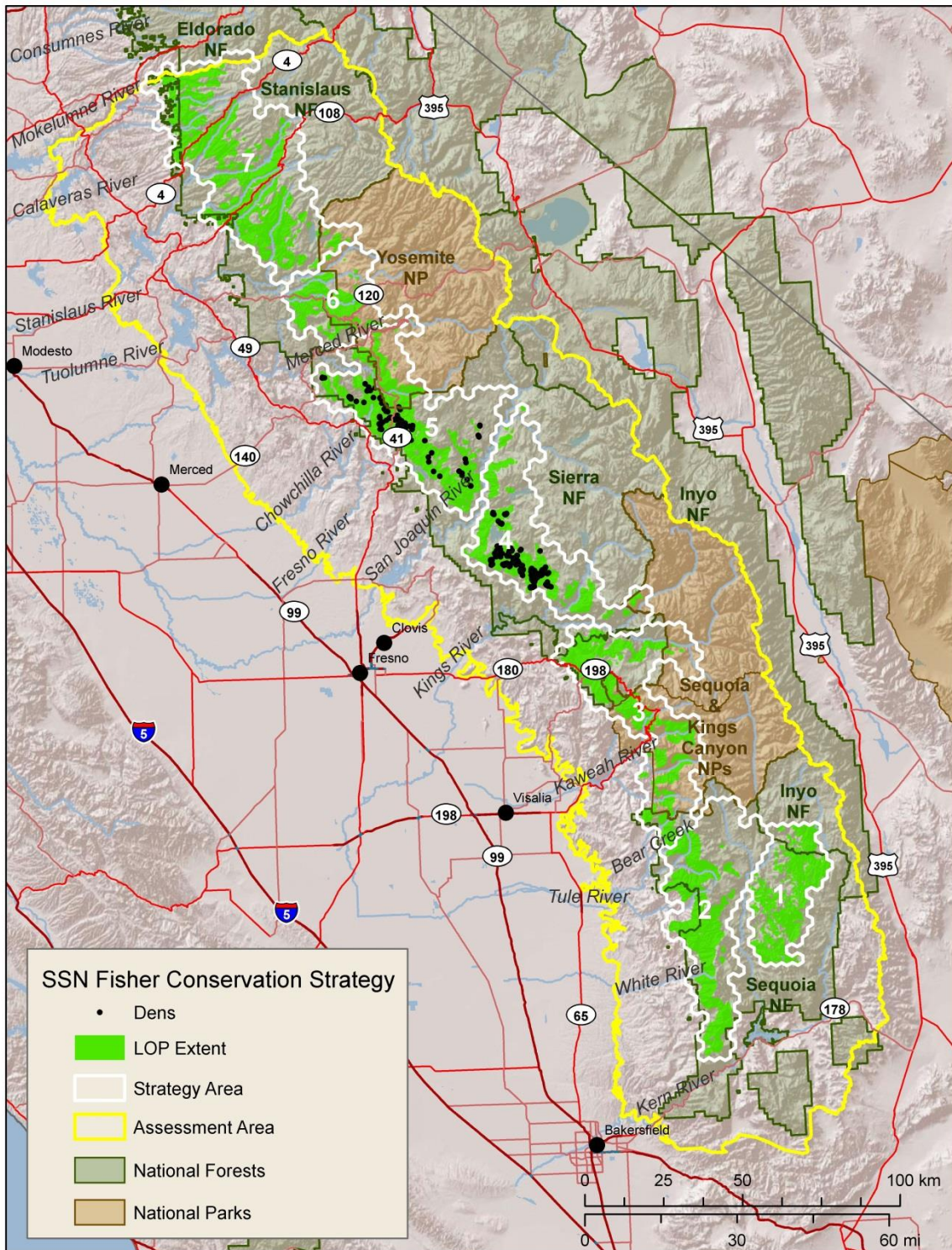
<b>LOP</b>	<b>Restricted activities<sup>a</sup></b>
March 1 to June 30	<p>Logging, thinning, or other tree-cutting activities within natural stands with CWHR diameter class 12 in or greater</p> <p>Salvage logging in moderate or low severity burns (&lt;75% BA mortality) or within 250 m of the perimeter of high severity burns (&gt;75% BA mortality) in stands that had CWHR diameter class 12 in or greater prior to the fire.</p> <p>Mastication within stands typed as Sierran mixed conifer (SMC), conifer-hardwood (MHC), and ponderosa pine (PPN) CWHR 4D, 5M, 5D, or 6</p> <p>Application of Glyphosate with mild surfactant (e.g., R-11) if vegetation and ground that is sprayed will not be dry within 4 hours</p> <p>Construction and development of infrastructure</p>
March 1 to May 1	Prescribed fire (unless carefully designed to minimize potential harm to fishers, including smoke accumulation in denning habitat; see text)
March 15 to May 1	<p>Burning large slash or woody debris piles (&gt;0.1 ac), piles adjacent to possible den structures, or in situations where simultaneous lighting would create intense smoke</p> <p>Hand thinning within natural stands with CWHR diameter class 12 in or greater</p> <p>Special use events for off-highway vehicles or over-snow vehicles.</p>

<sup>a</sup> Hazard tree removal was considered but exempted from LOP requirements for reasons detailed in text.

If project planners choose not to perform this analysis or to err on the side of caution, the actions listed in Table 7 should be strictly avoided during the specified periods. Projects in currently unoccupied Cores 6 and 7 are not required to conduct this project-specific evaluation, or to abide by LOP restrictions, until sentinel monitoring (described in Section 8.3) indicates occupancy by females.<sup>27</sup>

We especially emphasize the guidelines and LOP for use of wildland fire and prescribed fire—for which potential benefits to fisher habitat may outweigh the potential harm to fishers if projects are carefully designed and managed. Using fire as a management tool is important to achieving fisher conservation objectives, and burn opportunities are limited, with some of the best burning windows during spring. However, air quality effects of fires may be detrimental to fishers, especially during kit development (e.g., increased carbon monoxide levels in den structures during March 1 to May 1). In situations where wildland fire or prescribed fire are preferred tools to accomplish fisher conservation objectives, a less restrictive LOP of March 1 to May 1 is generally acceptable, and burns during this period may be justified if they are limited in extent and duration and implemented during weather conditions that minimize potential concentration of smoke in denning habitat.

<sup>27</sup> If sentinel monitoring is not performed per guidance provided in Section 8.3 to confidently conclude absence of female fishers, then the project-specific evaluation must be performed, or strict LOP restrictions applied.



**Figure 23—Limited Operating Period (LOP) spatial extent.** Delineated in Cores 2-7 using the fisher den model, plus CWHR high-value reproductive habitat supporting known den locations outside modeled denning habitat, both buffered by 250 m. Delineated in Core 1 using CWHR fisher high-value reproductive habitat buffered by 250 m.

These LOP guidelines could be further relaxed if coordinated prescribed fire plans are prepared to cover multiple years over large areas, as described in Section 4.5.2. Preparing fire management plans at fireshed scales will increase flexibility in using prescribed fire during spring by sequencing and dispersing treatments to minimize potential population-level effects. Such plans could support a shorter LOP than March 1 to May 1 for designated areas while demonstrating that risks to neonatal kits would be managed over the longer term and larger landscape.

Hazard tree removal was considered but generally exempted from LOP requirements, because hazard trees may represent a direct threat to human life or property and should be removed as early as possible, often in early spring. For example, hazard trees should be removed from campgrounds or other high-use areas early in spring, shortly after roads open and before public visitation rates increase. Furthermore, removal of one to several individual hazard trees is unlikely to directly harm a fisher. However, in some cases where numerous trees or trees having denning potential must be removed, every effort should be used to avoid doing so within the LOP footprint from March 1 to June 30.

Agencies and fisher experts should review these guidelines and the LOP at least biennially based on lessons learned from their application and incorporate new information on fisher behavior and development as it accrues. We also recommend that known den locations, the LOP footprint, and LOP activities (Table 7) be included in the Wildland Fire Decision Support System (WFDSS) to enable fire managers to evaluate sensitive resources in fire management settings.



## 5 Mortality-factor Management

As documented in the Conservation Assessment, the southern Sierra Nevada fisher population faces a variety of threats in addition to habitat loss and fragmentation. The cumulative effect of other mortality risks—such as roadkill, pesticide poisoning, and increased exposure to predators—may constrain population growth and potential for expansion into other suitable habitat areas. Specific management interventions—such as building or improving culverts to create safe road crossings and removing pesticides at trespass marijuana grow sites—should be strategically implemented to reduce fisher mortality and promote population increase.

### 5.1 Current Conditions

Fishers experience a diversity of human-influenced mortality factors that may elevate mortality rates or reduce reproductive rates, thereby reducing the potential for population expansion and recovery.

- Rodenticides and other poisons, primarily at trespass marijuana grow sites in Sierra Nevada mixed conifer forests, are implicated in reducing female survivorship (Thompson et al. 2013).
- Predation, especially by bobcats and mountain lions, is the primary ultimate cause of death for fishers in the Strategy Area, and predation rates may be elevated due to sub-lethal exposure of fishers to pesticides (which affects health and behavior) and habitat alteration that may increase access by predators into fisher habitat, for example via roads, trails, and open forest understory.
- Diseases and infections sometimes kill fishers, but they do not currently appear to be a population-level threat. However, in the future epizootics could have significant negative consequences.
- Fishers are sometimes killed on roads, and roadkill of female fishers in denning habitat during the reproductive season may be particularly harmful to the population.
- Fishers can become entrapped and die in human-built structures, such as water tanks and pipes.

### 5.2 Desired Conditions

Fishers experience natural types and rates of mortality health risks, with little or no increase due to human changes to the environment. More specifically, desired conditions are:

- Fisher exposure to poisonous substances is greatly reduced from current rates.
- Predation on fishers occurs at natural rates and with natural seasonal patterns and does not prevent fisher population growth. Human impacts to denning habitat that would facilitate access by large predators are avoided.
- Fisher health, including exposure to diseases, remains within the natural expected range of variability, and the fisher population remains large enough to be resilient in the face of occasional epizootics. No new diseases are transmitted to the population from human influences, such as diseases transmitted by cats or dogs.
- Fisher-vehicle collisions are rare.

- Fishers are not killed by human structures, such as by entrapment in water tanks and air pipes, or construction-related activities.

## 5.3 Conservation Measures

The following conservation measures are designed to reduce human-influenced mortality factors.

### 5.3.1 Reduce Pesticide Poisoning

Illegal marijuana cultivation sites represent a major risk to the southern Sierra Nevada fisher population via exposure of fishers and their prey to diverse pesticides, especially rodenticides and insecticides. These sites also alter fisher habitat by cutting trees, diverting water, and creating trail networks. Efforts are already ongoing to identify, clean up, and monitor these sites.

- Develop a grow-site distribution model to predict where additional sites are most likely to be found to assist law enforcement in searching for trespass marijuana grow sites.
- Continue and expand aggressive law enforcement to prevent and locate trespass marijuana grow sites; interrupt grow operations as early in the season as possible to prevent poisoning.
- Continue and expand remediation efforts at grow sites to remove toxicants and trash.
- Conduct research and monitoring to determine how long toxicants remain in the environment and affect wildlife, and assess and implement effective means of mitigating adverse effects.

### 5.3.2 Reduce Predation

Predation rates in the Assessment Area may be elevated due to pesticide exposure and human alterations to habitat. Roads, trails, open and early seral habitats, and edge habitats may increase access into fisher habitat by bobcats, mountain lions, and coyotes. Predation appears to be highest in spring when female fishers are denning.

- Maintain or increase understory heterogeneity in fisher denning habitat to promote escape cover such as shrub patches, coarse woody debris, and slash piles following vegetation treatments.
- Close, remediate, and re-vegetate unneeded roads, off-highway vehicle trails, skid trails, or other linear openings that facilitate access by coyotes, mountain lions, and bobcats into denning habitat.
- Where linear features are essential to hazard reduction or other management needs, create visual breaks in the continuity of openings with berms, shrub patches, and large logs, where feasible.
- Avoid creating permanent linear or otherwise continuous areas of open habitat in or near denning habitat. Vegetation treatments within denning habitats should be fine-grained and discontinuous to avoid creating continuously open understories that facilitate access by fisher predators.

### 5.3.3 Maintain Low Risk of Disease and Infections

Disease does not currently pose a major threat to fishers in the region, but epizootics have potential for population-wide impacts. Monitoring for disease outbreaks and implementing control measures (e.g., vaccinations) can be difficult and costly and are recommended only when disease is an imminent threat to one or more fisher subpopulations. Research on fisher diseases and opportunistic monitoring of fisher

health should continue in the Strategy Area. If monitoring indicates a major risk of outbreak, a contingency disease intervention plan should be developed (see Section 6).

#### 5.3.4 Reduce Fisher Vehicle Strikes

Fishers are sometimes killed by vehicles, especially on heavily traveled roads through denning habitat during spring, when females are constrained to foraging near the den and may frequently cross roads. Monitoring shows that fishers use culverts or other undercrossings and probably cross where openings without overhead cover are most narrow.

- Improve efficacy of road-crossing structures by regularly maintaining damaged or blocked culverts and retrofitting existing culverts to improve wildlife use. Retrofitting can include repairing perched inlets/outlets, draining pools blocking entrances, removing debris blocking entrances, creating pathways directing animals to culverts, or installing shelves in culverts to provide passage above high water flow.
- Install new wildlife undercrossings in fisher habitat, especially in modeled denning habitat or other heavily used areas, similar to efforts underway on the Sierra National Forest and Yosemite National Park. Construct underpass structures designed for wildlife (Corlatti et al. 2009, Kintsch and Cramer 2011), and use fencing or other barriers to help funnel animals to crossing structures.
- Reduce speed limits to 25 mph in identified roadkill areas. Use portable radar speed feedback signs to slow drivers during denning season (March 1–June 30). Work with Caltrans, California Highway Patrol, and National Park Service Law Enforcement to enforce speed limits along Highway 41/Wawona Road and other roads with documented roadkill.
- Research and apply vegetation management or other measures along roads to discourage above-ground crossings and funnel fishers to crossing structures, for example, by reducing roadside vegetation to increase visibility in upland areas, but maintaining natural vegetation in drainages close to the road to funnel fishers to culverts or undercrossings.
- Encourage rapid removal of road-killed wildlife, especially deer, to locations far from roads to reduce risk of fishers foraging near roads. Coordinate with Caltrans to deposit road-killed animals that could be scavenged by fishers  $\geq 0.25$  mile from highway corridors.

To maintain connectivity, evaluate filters and barriers to movement, and avoid building paved highways through high quality habitat areas and pinch points in fisher core or linkage areas.

#### 5.3.5 Reduce Impacts of Human Development and Infrastructure

Fishers are occasionally killed by entrapment in pipes, water tanks, and other human-created structures and could potentially be harmed during construction activities.

- Retrofit pipes, water tanks, and other such structures to avoid entrapment of wildlife.
- Identify and maintain or remove old tanks, pipes, irrigation canals, etc., potentially using citizen science volunteers. Folliard (1994) recommends that abandoned water tanks be covered, given drain holes, or modified by inserting branches, poles, or metal bars (which do not rot) so that wildlife can self-rescue from “accidental traps.”
- Avoid construction activities in or near fisher denning habitat from March 1 to May).

## 6 Population Intervention

Given the small size and limited distribution of the Sierra Nevada fisher population, active population interventions, such as captive breeding and translocation, may be warranted. The Strategy should develop a plan that establishes when and how population interventions are warranted based on identified intervention triggers and how they will be implemented. The plan should evaluate the likely genetic and demographic effects of removing individuals from existing subpopulations and should be designed to maximize potential success of establishing a breeding population north of the Merced River while minimizing potential harm to the existing population. It should also consider the distribution of mortality factors, such as the known or inferred density and distribution of trespass marijuana grow sites and fisher predators (cougar, bobcat, coyote).

In the interim, before a formal translocation plan is finalized, the Strategy recommends being flexible and open to new opportunities, such as the opportunistic translocation of orphan kits following the death of a denning female. In such situations, the Strategy supports management options that generate the greatest overall good for the southern Sierra Nevada fisher population.

The plan should consider the following population intervention tools:

- Fisher orphan rescue, rehabilitation, release, and monitoring if a mother is killed, especially to facilitate or augment natural northward population expansion into Cores 6 and 7.
- Additional or assisted dispersal across Yosemite Valley into Cores 6 and 7, if natural colonization is not documented by 2030.
- Vaccination programs in the event of a significant disease-related mortality event, particularly targeted efforts to arrest the spread of an epizootic.
- Captive breeding, as a last resort, in the event of extraordinary population decline.



## 7 Prey Management

It is unclear to what degree the fisher, as a generalist predator, may be limited by prey availability in the Sierra Nevada. Although the population has a diverse base of small and medium-sized prey—including various tree squirrels, ground squirrels, and woodrats—larger prey that are dietary staples of fishers in other regions—particularly porcupines and hares—are lacking in the Strategy Area. Habitat management measures called for by the Strategy may increase populations of squirrels, woodrats, and other important prey by increasing abundance and size of black oaks and increasing habitat heterogeneity, creating more natural mixes of late-seral and early seral forest conditions, and increasing tree gaps, shrub patches, and dead wood structures.

Porcupines appear to be largely extirpated from mid-elevation forests of the southern Sierra Nevada, perhaps due to porcupine control efforts during the 20<sup>th</sup> century and potentially exacerbated by ongoing rodenticide poisoning associated with trespass marijuana grow sites (review in Spencer et al. 2015). In addition to being important in fisher diets elsewhere, porcupines are *ecosystem engineers* whose gnawing on trees creates structural elements of fisher habitat, like cavities, epicormic branching, and forked tree tops.

Research should determine whether a porcupine management program—potentially including reintroduction or population supplementation—is warranted to benefit the fisher population. An interagency team, such as the existing Porcupine Subgroup of the Southern Sierra Nevada Fisher Working Group (Section 10.1), should convene to discuss and potentially develop a porcupine research, monitoring, and management plan. Research and monitoring should first confirm or refute the apparent absence of porcupines throughout much of the Strategy Area, determine reasons (threats and stressors) for their absence, and recommend management actions.

Porcupine reintroduction should be considered as a possible contingency action if there is sufficient information to conclude that (1) porcupines are absent from fisher core areas, (2) reasons for their absence are fully understood and can be adequately controlled, (3) reintroduction will not negatively impact fishers through indirect food web interactions (e.g., by increasing populations of mountain lions or bobcats), and (4) porcupine presence would not increase secondary poisoning of fishers (by eating porcupines that ingest rodenticides). Meeting these conditions would require that rodenticide contamination is sufficiently reduced and controlled that it would not preclude establishing a sustainable porcupine population.

## 8 Monitoring and Adaptive Management

During the first year of Strategy implementation, a Fisher Monitoring and Adaptive Management Plan should be created to achieve Strategy goals and objectives. The plan should establish appropriate thresholds for various monitoring metrics (e.g., trends in habitat suitability, fisher occupancy, genetic diversity, or population health) that would trigger additional scientific evaluation or management actions. To the degree feasible, monitoring should utilize and build on existing monitoring programs (e.g., the regional fisher monitoring program, FIA program), available datasets (e.g., EVEG data or future replacements), and protocols (e.g., common stand exam [CSE]) to be efficient and cost effective. This section briefly outlines major components of the monitoring program, but assumes that cost-benefit analyses of alternative monitoring approaches and specific sampling designs will be developed later, informed by power analyses or other means of establishing appropriate sampling intensities and designs.

### 8.1 Fisher Habitat Monitoring

The management grid system introduced in Section 3 provides a framework for tracking progress towards fisher habitat conservation targets (Section 4.1). The primary habitat monitoring metric is the number of suitable home range units within each core area using the female home range PCA hull equation (Section 3.1). Because this metric is assumed to integrate all landscape-scale habitat requirements of a breeding female, it reduces the need to track functional habitat types (e.g., resting, denning, and foraging habitats).

Nonetheless, until the home range system is fully tested (see caveats in Section 3.1.1), and because the PCA equation uses GIS data layers that do not account for finer-scale habitat characteristics (e.g., resting and denning structures, canopy structure), we recommend also tracking the abundance and distribution of fisher resting habitat at finer resolution until the reliability and sufficiency of the home range suitability metric can be confirmed. Specifically, we recommend the FIA-based resting habitat model of Zielinski et al. (2010) to track changes in fine-scale (1 ha, 2.47 ac) resting habitat value using regularly collected FIA plot data. Also, as forest conditions change, the PCA hull equation should be re-evaluated and updated.

We anticipate that home range suitability will be assessed every ~5 years (or following regular updates in EVEG, GNN, or alternative vegetation data layers). Trends in suitability status should first be assessed after 15 years and updated every 5 years thereafter. Similarly, the FIA-based resting model should be run at all FIA plots in each core area (or a sufficient sample of FIA plots, to be determined by power analyses) every 5 years, and trends starting after 15 years. The results of the two methods should be statistically compared to determine whether the home range suitability metric is adequately reflecting status and trends in FIA-based resting habitat value. Once this association is confirmed (after  $\geq 15$  years), the resting habitat method can be discontinued.

A critical data need for implementing this fisher monitoring program, and other monitoring programs, is regular and comprehensive updating of vegetation map layers (whether more consistent updating of EVEG, GNN, or some alternative). Inconsistent temporal and spatial mapping of vegetation layers is problematic for fisher habitat monitoring, and using an alternative, such as imputation from vegetation plot data, introduces “apples to oranges” comparison issues.

It is also desirable, though perhaps not critical, to update and track modeled resting, denning, and foraging habitat in each core area, using the Maxent models in Appendix A of Spencer et al. (2015). Acreages and trends in these functional habitat categories could be compared every 5 years with those of the home range suitability and FIA resting habitat suitability metrics using an appropriate spatial congruence index (Legendre and Legendre 1998). If these important functional habitat categories appear to be reliably reflected in the home range suitability metric after 15 years, this additional modeling could be discontinued.

## 8.2 Habitat Resiliency Monitoring

The management grid system also provides a framework for tracking progress towards habitat resiliency targets (Section 4.1). A small suite of reliable habitat resiliency metrics should be developed (e.g., stand density indices, modeled flame lengths, or probability of crown fire under appropriate fire weather conditions) and summarized within hexagonal cells. The number and proportion of suitable and potential fisher habitat cells in different resiliency classes can then be determined and tracked at ~5-year intervals as vegetation data are updated. Trends should be assessed after the first 15 years and updated every 5 years thereafter to determine progress toward resiliency targets.

## 8.3 Fisher Population Monitoring

In addition to tracking the amount and distribution of suitable habitat conditions, it is essential that the monitoring program continue to track fisher occupancy patterns in each core area to measure progress towards fisher population targets (Section 4.1) and to ensure that the population is responding appropriately to habitat conservation measures. It should also include genetic sampling to ensure that inter-core dispersal is adequate and that the population is not losing genetic diversity. Sentinel sampling of fisher presence or absence in currently unoccupied Cores 6 and 7 should be phased for efficiency to determine if and when a breeding population establishes there, which would also trigger changes in conservation measures there (e.g., Section 4.5.4).

### 8.3.1 Occupancy

The current regional monitoring program was designed to detect a 20% decline in occupancy in occupied areas, under the assumption that there is a positive relationship between occupancy and abundance. An initial assessment of the first 8 years of monitoring data found no evidence of a trend across the population or in any of three regional zones<sup>28</sup> identified within the population (Zielinski et al. 2013). However, this analysis did find a difference in occupancy rates between zones, with lowest occupancy in Zone 1 (Core 1) and highest in Zone 2. New analytical techniques have emerged in recent years (spatially explicit power analyses) that allow for more precise quantification of the abundance-occupancy relationship, and provide the ability to estimate the sampling design and intensity needed to detect a specified change in abundance using occupancy as a surrogate metric. Additionally, the integration of genetic sampling into the sampling design beginning in 2006 provides the ability to monitor the genetic characteristics of the population over time as well as to identify individual fishers and their sex at monitoring stations that obtain genetic samples.

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<sup>28</sup> The regional zones correspond with delineated fisher core areas as follows: Zone 1 = Core 1; Zone 2 = Cores 2 and 3; Zone 3 = Cores 4 and 5.

## 1. Monitoring in occupied Cores 1-5

To effectively monitor implementation of the Strategy, and its goal of increasing the population size (specifically increasing the number of females), the existing regional monitoring program sample design should be re-evaluated to determine what changes may be needed. We recommend that future monitoring maintain the existing, FIA-based, sampling grid so that future monitoring is spatially compatible with past sampling, and that any changes augment this existing grid rather than replace it. The following goals may require changes in overall number, sampling density, spatial distribution, or sampling techniques within monitoring units:

- Monitor for both increases and declines in occupancy (desired effect sizes determined by Strategy participants).
- Monitor trend in occupancy across the entire population, in the three regional zones used by Zielinski et al. (2013) and within individual cores.
- Use fisher detections at monitoring units, specifically locations of female fisher or family group detections, to evaluate home range template results (Section 8.1) and whether changes in habitat conditions (e.g., cells transitioning from unsuitable to suitable or vice versa) are corroborated by occupancy results.

## 2. Sentinel monitoring in Cores 6 and 7

We recommend a phased approach to monitoring in currently unoccupied Cores 6 and 7 to detect if and when fishers establish there. Initially, at least 15-20 locations should be monitored in Core 6 using the same protocols as the regional occupancy monitoring—including genetic analysis to determine sex—but with a different spatial sampling design. Whereas regional monitoring uses locations paired with FIA plots that fall within the elevation band used by fishers (which consequently samples a wide range of habitat conditions), these sentinel sampling locations should be focused in areas with the highest probability of detecting female fishers that disperse north from Core 5. Specifically, sample plots should be located in modeled denning habitat (or CWHR classes 4D, 5D, and 6) in Core 6, especially biased toward the southern portions of the core in Yosemite National Park and Stanislaus National Forest and excluding areas burned at high severity by the Rim Fire.

Detecting fisher(s) at a sentinel site would trigger the following actions: (1) establish additional sentinel monitoring sites in the immediate vicinity of the detection to cover any un-surveyed adjacent suitable denning habitat, and (2) extend sentinel sampling sites farther north into suitable denning habitat in Core 6 and Core 7. If fishers are detected repeatedly at multiple sentinel sampling sites, indicating consistent occupancy in Core 6 or 7, then extend the regional occupancy sampling design to cover the newly occupied areas, and shift sentinel monitoring sites to sample additional denning habitat adjacent to the newly occupied area.

### 8.3.2 Genetics

We recommend genetic monitoring through periodic analyses to assess changes in genetic diversity (allelic richness and heterozygosity), genetic connectivity, and inter-core dispersal. The regional monitoring program should collect hair samples for the genetic analyses. Supplemental genetic sampling may be needed periodically in Sequoia, Kings-Canyon, and Yosemite National parks—outside of the current sampling frame—to improve accuracy of the analyses by collecting from the entire geographic



range of the population. New microsatellite markers should be integrated into genetic monitoring, as they become available for the southern Sierra fisher population, to increase the precision of population genetic metrics and to improve power to detect changes in genetic connectivity. We anticipate that genetic metrics will be assessed once per fisher generation (every ~5 years).

## 8.4 Effects and Effectiveness Monitoring

In addition to the habitat and population recommendations above, more focused monitoring may be required for certain management actions, mortality factors, or other issues, especially to determine the effects and effectiveness of conservation measures and to track potential mortality factors. The project-specific evaluation documentation described in Section 4.4 should be considered one essential component of the monitoring record for habitat management actions, so that future decisions can be informed by results of previous decisions. The following specific monitoring tasks should also be considered in preparing the monitoring plan:

- Use before-after/control-impact designs and in-field vegetation sampling (e.g., using common stand exams and FVS) to determine the effects and effectiveness of various types of fuels treatments on vegetation and fisher habitat elements.
- Monitor wind conditions during spring prescribed burns to determine if smoke may be accumulating in fisher denning areas, per guidelines and the LOP footprint and schedule in Section 4.5.4.
- Monitor pesticide exposure rates in necropsied fishers or other opportunistically collected wildlife that serve as surrogates for fisher exposure rates.
- Monitor the number and area of trespass marijuana grow sites discovered and cleaned up annually.
- Monitor soil and water to determine how long toxicants remain in the environment and affect wildlife.
- Monitor the number of dead fishers detected annually along key stretches of road in fisher habitat (e.g., Highway 41/Wawona Road, Highway 198/General's Highway).
- Use unbaited camera stations to monitor wildlife use of culverts and other road crossing structures.

## 9 Research

The following research and modeling tasks should be performed as soon as possible to fill information gaps concerning fishers, conservation measure effects and effectiveness, and other topics important to reducing uncertainties and informing Strategy implementation. In addition, priority fisher research tasks developed by the Sierra Nevada Fisher Working Group (SSNFWG) should be included (Appendix B).

- Perform a telemetry study on 10-15 female fishers in Core 1 to measure home range size and habitat use. Use the results to develop or refine a Core 1-specific habitat model and PCA of home range composition, which can be used to develop conservation targets for use in the management grid system.
- Analyze habitat conditions that appear resilient and support breeding female fishers to refine the desired conditions described in Section 4.3 and conservation measures described in Section 4.5.
- Research use of post-fire habitats by fishers using scat-detecting dogs or other appropriate means, including relative use by fishers of different burn-severity classes and areas subject to post-fire management actions (e.g., salvage, planting).
- Research and model the most appropriate metrics of habitat resiliency and fire risk (e.g., stand density index, flame length, or probability of crown fire under moderate weather conditions) so that the management grid system can also track progress towards resiliency goals and be used as decision support for planning and implementing use of wildland and prescribed fires.
- Develop a statistical “slider tool” similar to the one developed for fisher home range suitability analysis that predicts changes in flame lengths or other appropriate metrics of habitat resiliency as a result of changing habitat conditions.
- Develop statistical equations or cross-walk tables to convert between FVS-derived and EVEG measures of canopy cover.
- Use the spatially explicit population model HEXSIM to analyze the sensitivity of the fisher population to changes in habitat value under alternative management and disturbance scenarios, potential rate of population expansion (e.g., into Cores 6 and 7), and other relevant questions.
- Use before-after/control-impact designs to better assess effects and effectiveness of mechanical fuel treatments on prescribed fire behavior and inform metrics of habitat resiliency.
- Develop a predictive model of trespass marijuana grow site probability on the landscape to aid law enforcement and remediation efforts (e.g., using Maxent and localities of known grow sites to determine landscape variables influencing the probability of grow sites, such as distance from roads, water sources, vegetation condition, terrain, and other factors).
- Investigate fire behavior and effects on vegetation in different arrangements of fuels, such as open versus closed canopies or stands of differing spatial heterogeneity. Many opinions about what constitutes “fire-resilient” stand conditions are not supported by empirical studies.
- Research climate change impacts on vegetation and fishers, and assess and refine potential climate adaptation measures.

## 10 Agency Responsibilities and Implementation Considerations

The Southern Sierra Nevada Fisher Conservation Strategy is designed to meet the needs of agencies and other entities with an interest in conserving the population of Pacific fishers in the southern Sierra Nevada, including but not limited to the California Department of Fish and Wildlife (CDFW), National Park Service (NPS), Sierra Nevada Conservancy (SNC), USDA Forest Service (USFS), and US Fish and Wildlife Service (USFWS). Because no one agency or land management entity can implement all conservation measures needed to sustain and recover the southern Sierra Nevada fisher population, the Strategy is a multi-agency, all-lands, programmatic plan requiring interagency collaboration. Individual agencies can adopt or use aspects of the Strategy per their organizational policies, regulations, and objectives and within their financial and regulatory constraints. It is expected that each agency will incorporate conservation measures into project-level and larger-scale planning documents. Interagency coordination and collaboration will make implementation more effective and efficient, and multiple agencies will use tools such as a Memorandum of Understanding or Agreement (MOU/MOA) or Conservation Agreement (CA) to coordinate specific conservation measures and timelines. If the southern Sierra Nevada fisher population is federally listed under the Endangered Species Act, the US Fish and Wildlife Service will use the Conservation Strategy to inform development of a Recovery Plan.

Whereas the Conservation Strategy is programmatic in nature, implementation will occur primarily at the individual project scale and require project-specific environmental analysis, pursuant to the National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA). However, successful implementation of the Conservation Strategy requires that the suite of forest management actions be tracked and considered cumulatively, to ensure that the fisher population and its habitat are on a trajectory toward recovery.

The Conservation Strategy also recognizes that some projects may not fully implement some conservation measures, due to health and safety reasons, project site constraints, or other specific project issues. It is expected that exceptions to the Conservation Strategy will be discussed in the environmental document for the project. These exceptions should be tracked cumulatively across the Strategy Area.

The authors of this Conservation Strategy recommend the following next steps for implementation:

- Incorporate applicable conservation measures into planning processes of individual agencies, as appropriate (see the agency-specific discussion below for examples of what this entails).
- Maintain a centralized database that incorporates data from individual partners and tracks implementation of the Conservation Strategy and progress toward conservation targets.
- Provide any training needed for use of decision-support tools and analytical methods (e.g., using the PCA slider tools for project evaluation).
- Continue current monitoring efforts and pursue additional or modified monitoring and research tasks recommended by the Strategy.

- Jointly implement the monitoring program (Section 8), including compliance and implementation monitoring and effectiveness monitoring covering habitats throughout the core areas (e.g., tracking and monitoring of Forest Service and NPS projects).
- Distribute the Strategy and outreach broadly, so that others can contribute to implementation.
- Reconvene all partners for regular updates and refinement, as well as 15-20 years after implementation for a comprehensive re-evaluation of the Strategy and next steps.

The following sections generally describe how participating agencies expect to implement this Strategy.

## 10.1 Southern Sierra Nevada Fisher Working Group (SSNFWG)

The work of the Southern Sierra Nevada Fisher Working Group (SSNFWG) has been foundational to the development of the Conservation Assessment and this Conservation Strategy. Informally convened beginning in 2009, the SSNFWG approved a formal charter in 2010 with the following mission:

*To provide a forum for wildlife biologists, scientists, and managers to collaboratively identify, review, develop, and communicate research, management, and conservation information and recommendations that promote the long-term viability of the fisher (Pekania pennanti) in the Southern Sierra Nevada.*

Since 2010, the group has met twice annually with a focus on the following goals: (1) promote the sharing of fisher ecological and management information; (2) collaboratively identify, promote, prioritize, review, and share fisher ecological and management research; (3) provide technical assistance to managers and policy directors for fisher management and conservation; and (4) develop collaborative relationships among government and private individuals and organizations that promote the long-term viability of fishers in the southern Sierra Nevada.

The SSNFWG includes researchers and natural resource managers from state and federal agencies, universities, nongovernmental organizations, and other individuals having relevant experience with fishers and forest management in the Sierra Nevada. Members volunteer their time and efforts individually or through their agency or organization. The group is facilitated by a leadership team of five to seven representatives of agencies, universities, research organizations, and conservation groups. The leadership team, in coordination with members, also assigns ad hoc subgroups to work collaboratively on particular focus areas, such as the Orphan Fisher Kit Subgroup, Rodenticide Poisoning Subgroup, Roads Subgroup, Research Subgroup, Porcupine Subgroup, and Denning Habitat Subgroup.

The SSNFWG is strategically poised to help refine and implement this Conservation Strategy, prioritize research and monitoring tasks, coordinate and consult with partner agencies to help them fulfill their roles and responsibilities, and incorporate new information in the adaptive management and monitoring process. The SSNFWG could serve as the deliberative body that recommends entities to implement particular tasks, such as updating and developing fisher habitat models, Strategy boundaries, conservation targets and measures, and contingency plans for unforeseen events. Tasking the SSNFWG with these responsibilities will require funding some members of the group for whom involvement is not paid for by their agencies.



Following are some specific examples of tasks identified in this Strategy document that the SSNFWG (or subgroups) could either address directly or provide technical assistance to agencies with primary responsibility for a task. These tasks should be further explored by the SSNFWG membership to determine staffing potential and prioritization:

- Analyze forest conditions in fisher home ranges to identify conditions within NRV, resilient to fires and other disturbances, and suitable to support breeding females.
- Develop appropriate conversion equations or cross-walk tables for canopy cover estimates from FVS, EVEG, or other appropriate data sources.
- Develop a habitat resiliency “slider tool” to help understand how fisher conservation measures involving mechanical vegetation treatments may affect habitat resiliency, for example, due to changes in integrated flame length or probability of crown fire under various weather conditions.
- Determine when and how to reassess and update the PCA equation used to score management grid cells for female home range habitat suitability based on new data and in response to new scientific information or changing conditions.
- Develop a separate model of habitat suitability for Core 1 (Kern Plateau) to establish and track conservation goals there.
- Adjust the Strategy Area boundary, delineated linkages, core areas, and conservation targets based on shifts in habitat distribution due to climate change and other factors.
- Oversee fisher population modeling and sensitivity testing of the conservation targets and measures using the spatially explicit population model HEXSIM.
- Revise conservation measures in response to monitoring results, other new information, and changing conditions in the adaptive management strategy.
- Prepare the Monitoring and Adaptive Management Plan based on recommendations in Section 8.
- Prepare more detailed, scientifically justified guidance for management actions in or near denning habitat to minimize disturbance to mother and kits, such as allowable decibel levels in denning habitat (Section 4.5.4).
- Research and develop contingency plans for unforeseen events such as epizootics, significant drops in fisher occupancy patterns, or large disturbance events in fisher core and linkage areas.
- Research and develop a fisher population intervention plan (Section 6).
- Continue monitoring fisher roadkill and use of culverts and other road-crossing structures, and advise on retrofitting or creating new road-crossing structures (tasks already performed by the Wildlife Vehicle Collision Subgroup).
- Research and develop, if deemed feasible and appropriate, a porcupine management program, potentially including a reintroduction or population supplementation plan (Section 7).
- Refine or develop Minimum Impact Suppression Tactics (MIST) for fisher habitat.

- Continue maintenance of the SSNFWG Research and Monitoring Priorities table (task already performed by the Research Subgroup).
- Develop a predictive model of trespass marijuana grow site probability to aid law enforcement and remediation efforts (currently under development).
- Conduct research and monitoring to determine how long toxicants remain in the environment and affect wildlife, and assess and implement effective means of mitigating their impacts.
- Develop a fisher climate adaptation plan.

## 10.2 US Fish and Wildlife Service

The FWS will utilize the scientific information and goals and objectives in the Conservation Strategy in activities under its authorities. In addition, if the species is listed, the Conservation Strategy will be used to help develop a Recovery Plan for the southern population. The FWS will use the information in the Strategy to inform consultation for projects or plans that may affect the fisher or its habitat. The FWS will participate in the implementation of the Strategy with all interested agencies and stakeholders.

## 10.3 California Department of Fish and Wildlife

The CDFW will continue its role in monitoring, especially of fisher diseases and toxicant exposure. The CDFW Wildlife Investigations Lab has regulatory-mandated responsibility (CA Fish & Game Code) to “investigate all diseases of, and problems relating to, birds, mammals, or fish, and maintain laboratories to assist in such investigation.” The CDFW will also use this Strategy to inform consultation for projects or plans that may affect the fisher or its habitat, and it will participate in implementing the Strategy subject to departmental policies and jurisdictional obligations.

## 10.4 US Forest Service

The US Forest Service (USFS) will use the information in the Conservation Strategy and, specifically, the desired conditions and conservation measures, to inform revisions of Forest Plans for the national forests covered by the Conservation Strategy (Sequoia, Sierra, Inyo, and Stanislaus). The Strategy will inform project design within the core areas that may affect fishers or their habitat, and will be used in the project environmental analyses. The USFS will monitor fishers and their habitat and work with partner agencies to maintain databases, update vegetation data, and other actions needed to use the decision-support tools and implement other components of the Conservation Strategy. The Pacific Southwest Research Station will continue its research on the fisher. The USFS will participate in implementation of the Strategy with all agencies and stakeholders and pursue interagency agreements (MOU, MOA, or Conservation Agreement) as needed. If the species is listed, the USFS will consult with FWS as required by ESA, using the Conservation Strategy to inform the consultation, and work with the FWS on a Recovery Plan.

The USFS will also implement other recommendations of the Strategy as appropriate, such as importing linkage area polygons into the Wildland Fire Decision Support System (WFDSS), continuing and refining as necessary the regional fisher monitoring program, maintaining the monitoring database, and analyzing and reporting on findings according to the schedule established by the monitoring program.

## 10.5 National Park Service

NPS will plan all upcoming projects (including fire and implementation of the Merced and Tuolumne river plans and the Mariposa Grove Plan) to comply with the Conservation Strategy and legal requirements of the ESA for fisher and other listed species, Wild and Scenic River Act, State Historic Preservation Act, and Wilderness Act. Considerations will include maintaining or enhancing habitat, protecting movement corridors, and enforcing LOPs and avoidance areas, as detailed in the Strategy. The NPS will maintain fisher habitat by reducing the potential for high-severity stand-replacing fires, a management action that may sometimes conflict with the need to protect/enhance habitat.

The NPS will prioritize the areas just north of the Merced River and around Wawona for inventory and monitoring, as funding and time allow. Post-fire habitat monitoring will also continue as funding and personnel availability allow. The NPS will have all fisher carcasses tested for rodenticides and prioritize early detection and clean-up of trespass marijuana grow sites, install road-crossing structures, reduce legal driving speeds, increase road visibility in high wildlife mortality areas, and manage vegetation to funnel fishers to road crossings, as warranted based on monitoring data.

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# Appendix A—Methods for Select Analyses

This appendix summarizes methods and results of analyses used in developing the Conservation Strategy. It doesn't repeat relatively straightforward techniques described in the main text or in the Conservation Assessment. The intent is to provide sufficient information on the more complex analyses mentioned, but not fully described, in the Strategy text so that technical reviewers can evaluate the methods and the analyses can be repeated or updated with new data in the future.

Unless otherwise stated, all analyses were performed by Conservation Biology Institute in consultation with members of the Fisher Technical Team.

## A-1 Calculating Female Home Range Potential and Carrying Capacity

We developed a principal components analysis (PCA) that characterizes the composition of adult female fisher home ranges, and used it to rate the suitability of hexagonal cells within the management grid as potential breeding home range areas (Strategy Section 3.1.1). The number of suitable and unsuitable grid cells provides a rough estimate of potential breeding carrying capacity in each core area and a means of tracking or simulating carrying capacity over time.

### A-1.1 Delineating Home Ranges

C. Thompson and J. Garner (PSW) provided 83 annual home range polygons produced from telemetry data for adult females from three fisher telemetry studies in the Strategy Area: Sierra Nevada Adaptive Management Project (SNAMP, 54), Kings River Fisher Project (KRFP, 22), and Zielinski et al. (2004) on Sequoia National Forest (SEQ, 7). Thompson and Garner delineated the home ranges using different fixed-kernel contour thresholds (Worton 1989) for each study to account for methodological differences and make the home range size estimates more comparable across the studies. Fishers are more easily detected using aerial telemetry (SNAMP study) than ground-based telemetry (KRFP and SEQ studies), especially during long-range movements. The greater sampling success in outlying portions of home ranges by SNAMP results in larger home range estimates for a given contour threshold. In addition, both the SNAMP and KRFP studies tracked fishers longer and had greater sample sizes than the SEQ study. To adjust for these differences and make home range estimates more general across the Strategy Area, Thompson and Garner compared median home range sizes in each study at various contour thresholds and selected those that (1) reduced gross size differences among the studies and (2) fit expert opinion about how variations in habitat conditions affect home range sizes: the 95% contour for SEQ, 90% for KRFP, and 85% for SNAMP (Table A-1). Precise home range delineation and perfect comparability among studies are not important for purposes of characterizing home range-scale habitat quality, so long as the home range polygons generally encompass the habitat conditions experienced by adult female fishers within their home ranges.

We assume that these home ranges represent areas within which female fishers have successfully reproduced. Reproduction has been confirmed in nearly all home ranges in the SNAMP and KRFP studies during at least 1 year of study (C. Thompson, personal communication). Although breeding success is not known for the SEQ females, they represent a small proportion of the total sample ( $7/83 = 8.4\%$ ) and likely also represent suitable breeding habitat due to abundant CWHR high reproductive habitat, high tree basal area and canopy cover, and abundant black oaks (Zielinski et al. 2004 and our analyses).

**Table A-1—Mean and standard deviation (SD) home range area by study site.** Home range polygons delineated as fixed-kernel contours of 85% (SNAMP), 90% (KRFP), and 95% (SEQ) to adjust for methodological and sampling differences between studies.

Region	Number	Mean area (km <sup>2</sup> )	SD
SNAMP	54	20.96	26.71
KRFP	22	18.21	17.04
SEQ	7	12.22	4.31
All	83	19.49	23.43

## A-1.2 Home Range Principal Components Analysis

We compiled a set of 41 environmental variables (rasters at 30-m resolution) that are important to fisher habitat selection and potentially affected by vegetation management activities (Table A-2). The data were derived from two sources: EVEG (Existing Vegetation, USDA Forest Service, Pacific Southwest Region, Remote Sensing Lab)<sup>1</sup> and GNN (LEMMA working group (Ohmann et al. 2014))<sup>2</sup>. We attempted to rely solely on EVEG as a data source, as it is a USFS product that is periodically updated and regularly used by resource managers. However, GNN provides some relevant forest structural variables not available from EVEG, and it is available annually from 1990 to 2012, which enabled us to examine vegetation changes over time (Section A-3). We therefore derived two PCAs: one using variables selected from EVEG and GNN to depict current habitat conditions (this section) and a second using only GNN variables to assess changes over time (Section A-3).

The landscape configuration of CWHR fisher high reproductive habitat was quantified with FRAGSTATS (McGarigal et al. 2002) to delineate patches for class metrics. FRAGSTATS was run on each individual home range and grid cell separately in batch mode. CWHR high reproductive habitat was derived from EVEG and defined as:

WHRTYPE of Douglas Fir, Eastside Pine, Jeffrey Pine, Lodgepole Pine, Montane Hardwood-Conifer, Montane Hardwood, Montane Riparian, Ponderosa Pine, Red Fir, Subalpine Conifer, Sierran Mixed Conifer, or White Fir; and

WHRSIZE and WHRDENSITY of 4D (dbh 11.0 - 23.9 in. and canopy closure  $\geq$ 60%), 5D (dbh  $\geq$ 24.0 in. and canopy closure  $\geq$ 60%), 5M (dbh  $\geq$ 24.0 in. and canopy closure 40.0 - 59.9%), and 6 (a distinct layer of size class 5 trees over a distinct layer of size class 4 and/or 3 trees, and total tree canopy of the layers  $\geq$ 60% (layers must have  $\geq$ 10.0% canopy cover and distinctive height separation)).

Environmental variable layers were summarized (mean, standard deviation, percent area by class) by individual home ranges and cells using the National Water-Quality Assessment (NAWQA) Area-Characterization Toolbox for ArcGIS Desktop software version 9.3.1 (Price et al. 2010). Variable values

<sup>1</sup> <http://www.fs.usda.gov/detail/r5/landmanagement/resourcemanagement/?cid=stelprdb5347192>

<sup>2</sup> <http://lemma.forestry.oregonstate.edu/>

for home ranges and grid cells were combined into a spreadsheet for import into R (R Core Team 2014, The R Foundation for Statistical Computing, version 3.1.1) for statistical analysis.

**Table A-2—Potential environmental variables evaluated for use in the PCA.** Variable names in italics were selected for inclusion in the final EVEG-GNN PCA.

<b>Configuration (FRAGSTATS + EVEG)</b>	
AI	Aggregation Index - the number of like adjacencies involving CWHR high reproductive habitat, divided by the maximum possible number of like adjacencies involving CWHR high reproductive habitat, which is achieved when the class is maximally clumped into a single, compact patch; multiplied by 100 (to convert to a percentage)
COHESION	Computed from the information contained in patch area (CWHR high reproductive habitat) and perimeter, proportional to the area-weighted mean perimeter-area ratio divided by the area-weighted mean patch shape index (i.e., standardized perimeter-area ratio)
ED	Edge density (CWHR high reproductive habitat)
ENN_AM	Area-weighted mean Euclidean nearest neighbor distance for CWHR high reproductive habitat patches
PD	Patch density (CWHR high reproductive habitat)
<i>PLADJ</i>	Number of like adjacencies involving the focal class (CWHR high reproductive habitat), divided by the total number of cell adjacencies involving the focal class (CWHR high reproductive habitat); multiplied by 100 (to convert to a percentage); transformed by raising to the power of 13
<b>Composition and structure (FRAGSTATS + EVEG)</b>	
<i>PLAND</i>	Proportion in CWHR high reproductive habitat; transformed by raising to the power of 3
<b>Composition and structure (EVEG)</b>	
CC	Percent area by tree canopy cover from above class (relative percentages of non-overlapping vegetation cover as seen from above in a delineated area on aerial photos or imagery), 10 percent classes
<i>TTCFA_GE70</i>	Percent area with tree canopy cover $\geq 70\%$ ; transformed by raising to the 1.5 power
<i>TTCFA_LT40</i>	Percent area with tree canopy cover $< 40\%$ ; transformed with log
SC	Percent area by shrub canopy cover class (relative percentages of non-overlapping vegetation cover as seen from above in a delineated area on aerial photos or imagery), 10% classes
<b>Composition and structure (GNN)</b>	
<i>BA_MN</i>	Basal area ( $\text{m}^2/\text{ha}$ ) of live trees $\geq 2.5$ cm dbh (mean)
<i>DDI</i>	Diameter diversity index (mean); DDI is a measure of the structural diversity of a forest stand, based on tree densities in different dbh classes; transformed by raising to the power of 3
<i>DWN_WD_VOL</i>	Volume ( $\text{m}^3/\text{ha}$ ) of down wood $\geq 25$ cm diameter at large end and $\geq 3\text{m}$ long (mean)



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**Composition and structure (GNN)**


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PCT_LAYERS	Percent area by class: number of tree canopy layers present (1-3). Trees within a plot are divided into 3 equal strata based on the height of the tallest tree. The total crown cover in each stratum is calculated by summing the canopy cover values for all trees in the stratum. The number of layers is determined by the number of strata that contain $\geq 10\%$ cover
PERC_CANCOV_MN	Canopy cover of all live trees (mean): calculated using methods in the Forest Vegetation Simulator for Inventory plots; sum of ocular estimates for Ecology plots
PERC_CANCOV_SD	Canopy cover of all live trees (standard deviation): calculated using methods in the Forest Vegetation Simulator for Inventory plots; sum of ocular estimates for Ecology plots
QUKE_BA	Basal area ( $\text{m}^2/\text{ha}$ ) of black oak (mean); transformed with square-root.
SNAG_DENS	Density of snags $\geq 25$ cm dbh and $\geq 2$ m tall (mean)

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The variable selection and PCA modeling process was iterative, involving expert discussion and revisions by a small group of fisher experts, ecologists, a statistician, and the GIS modeler<sup>3</sup> to review and discuss interim results and decide on revisions needed to meet the goals, such as eliminating variables that were found problematic for one reason or another (e.g., poor accuracy or close correlation with another variable that explained more variance). The goal was to create a PCA (using the *princomp* command in R; R Core Team 2014, The R Foundation for Statistical Computing, version 3.1.1) that accounted for  $\geq 90\%$  of variation in home range characteristics using a small suite of variables that (1) are known to be associated with fisher habitat selection, (2) represent different fisher niche dimensions to the degree possible, (3) can be understood and used by resource managers, and (4) are likely to be affected by management actions (i.e., vegetation variables rather than terrain or climate variables).

The final PCA uses eight variables (some of which were transformed to be more normally distributed, Table A-2). The first three principal components account for 94.5% of the variation in home ranges (Table A-3). The first component is most strongly associated with the proportion of home range in CWHR high reproductive habitat (PLAND) and percentage of like adjacencies (i.e., aggregation) of high reproductive habitat (PLADJ), as well as the proportion of home range with total tree cover from above  $< 40\%$  (TTCCA\_40) (Table A-4). The second component is most correlated with proportion of home range having total tree cover from above  $\geq 70\%$  (TTCCA\_70), black oak basal area (QUKE\_BA), and snag density (SNAG\_DENS). The third component is dominated by black oak basal area. This third component strongly differentiates the Sequoia home ranges from those within SNAMP and KRFP, with significantly higher black oak basal area in the Sequoia home ranges. The SNAMP home ranges capture the greatest range of variability along components 1 and 2, with KRFP home ranges overlapping or nested within the SNAMP range of variability (Figure A-1).

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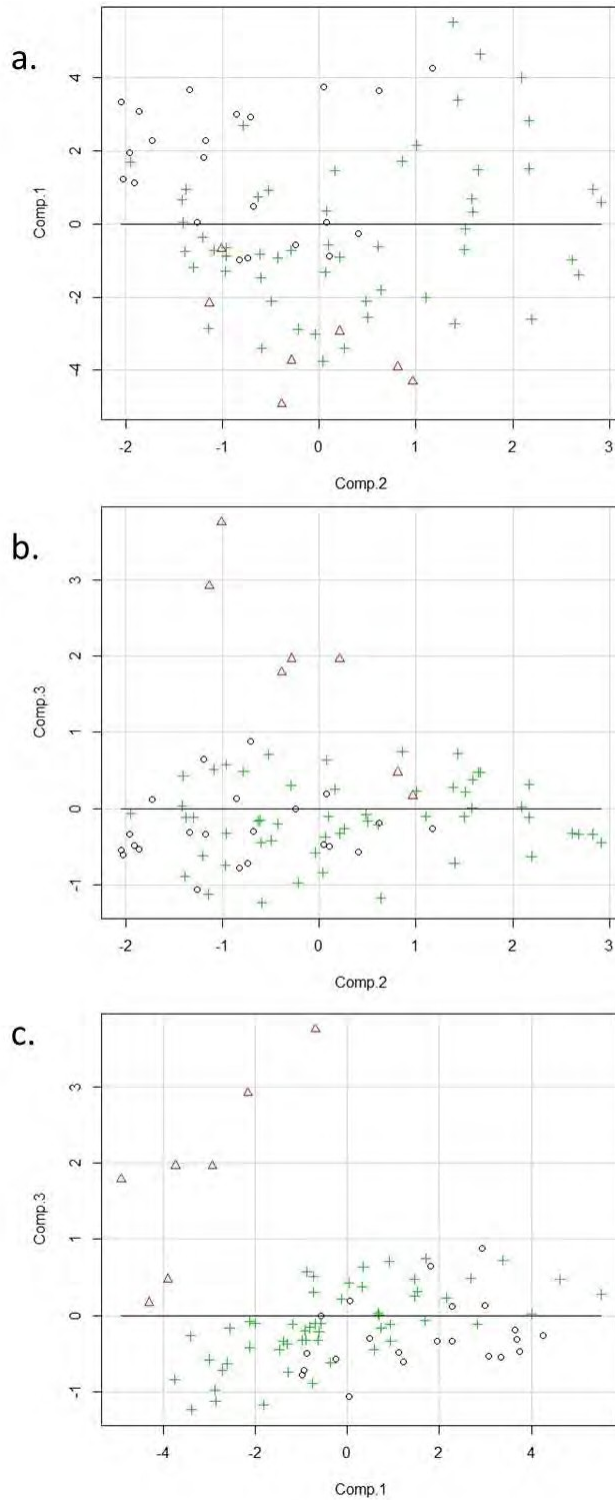
<sup>3</sup> W. Zielinski (PSW), C. Thompson (PSW), S. Britting (Sierra Forest Legacy), W. Spencer (CBI), S. Sawyer (USFS), J. Baldwin (PSW), and H. Romsos (CBI).

**Table A-3—Variation explained by PCA components.**

	<b>Comp.1</b>	<b>Comp.2</b>	<b>Comp.3</b>	<b>Comp.4</b>	<b>Comp.5</b>	<b>Comp.6</b>	<b>Comp.7</b>	<b>Comp.8</b>
SD	2.298	1.276	0.808	0.451	0.298	0.261	0.209	0.190
Proportion of variance	0.660	0.203	0.082	0.025	0.011	0.008	0.005	0.005
Cumulative proportion	0.660	0.863	0.945	0.970	0.982	0.990	0.995	1.000

**Table A-4—PCA loadings for the first 3 components.**

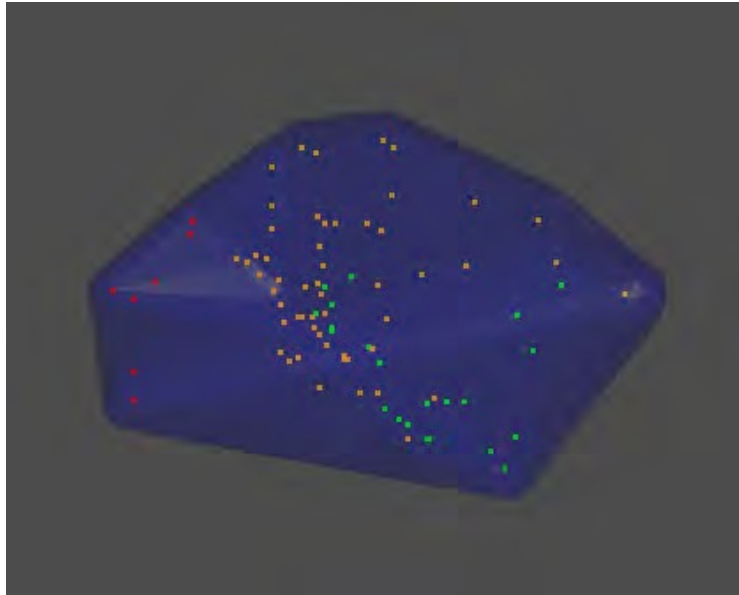
	<b>PC1</b>	<b>PC2</b>	<b>PC3</b>
BA_MN	-0.36	0.36	0.27
DDI	-0.37	0.35	0.04
QUKE_BA	-0.25	-0.42	0.76
SNAG_DENS	-0.26	0.57	0.20
TTCFA_LT40	0.41	0.18	0.10
TTCFA_GE70	-0.34	-0.45	0.00
PLADJ	-0.40	-0.09	-0.35
PLAND	-0.40	-0.10	-0.41



**Figure A-1—Two-dimensional scatterplots of home range PCA scores.** (a) First two components, (b) second and third components, and (c) first and third components. Black circles indicate KRFP, green + indicates SNAMP, and red triangle indicates SEQ home ranges.

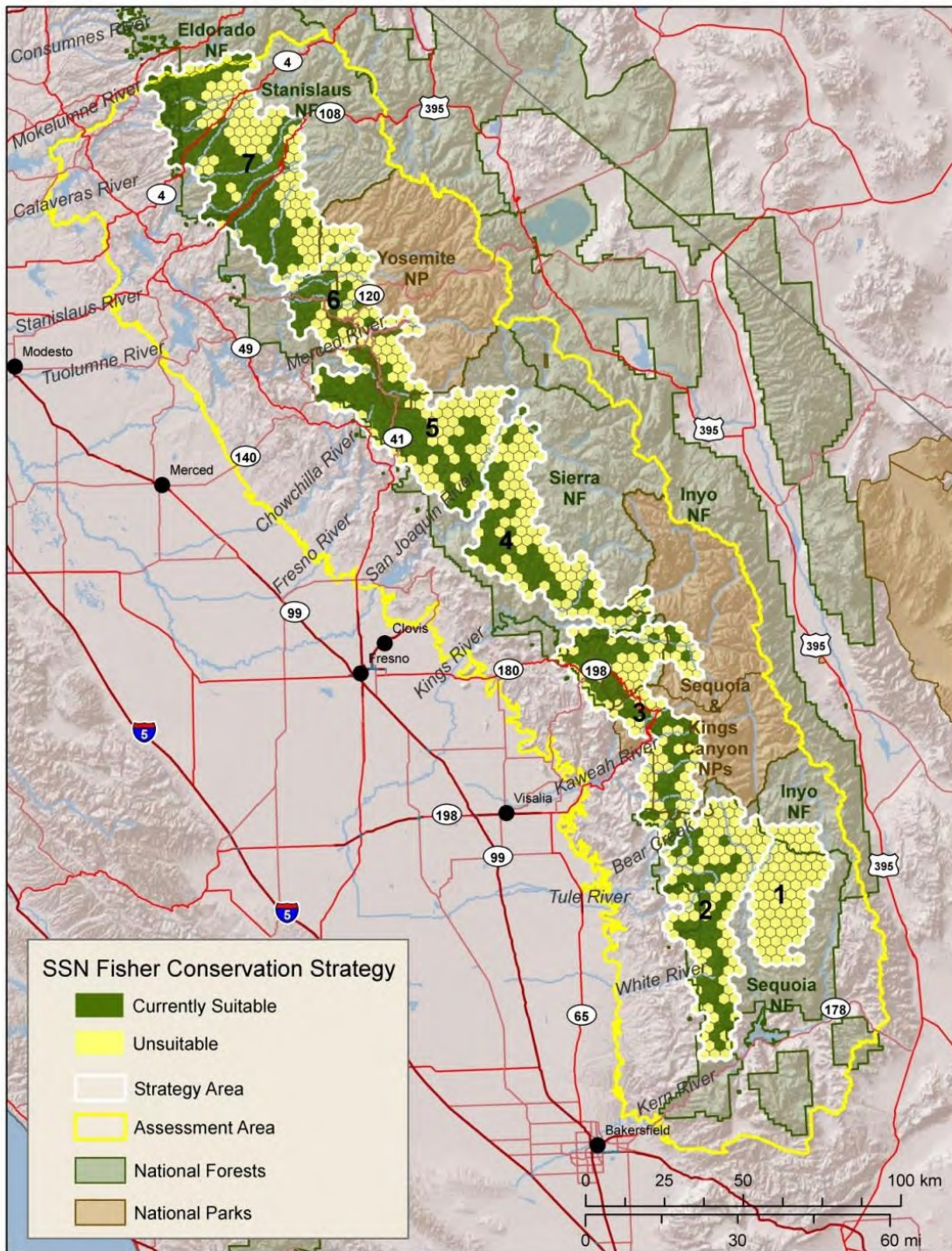
### A-1.3 Scoring Grid Cell Suitability

A three-dimensional convex hull encompassing the home range PCA scores in multivariate space was constructed using the first three principal components after buffering each home range point by 0.5 units (Figure A-2). PCA scores were then calculated for each management grid cell. Cells with scores falling within the hull were considered suitable, and those falling outside were considered unsuitable. For those falling outside the hull, the distance (in multivariate space) of each cell score from the home range PCA hull (*distance from hull*) was evaluated to provide a relative measure of how unsuitable a cell may be (see Section A-3).



**Figure A-2—Three-dimensional convex hull enclosing home ranges in PCA space.** Red points are SEQ, green KRFP, and orange SNAMP home range PCA scores.

Of the 1,012 total cells comprising the Strategy Area, 415 were classified as currently suitable (Figure A-3). The distribution of suitable cells coincides well with the home ranges used to build the PCA, with all home ranges overlapping one or more suitable cells (Figure A-4). Predicted suitable cells also contain 86% of known den sites and 78% of modeled denning habitat (Figure A-5). In addition, 72% of survey female fisher detections by the regional fisher monitoring program from 2006 to 2013 (J. Tucker, unpublished data) were in predicted suitable cells; and detections outside suitable cells are all close to suitable cells (except in Core 1 where the PCA underestimates suitability) (Figure A-6).



**Figure A-3—Management grid system showing cells predicted to be suitable or unsuitable to support female home ranges, based on the PCA hull. Note lack of predicted suitable cells in Core 1 despite female detections there.**



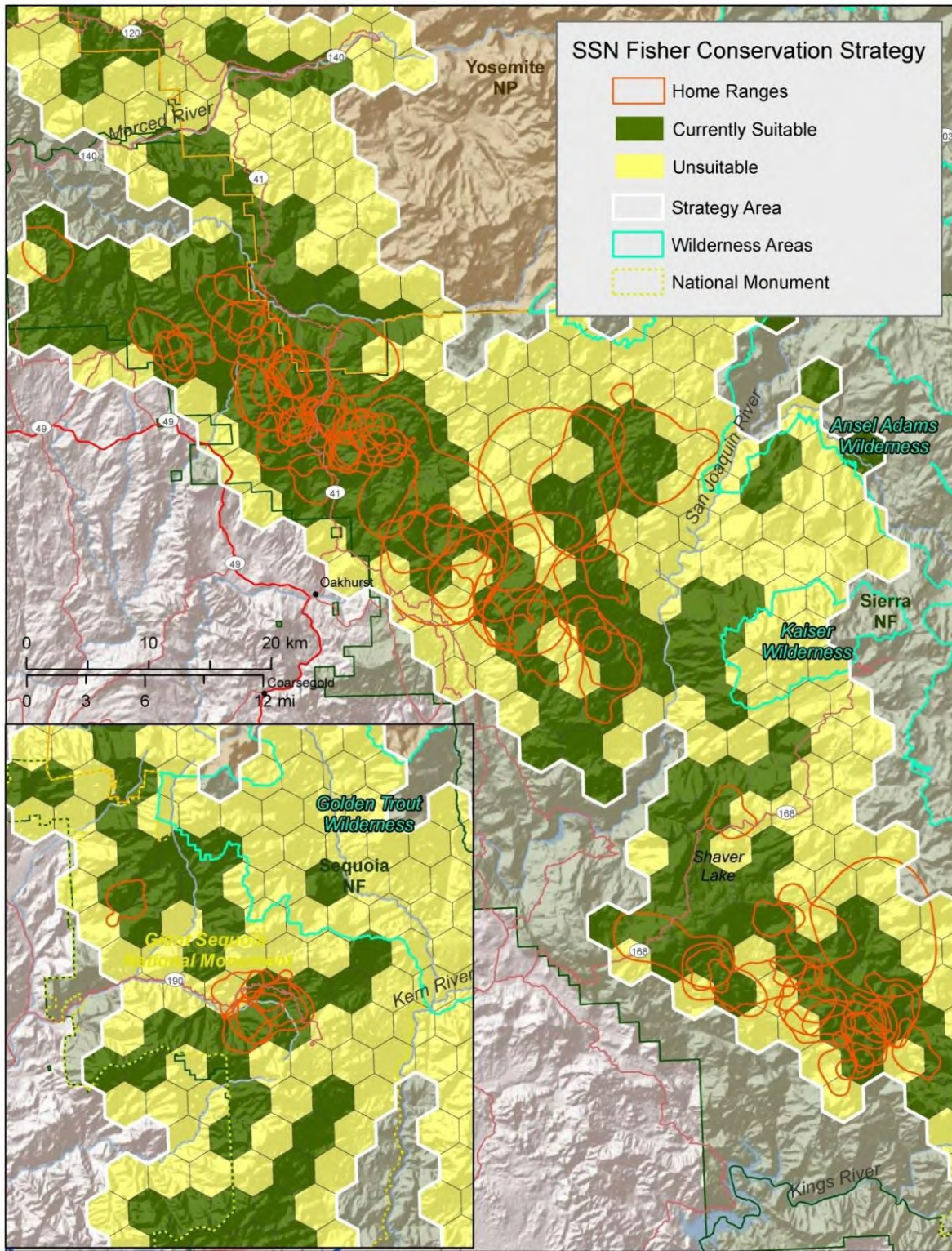
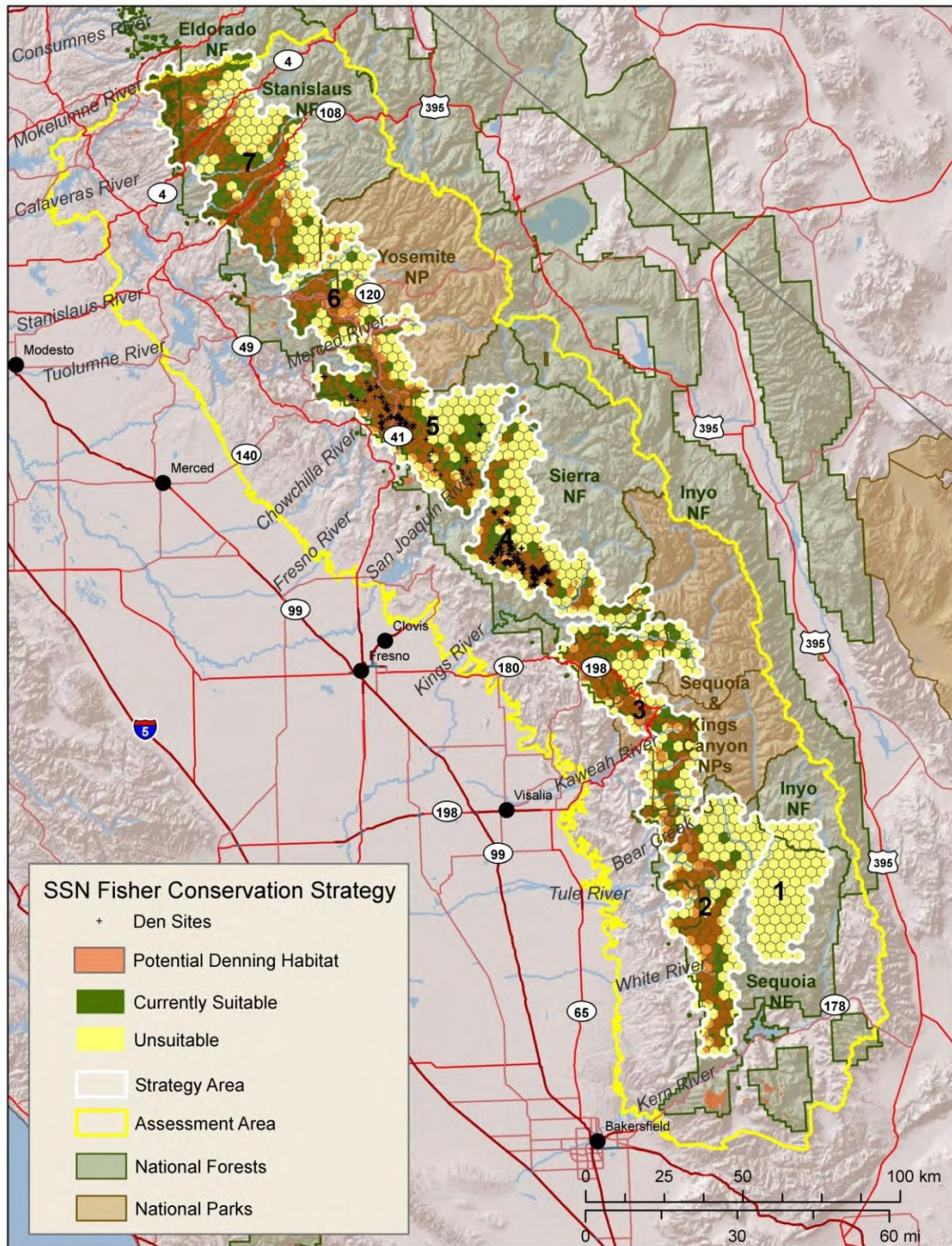


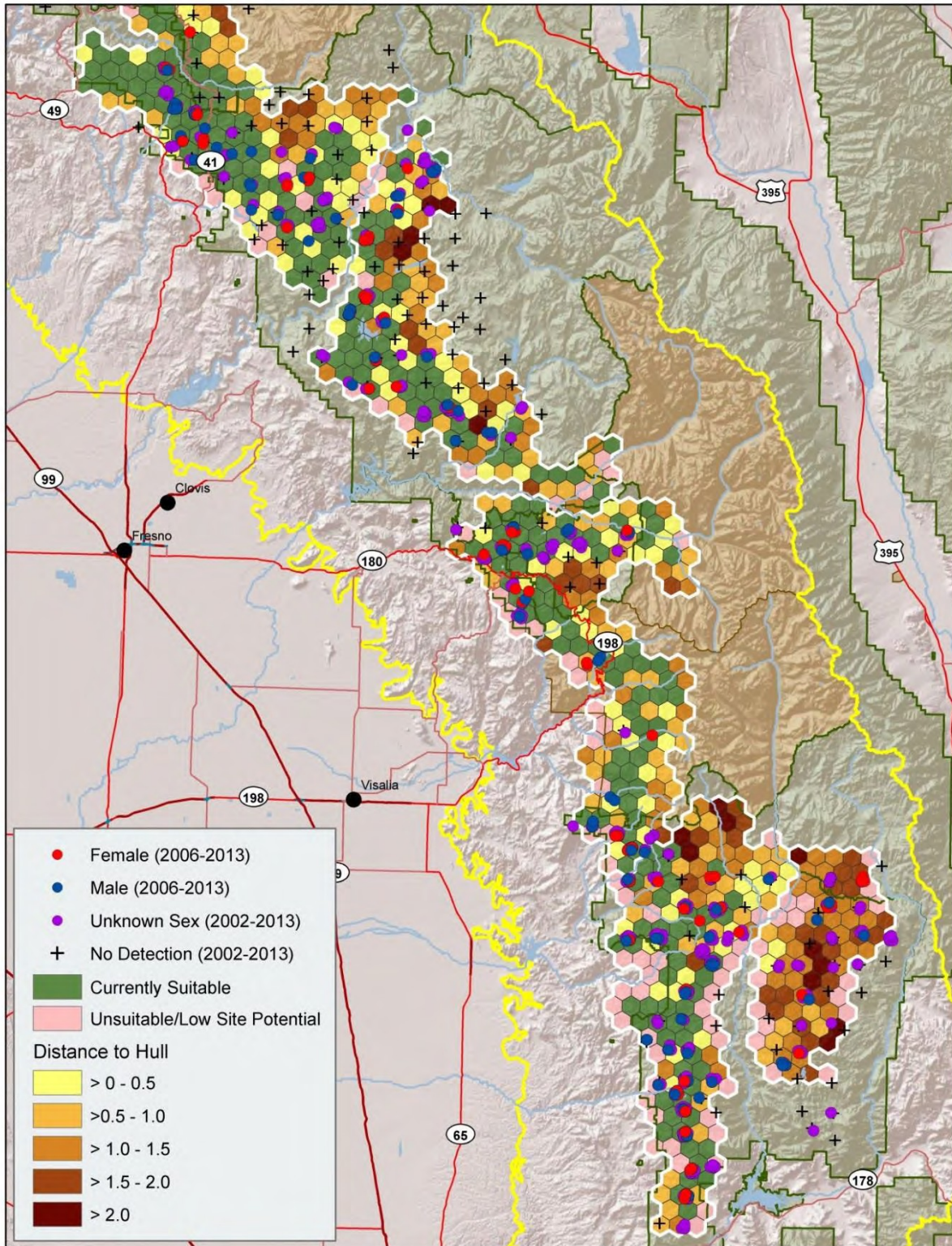
Figure A-4—Agreement between suitable cells and home ranges used in the PCA.





**Figure A-5—Agreement between modeled denning habitat, known den sites on Sierra NF, and suitable cells.** See Spencer et al. (2015) for methods used to model denning habitat.





**Figure A-6—Fisher detections 2006-2013 by sex (where known) relative to predicted cell suitability.** Source: Tucker, unpublished data, USFS regional fisher monitoring program.

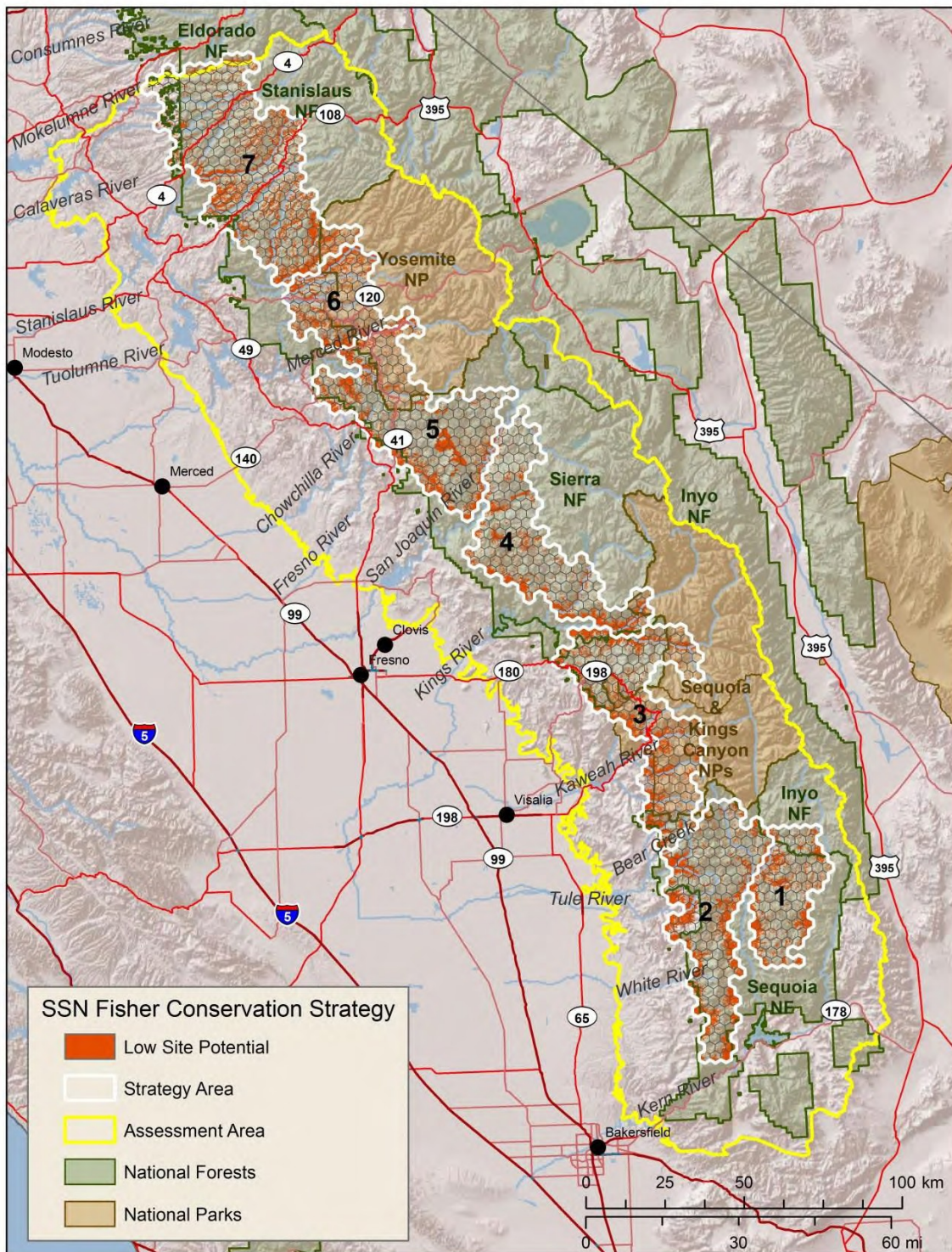
## A-1.4 Characterizing Low Site Potential Cells

Some unsuitable cells have a very low likelihood of ever supporting forest vegetation with large trees, and therefore suitable to support a breeding female fisher, due to low site productivity (e.g., due to physical factors like shallow soils). Cells that were predicted to be unsuitable for fishers in 2012 by the EVEG-GNN PCA, as well as in all 3 years analyzed using a GNN-only PCA (1990, 2000, and 2012; see Section A-3.1), were evaluated to determine their percent area classed as having low site potential according to various available data layers (Table A-5). Cells found to be unsuitable in all four PCAs, and having >50% of their area mapped in any of the classes listed in Table A-5 (Figure A-7), were defined as having low potential to ever support a female fisher home range (107 total cells). Excluding those cells, 905 of the original 1,012 cells are considered to have current or future potential to support a female fisher (Figure A-8).

**Table A-5—Low site potential classes and data sources.**

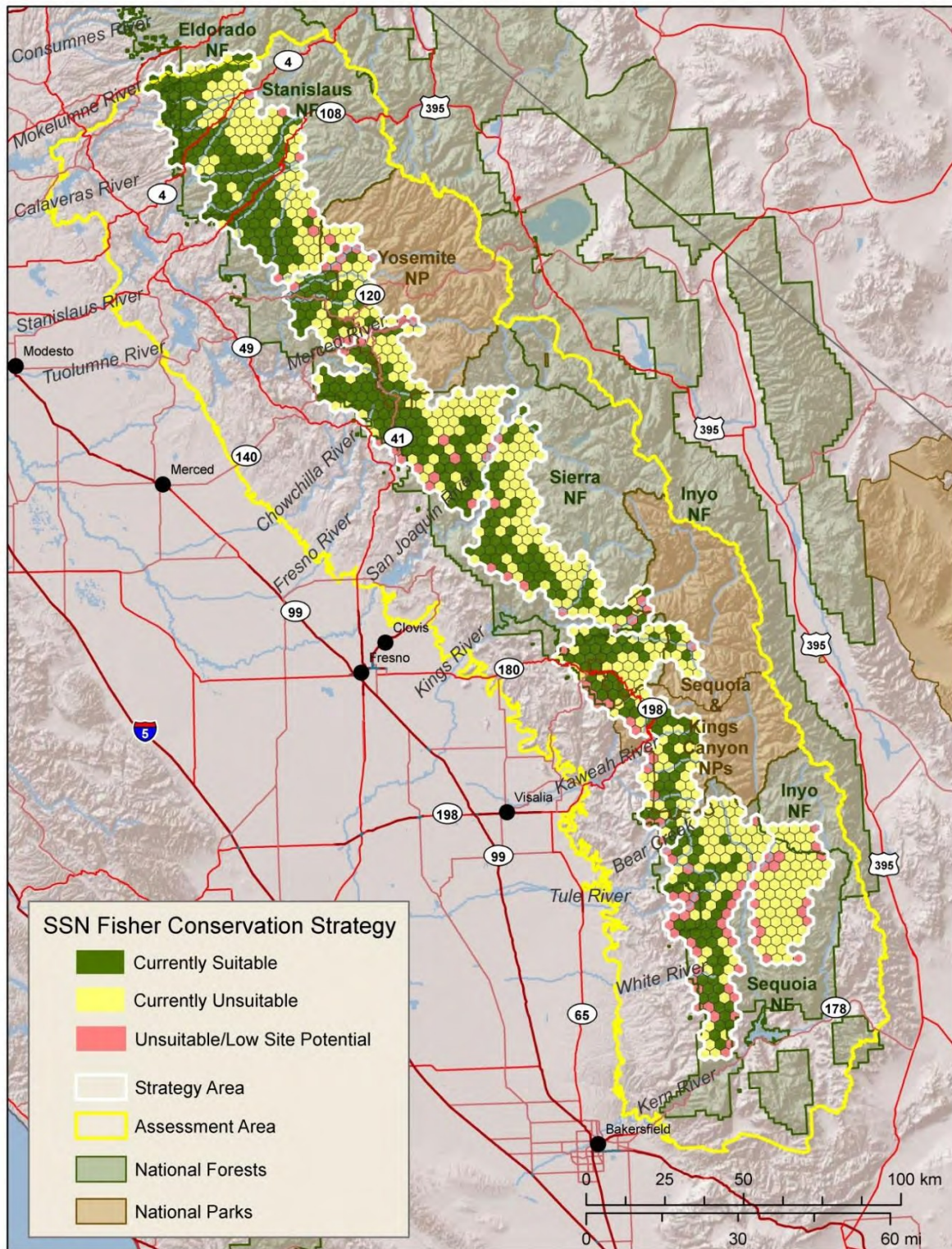
Class	Attribute	Source
Non-productive forest, non-forest	PROD	Existing Vegetation, USDA Forest Service - Pacific Southwest Region - Remote Sensing Lab, <a href="http://www.fs.usda.gov/detail/r5/landmanagement/resourcemanagement/?cid=stelprdb5347192">http://www.fs.usda.gov/detail/r5/landmanagement/resourcemanagement/?cid=stelprdb5347192</a>
Non-productive forest, non-forest	Productivity	Land Suitability Class (Sequoia, Sierra, Inyo, and Stanislaus national forests), USDA Forest Service - Pacific Southwest Region - Remote Sensing Lab, <a href="http://www.fs.usda.gov/detail/r5/landmanagement/gis/?cid=STELPRDB5327840">http://www.fs.usda.gov/detail/r5/landmanagement/gis/?cid=STELPRDB5327840</a>
Non-forest	WHRLIFEFORM	Existing Vegetation, USDA Forest Service - Pacific Southwest Region - Remote Sensing Lab, <a href="http://www.fs.usda.gov/detail/r5/landmanagement/resourcemanagement/?cid=stelprdb5347192">http://www.fs.usda.gov/detail/r5/landmanagement/resourcemanagement/?cid=stelprdb5347192</a>
Unsuitable for timber production	Suitability	Land Suitability Class (Sequoia, Sierra, Inyo, and Stanislaus national forests), USDA Forest Service - Pacific Southwest Region - Remote Sensing Lab, <a href="http://www.fs.usda.gov/detail/r5/landmanagement/gis/?cid=STELPRDB5327840">http://www.fs.usda.gov/detail/r5/landmanagement/gis/?cid=STELPRDB5327840</a>
Unsuitable for timber production	Suitability	UnsuitableForestLandAreas95_1, USDA Forest Service - Pacific Southwest Region - Remote Sensing Lab, <a href="http://www.fs.usda.gov/detail/r5/landmanagement/gis/?cid=fsbdev3_0482">http://www.fs.usda.gov/detail/r5/landmanagement/gis/?cid=fsbdev3_0482</a>
Non-forest historical reference conditions	GROUPVEG	LANDFIRE Biophysical Settings (LANDFIRE 2012 (LF 1.3.0)), US Geological Survey, Earth Resources Observation and Science (EROS) Center, <a href="http://www.landfire.gov/NationalProductDescriptions20.php">http://www.landfire.gov/NationalProductDescriptions20.php</a>





**Figure A-7—Areas classed as having low site potential to support fisher habitat.** Low site potential includes areas classed as non-productive forest, non-forest, unsuitable for timber production, or non-forest historical reference conditions (Table A-5).





**Figure A-8—Cells predicted to be currently suitable, potentially suitable in the future, or having low potential to ever become suitable to support a female fisher.**

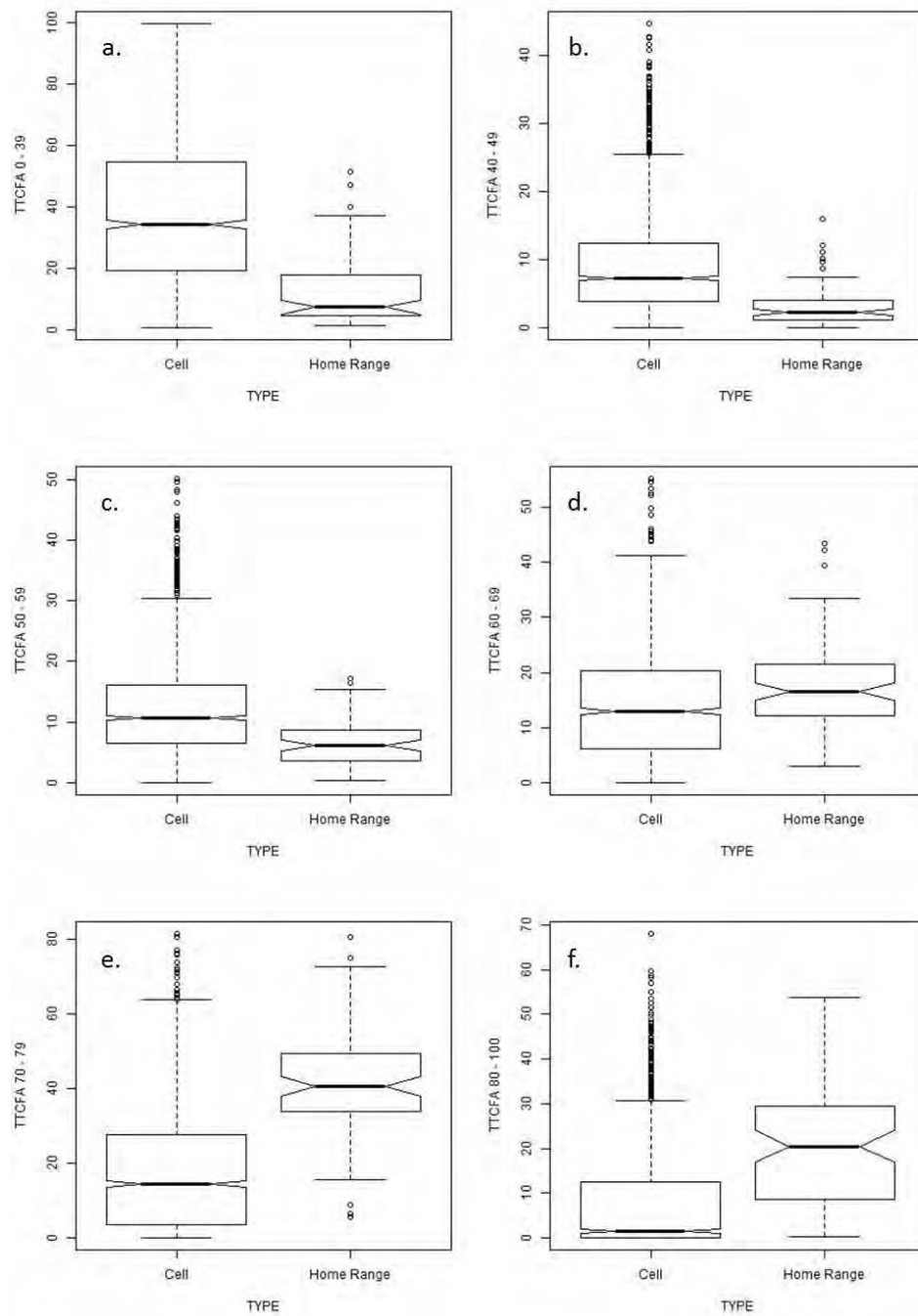
## A-2 Female Home Range Composition Analyses

In addition to the PCA analysis described in Section A-1.2, we investigated female home range habitat selection using a variety of other univariate and multivariate techniques to better understand how females are selecting for or against various vegetation conditions.

### A-2.1 Boxplot Analysis

We compared the composition of the 83 female home ranges and grid cells throughout the Strategy Area using univariate use-availability boxplots to evaluate selection of home range habitat conditions by female fishers. The analysis used all variables listed in Table A-2, as well as additional canopy cover classes (EVEG data classifying canopy cover in 10% bins, from 0 to 100%).

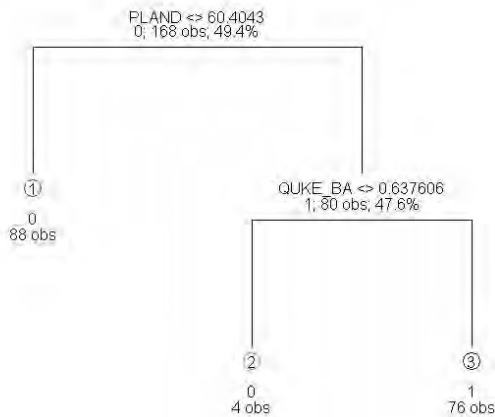
Section 3.2 of the Strategy presents boxplot results for the variables used in the final PCA (Table A-4). Figure A-8 shows the canopy cover selection analysis in more detail, due to the importance of canopy cover to both fisher habitat suitability and forest resiliency. Comparing the proportions of different canopy cover classes within female home ranges and their availability throughout the Strategy Area clearly shows that fishers select significantly against areas with <60% canopy cover (Figure A-9a-c), use areas with 60-69% canopy cover in approximately in proportion to their availability or with slight positive selection (Figure A-9d), and select significantly and positively for areas with >70% canopy cover. These boxplot results were used to inform variable selection for the PCA and the description of desired habitat conditions for female fishers—in particular to recommend proportions of open canopy (<40%) and dense canopy (>70%) forests in management grid cells targeted to remain or become suitable to support female fishers (Strategy Section 4.3.2).



**Figure A-9—Boxplots comparing use by female fishers with availability of tree canopy cover classes in the Strategy Area.** Use represented as the proportion of female home range polygons (N = 83) and availability as proportion of hexagonal cells (N = 1,012) in a cover class. Bold horizontal lines are medians; boxes are the middle two quartiles; whiskers approximate 95% confidence intervals; and circles are outliers. If notches around the medians do not overlap, use and availability can be considered significantly different with 95% confidence (Chambers et al. 1983).

## A-2.2 Classification and Regression Tree Analysis

We used classification and regression tree (CART) analysis as another approach to understanding female fisher habitat selection at the home range scale using the same home ranges as for the PCA (N = 83). The CART compares home range characteristics to a random selection (N = 85) of grid cells that were classed as currently unsuitable by the PCA hull analysis (excluding cells in Core 1 and cells classed as having low site potential). We used the package *rpart* for R (Therneau et al. 2014) and the same eight predictors as the final PCA. We used the Gini rule for splitting and 10-fold cross validation and pruned the resulting tree to the smallest tree having cross-validation error within one standard error of the minimum (tree size = 3; two nodes; Figure A-10). According to the pruned tree, cells with >60.4% area in high value CWHR reproductive habitat (PLAND) and mean black oak basal area (QUKE\_BA) >0.64 m<sup>2</sup>/ha are classified as suitable. This classification results in an overall accuracy rate of 0.95 and precision of 0.99, with 75 of 83 home ranges and 84 of 85 unsuitable cells correctly classified.



**Figure A-10—Pruned classification and regression tree for female fisher home range suitability using package *rpart*.**

## A-2.3 CWHR Size and Density Class Selection

The PCA, CART, and boxplot analyses (Strategy Sections 3.1 and 3.2) all demonstrate strong associations between female fisher home ranges and CWHR high reproductive habitat (e.g., variable PLAND), which includes CWHR size and density classes 4D, 5M, 5D, and 6 (Table A-6). However, class 5M has more open canopy than the fisher literature and our various analyses suggest is suitable for fishers. Consequently, we evaluated if fishers differentially select among the different size and cover classes comprising CWHR high value reproductive habitat by comparing their abundance in areas used by female fishers with availability in the Strategy Area.

**Table A-6—CWHR size and canopy cover classes used in habitat selection analysis**, restricted to CWHR vegetation types Douglas Fir, Eastside Pine, Jeffrey Pine, Lodgepole Pine, Montane Hardwood-Conifer, Montane Hardwood, Montane Riparian, Ponderosa Pine, Red Fir, Subalpine Conifer, Sierran Mixed Conifer, and White Fir.

Habitat Class	CWHR Size (dbh)	CWHR Canopy Closure
CWHR 4D	4 (11.0-23.9 in.)	D (≥60%)
CWHR 5M	5 (≥24.0 in.)	M (40.0-59.9%)
CWHR 5D	5 (≥24.0 in.)	D (≥60%)

We defined fisher use areas as (1) the 83 female home range polygons, and (2) modeled fisher denning habitat (Spencer et al. 2015, Appendix A). We used several statistical tests to evaluate selection by comparing proportions between use areas and the Strategy Area as a whole, including *Jacobs index* (Jacobs 1974), *Manly's alpha* (Manly 1974), and one-sample t-tests.

Jacobs index (D) ranges from -1 for complete avoidance to +1 for exclusive use:

$$D = (r-p)/(r+p-2p),$$

where r is the proportion of the habitat type in use areas (home ranges or denning habitat) and p is the proportion of the habitat type in available areas.

Manly's alpha measure of resource selection (Manly 1974):

$$\alpha_i = \frac{r_i}{n_i} \frac{1}{\sum_{j=1}^m (r_j/n_j)}$$

where  $r_i$  and  $r_j$  are the proportions of habitat type i and j used,  $n_i$  and  $n_j$  are proportion of habitat type i and j available, and m is the number of habitat type categories, ranging from 0 to 1, with neutral selection at 1/m, positive selection at values > 1/m, and negative selection at values < 1/m.

Jacobs index and Manly's alpha values both suggest that female fishers avoid CWHR high reproduction habitat classed as 5M, while selecting for CWHR reproduction habitat classed as 4D or 5D (Table A-7 and A-8).

To further evaluate the significance of the apparent selection against CWHR 5M by female fishers, we also performed a one-sided t-test to compare proportion of class 5M in home ranges (n = 83) versus availability in the Strategy Area. These results (Table A-9) demonstrate that female fishers include significantly less CWHR 5M, and significantly more CWHR 4D and 5D, in their home ranges than would be expected if these classes were being used in proportion to their availability.



**Table A-7—Jacobs Index (D) for denning habitat and home ranges.** Values >0 indicate positive selection, <0 negative selection.

Habitat class	Denning habitat	Home range mean
CWHR 4D	0.38	0.41
CWHR 5M	-0.24	-0.22
CWHR 5D	0.38	0.37
Non-CWHR	-0.57	-0.60

**Table A-8—Manly’s alpha for denning habitat and home ranges.** Values >0.25 indicate positive selection, <0.25 negative selection.

Habitat class	Denning habitat	Home range mean
CWHR 4D	0.36	0.37
CWHR 5M	0.13	0.14
CWHR 5D	0.41	0.40
Non-CWHR	0.10	0.09

**Table A-9—One sample t-tests of fisher selection of CWHR size and density classes in home ranges.** Percent areas were square root transformed.

Habitat class	Mean (SD) % area in home ranges	% of Strategy Area	t	df	p-value
CWHR 5M	1.48 (1.52)	2.31	-6.8924	82	5.182e-10
CWHR 4D	48.84 (17.12)	28.37	9.6473	82	1.862e-15
CWHR 5D	26.26 (12.38)	14.06	9.2373	82	1.214e-14

## A-3 Projecting Future Potential of Grid Cells

Establishing conservation targets for habitat quality and quantity and population size (or carrying capacity) requires an understanding of how much suitable habitat is possible or desirable at various times in the future, given vegetation dynamics (disturbance and succession processes) and variation across the landscape in the potential to support fisher habitat. We performed a time-series analysis using GNN vegetation data from 1990 to 2012 to understand the probabilities and rates of change in vegetation characteristics and home range habitat value, and used Markov chain analysis to project trends ~30 years into the future. This establishes a “baseline” or “status quo” scenario of how the amount and distribution of suitable grid cells is likely to change over the next 3 decades if disturbance and succession processes observed between 1990 and 2012 continue at about the same rates in the near future.

### A-3.1 GNN Time-Series Analysis

GNN vegetation data are available as a yearly time series from 1985 to 2012, whereas EVEG data are not available as a consistent extent-wide time series. We therefore developed a GNN-only version of the home range PCA equation to perform time-series analyses. In addition to the most recent 2012 GNN data used for the original PCA, we obtained GNN data from 1990 and 2000 to evaluate changes in PCA scores at roughly decadal time steps.

The GNN-only PCA uses approximately the same variables as the original GNN-EVEG version, but with GNN-based proxy variables substituted for the EVEG-based variables (Table A-10). The GNN attribute *canopy cover for all live trees calculated using methods in the Forest Vegetation Simulator for Inventory plots; sum of ocular estimates for Ecology plots* was used to create GNN versions of TTCFA\_GE70 and TTCFA\_LT40, and to establish CWHR density class for the variables that require that as an input (PLADJ and PLAND). CWHR size class was estimated from the GNN attribute *quadratic mean diameter of all dominant and codominant trees*. CWHR type was held constant from EVEG.

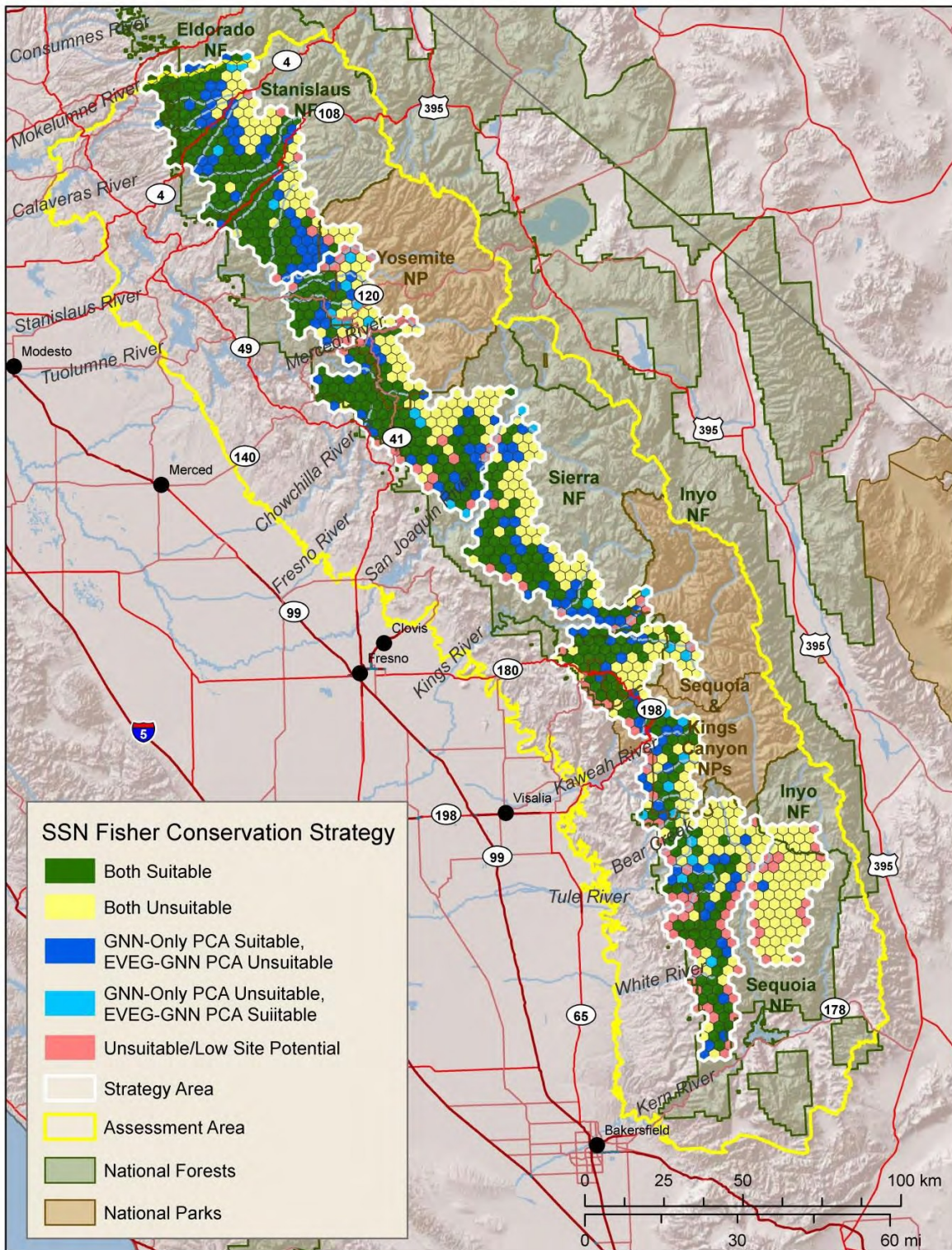
Although the GNN-only PCA is similar to the original EVEG-GNN PCA in projecting grid cell suitability, the GNN-only version is somewhat more liberal in scoring cells as suitable (Figure A-11). The two versions have a spatial congruence index (Legendre and Legendre 1998) of 0.80 and scored 79% of cells the same (382 cells were suitable and 336 unsuitable in both versions). Of the 905 total cells not characterized as having low site potential, the GNN-only PCA scored 154 (17%) as suitable that the EVEG-GNN version scored as unsuitable, and 33 (4%) as unsuitable that the EVEG-GNN version scored as suitable.

The GNN time series revealed a net gain of 7.8% suitable cells from 1990 to 2012, from 497 to 536 (Figures A-12 and A-13); 449 cells remained suitable in all three time periods; 430 remained unsuitable in all three periods (of which 107 were classed as having low site potential, Section A-1.4); and 133 cells changed status over time. Of the cells that changed status, an average of 5% (27) of suitable cells became unsuitable between time steps, while an average of 12% (46) of unsuitable cells (not including those with low site potential) became suitable. Many cells that transitioned from suitable to unsuitable had experienced large areas of moderate to severe fire during the previous decade (Section A-3.3). Most unsuitable cells that became suitable in the next time step were close to the convex PCA hull (i.e., only slightly unsuitable): on average 85% of cells that transitioned from unsuitable to suitable between time

steps were within 0.5 units of the hull, and no cells >1.5 units from the hull became suitable by the next time step. Approximately 22% of all the unsuitable cells within 0.5 units became suitable by the next time step, and about 3% of cells 0.5-1 units from the hull became suitable by the next time step (Figure A-14).

**Table A-10—Crosswalk between EVEG-derived variables and GNN-derived variables for use in the GNN-only PCA.**

<b>Variable</b>	<b>EVEG Attribute</b>	<b>GNN Attribute</b>
TTCFA_GE70	TOTAL_TREE_CFA (= 75, 85, OR 95)	CANCOV (≥70)
TTCFA_LT40	TOTAL_TREE_CFA (= 00, 05, 15, 25, OR 35)	CANCOV (<40)
CWHR high reproductive habitat (for PLAND and PLADJ)		
WHRTYPE of Douglas Fir, Eastside Pine, Jeffrey Pine, Lodgepole Pine, Montane Hardwood-Conifer, Montane Hardwood, Montane Riparian, Ponderosa Pine, Red Fir, Subalpine Conifer, Sierran Mixed Conifer, or White Fir	WHRTYPE (= DFR, EPN, JPN, LPN, MHC, MHW, MRI, PPN, RFR, SCN, SM', OR WFR)	NA (USE EVEG)
WHRSIZE and WHRDENSITY of 4D (dbh 11.0 - 23.9 in. and canopy closure ≥60%), 5D (dbh ≥24.0 in. and canopy closure ≥60%), 5M (dbh ≥24.0 in. and canopy closure 40.0 - 59.9%), and 6 (a distinct layer of size class 5 trees over a distinct layer of size class 4 and/or 3 trees, and total tree canopy of the layers ≥60% (layers must have ≥10.0% canopy cover and distinctive height separation)).	WHRSIZE = 4 AND WHRDENSITY = D; WHRSIZE = 5 AND WHRDENSITY = D; WHRSIZE = 5 AND WHRDENSITY = M; WHRSIZE = 6	CANCOV ≥60 AND QMD_DOM ≥27.94; CANCOV ≥60 AND QMD_DOM ≥60.96; CANCOV ≥40 AND QMD_DOM ≥60.96



**Figure A-11—Spatial congruence in grid cell suitability predictions between the EVEG-GNN PCA and GNN-only PCA.**



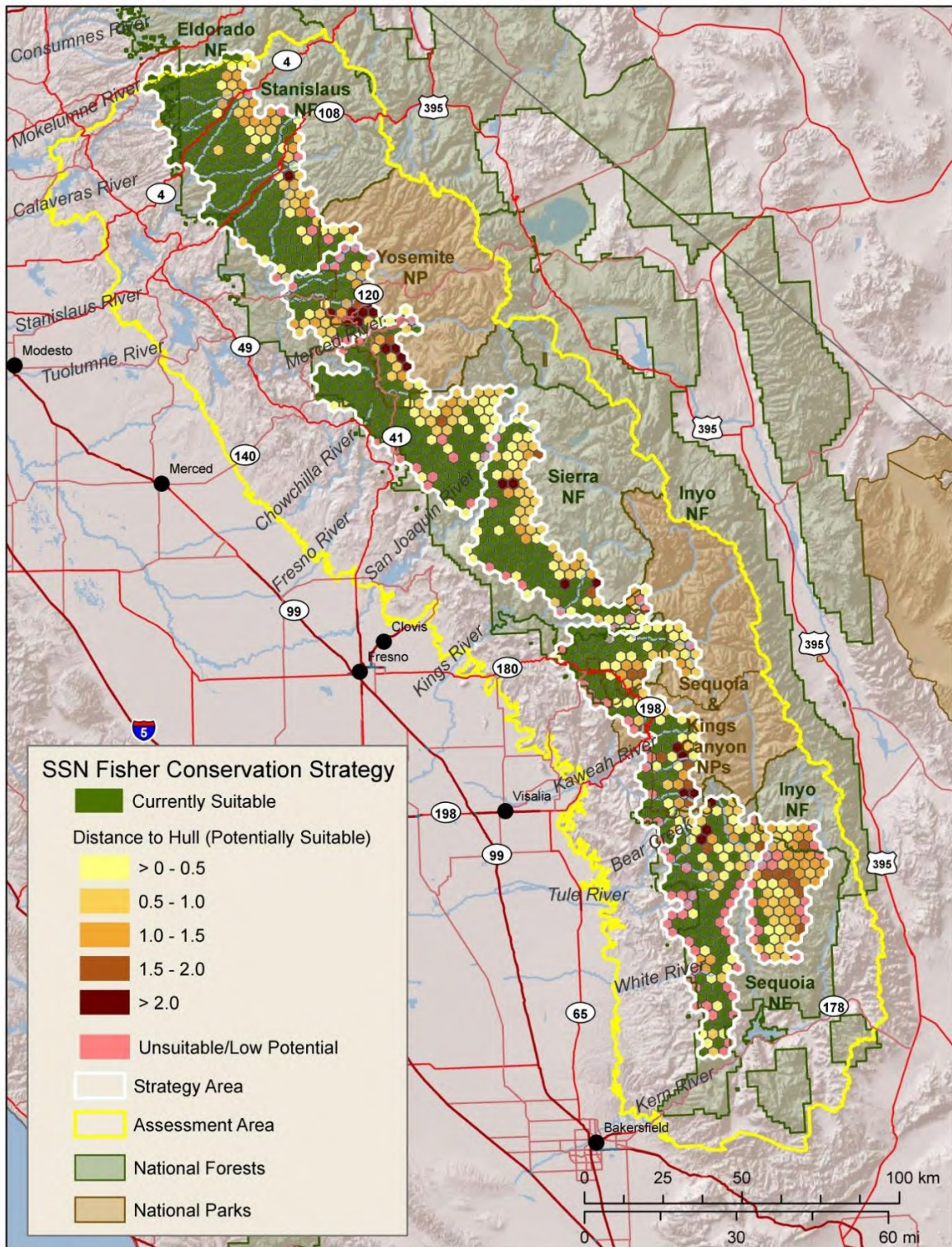
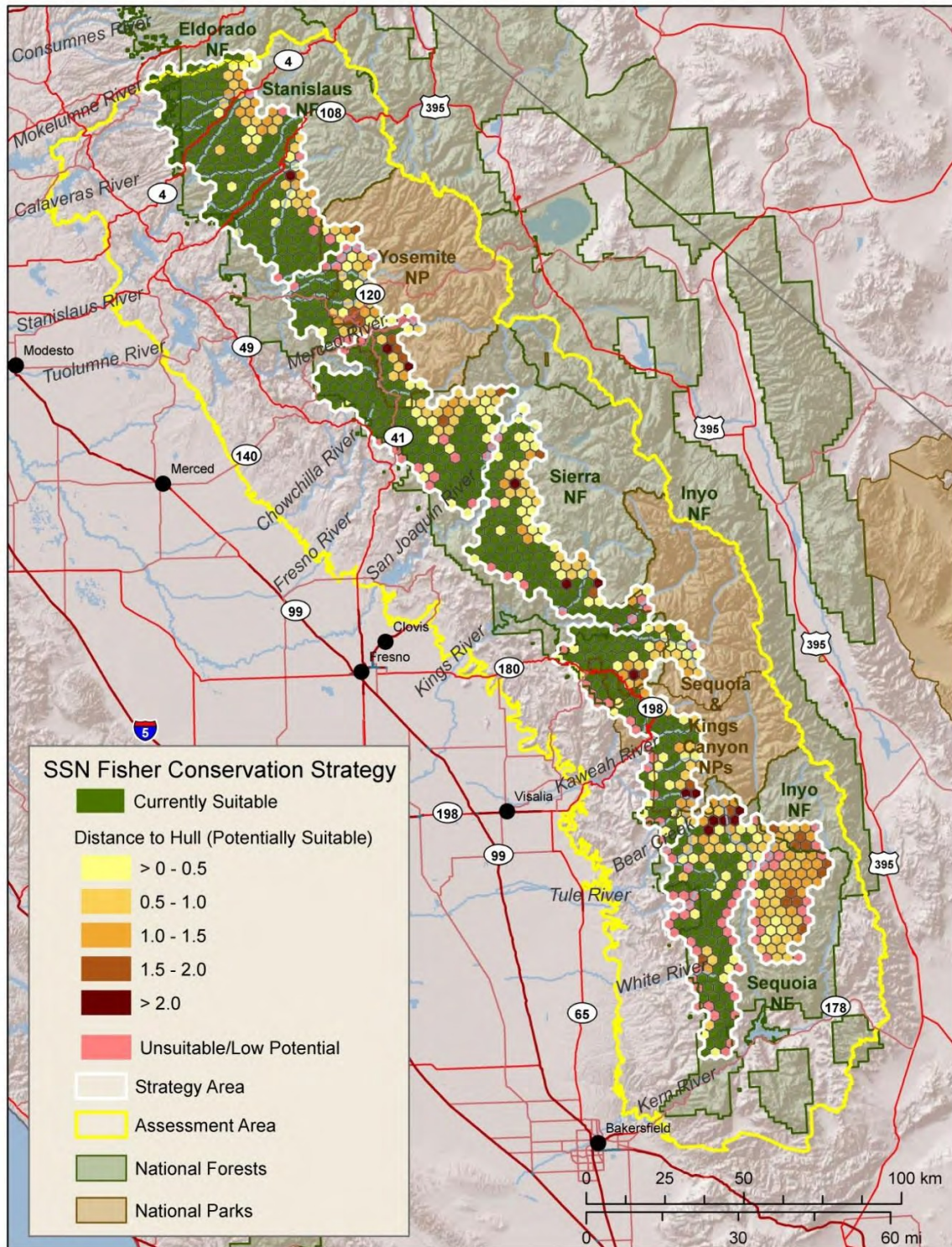
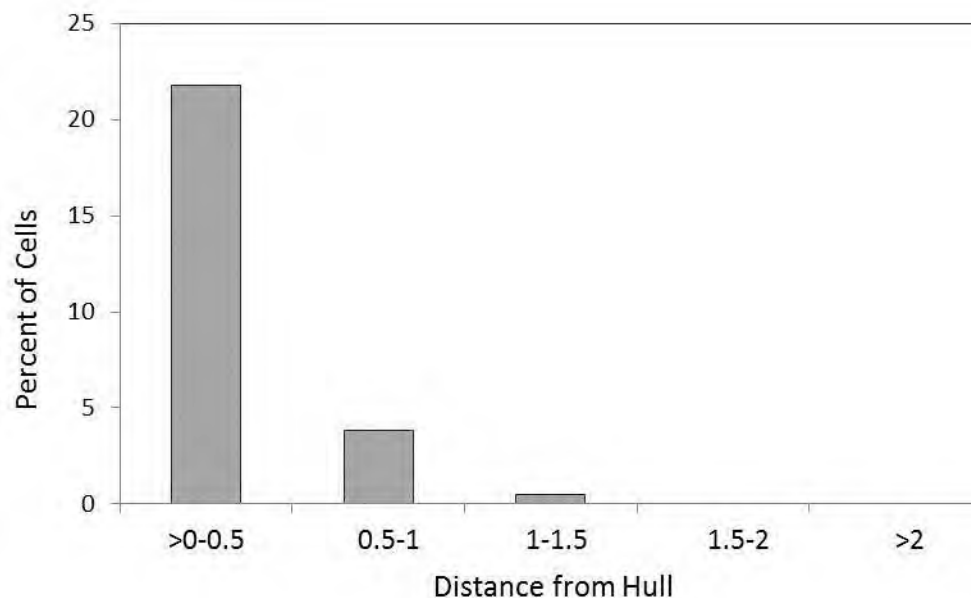


Figure A-12—Grid cell suitability predictions using GNN-only PCA for 1990. Unsuitable cells are displayed by distance from hull.





**Figure A-13—Grid cell suitability predictions using GNN-only PCA for 2012. Unsuitable cells are displayed by distance from hull.**



**Figure A-14—Percent of cells transitioning from unsuitable to suitable during a roughly decadal time step (1990 to 2000 or 2000 to 2012) as a function of distance from hull in PCA space.**

### A-3.2 Markov Chain Analysis

Changes in cell suitability from the GNN time-series analysis were used to calculate state transition probabilities and perform a Markov chain analysis (markovchain package in R; Spedicato 2015) to project the future number of suitable cells that might be expected in the Strategy Area. After removing the 107 low site potential cells, the remaining 905 cells were classed into six potential states for each time period (1990, 2000, and 2012) using distance from the PCA hull (Table A-11). Inputs required for the Markov chain analysis are transition probabilities between states and a starting distribution. We determined transition probabilities over two time steps (T1: 1990-2000 and T2: 2000-2012) and averaged them to get mean transition probabilities over an approximately 10-year time step (Table A-12). Starting distribution of cells among states was determined using the GNN-only PCA analysis for 2012 (Table A-13). Bootstrapping ( $N = 1,000$ ) was used to calculate 95% confidence intervals (CI) of projected proportions of cells by state in 10, 20, 30, 40, 50, 100, and 1,000 years and at a steady state (Table A-14).

The results suggest that, assuming the rates and effects of disturbance-succession processes observed from 1990 to 2012 continue into the future, the number of suitable cells will increase at a declining rate until reaching a steady-state many years (centuries) in the future (Table A-14). Of greatest interest, however, are changes over the next few decades. The analysis shows an increase in expected number of suitable cells of ~2.8% in 10 years, 5.0% in 20 years, and 7.3% in 30 years (Table A-14).

**Table A-11—States used in Markov chain analysis.** Distance from the PCA hull (in PCA units, 0-2) serves as an index of relative *unsuitability*; suitable cells are inside the convex hull (distance = 0).

State	Distance from Hull
S1	>2.0
S2	1.5 – 2.0
S3	1.0 – 1.5
S4	0.5 – 1.0
S5	> 0 – 0.5
S6	0 (suitable)

**Table A-12—Mean transition probabilities between states over a ~10-year time step** calculated as the mean transition rate for the periods 1990-2000 and 2000-2012.

	S1 <sub>t2</sub>	S2 <sub>t2</sub>	S3 <sub>t2</sub>	S4 <sub>t2</sub>	S5 <sub>t2</sub>	S6 <sub>t2</sub>
S1 <sub>t1</sub>	<b>0.615</b>	0.312	0.052	0.021	0	0
S2 <sub>t1</sub>	0.026	<b>0.501</b>	0.393	0.053	0.026	0
S3 <sub>t1</sub>	0	0.047	<b>0.692</b>	0.212	0.042	0.006
S4 <sub>t1</sub>	0.004	0.016	0.068	<b>0.698</b>	0.165	0.049
S5 <sub>t1</sub>	0.004	0.003	0.007	0.093	<b>0.614</b>	0.279
S6 <sub>t1</sub>	0.002	0	0.003	0.007	0.041	<b>0.947</b>

**Table A-13—Starting distribution of cells among states used in Markov chain analysis** using results of the GNN-only PCA analysis for 2012.

State	% of cells	No. of cells
S1	0.014	14
S2	0.026	26
S3	0.066	67
S4	0.126	128
S5	0.132	134
S6	0.530	536
Low site potential	0.106	107
Total	1.000	1012

**Table A-14—Future projections of suitable cells (S6) predicted by Markov chain analysis.**

	<b>Proportion Suitable</b>	
	<b>(95% CI)</b>	<b>Total suitable</b>
<i>Starting</i>	0.591 (0.56 – 0.622)	535
In 10 years	0.608 (0.573 – 0.642)	550
In 20 years	0.622 (0.584 – 0.659)	562
In 30 years	0.634 (0.593 – 0.675)	574
In 40 years	0.645 (0.601 – 0.689)	584
In 50 years	0.655 (0.606 – 0.703)	592
In 100 years	0.689 (0.625 – 0.746)	624
In 1,000 years)	0.720 (0.649 – 0.791)	652
Steady state	0.720 (0.649 – 0.791)	652

The rates of change observed in this GNN-only PCA Markov chain analysis (from Table A-14) were next applied to the starting distribution of suitable cells from the EVEG-GNN PCA (which FTT members think more accurately predicts fisher habitat value than the GNN-only version) to project the future number of suitable cells expected in ~30 years (Table A-15). The analysis predicts that, if the effects of disturbance and succession on habitat value observed during 1990-2012 continue at roughly the same rates for the next 3 decades, we can expect an additional increase of ~30 suitable cells in the Strategy Area by the year 2040 (from 415 to 445).

These future projections should be considered hypotheses about the potential change in amount of suitable home range habitat. If future management actions are actually more successful at restoring habitat value and resiliency than past actions, these estimates could be surpassed; if, on the other hand, the coming decades experience more severe disturbance due to climate change, drought, insect outbreaks, and large severe fires, the estimates may not be met.

**Table A-15—Number of suitable cells by core determined by applying projected change in number of suitable cells to current distribution of suitable cells.**

	<b>Core 1<sup>a</sup></b>	<b>Core 2</b>	<b>Core 3</b>	<b>Core 4</b>	<b>Core 5</b>	<b>Core 6</b>	<b>Core 7</b>	<b>Total</b>
<i>Starting</i>	0	51	64	53	88	29	130	415
In 10 years	0	52	66	54	90	30	134	427
In 20 years	0	54	67	56	92	30	137	436
In 30 years	0	55	69	57	94	31	139	445
In 40 years	0	56	70	58	96	32	142	453
In 50 years	0	56	71	59	97	32	144	459
In 1,000 years	0	62	78	65	107	35	158	506

<sup>a</sup>Core 1 is known to be occupied even though the analysis shows no suitable cells there, probably due to unique environmental conditions compared to other cores. A separate scoring equation will be developed for Core 1.

### A-3.3 Disturbance and Recovery Dynamics

We also used the GNN time-series data to examine changes in cell status in response to disturbances by management actions and fires, and rates of recovery following disturbance. In particular, we looked at the suitability status of cells affected by moderate and high severity fires (*Composite Burn Index 1.25 – 3*; *VegBurnSeverity14\_3*, USDA Forest Service, Pacific Southwest Region, Fire and Aviation Management) and management actions that remove trees (*harvest activities*; Table A-16) from the US Forest Service FACTS database (*PacificSouthwestRegionPast20YearsAccomplishments*; 2014, USDA Forest Service, Pacific Southwest Region) between time periods. We compared cell status (remain or become suitable, become unsuitable) 1990-2000 and 2000-2012 to the total percent area of cell disturbed from 1991-1999 and 2001-2011. We also examined how cell status changed in the three time steps following moderate and severe fires in the 1980s to track recovery rates (harvest data were not available prior to 1994, and were determined to be unreliable for this analysis as discussed below). Statistical comparisons of status changes between differing levels of disturbance were performed using t-tests and box plots ( $P < 0.05$  for significance level).

**Table A-16—Management actions involving cutting of trees included in GNN time series disturbance analysis.**

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Activity
Commercial Thin
Group Selection Cut (UA/RH/FH)
Improvement Cut
Overstory Removal Cut (from advanced regeneration) (EA/RH/FH)
Patch Clearcut (EA/RH/FH)
Precommercial Thin
Salvage Cut (intermediate treatment, not regeneration)
Sanitation Cut
Seed-tree Final Cut (EA/NRH/FH)
Seed-tree Seed Cut (with and without leave trees) (EA/RH/NFH)
Shelterwood Establishment Cut (with or without leave trees) (EA/RH/NFH)
Shelterwood Preparatory Cut (EA/NRH/NFH)
Shelterwood Removal Cut (EA/NRH/FH)
Stand Clearcut (EA/RH/FH)
Stand Clearcut (w/ leave trees) (EA/RH/FH)
Thinning for Hazardous Fuels Reduction

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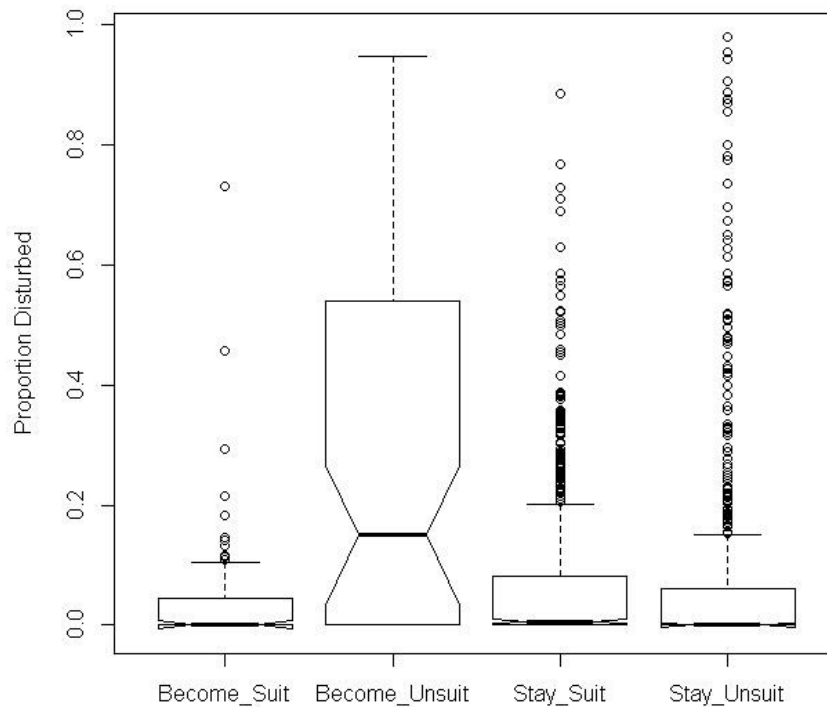
Pooling the effects of both fires and harvest activities, cells that changed from suitable to unsuitable contained significantly more (on average 3-5 times) disturbance as those that remained suitable during both periods (1990-2000:  $t = 3.2958$ ,  $df = 24.223$ ,  $p\text{-value} = 0.003018$ , 2000-2012:  $t = 3.4129$ ,  $df = 28.714$ ,  $p\text{-value} = 0.001932$ ) (Table A-17). Figure A-15 further illustrates effects of disturbance proportions on cell suitability status using box plots. Cells that changed from suitable to unsuitable experienced significantly higher median amounts of disturbance, and much higher variability in amounts of disturbance, than those remaining suitable or becoming suitable during a time step.



The large scatter of apparently high disturbance rates for some cells that remained or became suitable reflects large areas mapped as experiencing harvest treatments in the FACTS database (not large areas of moderate-severe fires). These apparently large areas of disturbance are misleading in many cases due to idiosyncrasies of the FACTS database. Many map polygons in the FACTS database represent generalized project areas within which smaller (often unmapped) areas were actually treated in various ways; the intensity of different treatment types and their effects on fisher habitat quality are highly variable; and it is unclear from the database whether all treatments actually occurred during a time step, or were planned but not yet implemented during that period. These uncertainties in the FACTS database introduce large uncertainties when attempting to use these data to determine how much disturbance by vegetation management treatments fisher will tolerate (Zielinski et al. 2013). In subsequent analyses of disturbance and recovery processes, we therefore focused on the more reliable fire data. Nonetheless, the results illustrated in Figure A-14 suggest that cells may remain or become suitable despite small amounts of disturbance from fires or vegetation treatments (<~10% of area per decade) but that larger amounts (>~20%) are likely to make suitable cells unsuitable.

**Table A-17—Mean (SD) percent area of cell disturbed between time steps by cell status change category (excluding low site potential cells).**

<b>Status Change</b>	<b>1990-2000</b>	<b>2000-2012</b>	<b>Pooled Time Periods</b>
Remained suitable	4.4 (9.2)	8.7 (13.8)	6.6 (11.9)
Remained unsuitable	3.4 (9.1)	11.4 (20.6)	7.3 (16.2)
Became suitable	3.5 (6.5)	4.9 (13.1)	4.2 (10.1)
Become unsuitable	24.9 (31.0)	27.6 (29.6)	26.3 (30.0)
All	4.5 (10.8)	10.2 (17.6)	7.3 (14.9)



**Figure A-15—Changes in cell suitability as a function of proportion of cell disturbed by fires or tree-cutting activities during the preceding decade.** Bold horizontal lines are medians, boxes are the middle two quartiles, whiskers approximate 95% CIs, and points are outliers. If notches around medians do not overlap, amounts of disturbance can be considered significantly different between suitability classes with 95% confidence (Chambers et al. 1983).

### Changes following fires

Several large and intense fires occurred during the 1980s: the Paper and Clavey complexes (1987) along the western edge of Core 7, the Larson Complex (1987) in Core 6, and the Balch (1989), Deer (1986), and Obelisk (1988) in Core 4. Figure A-16 maps these fires and cell suitability status and recovery in the three time steps following the fires from the GNN time-series analysis. A number of cells that were unsuitable in 1990, following moderate-severe fire in the preceding decade, became suitable by 2000, and even more by 2012. Excluding low potential cells, all but one of the 14 cells within Paper, Clavey, and Larson complex fires that were unsuitable in 1990 became suitable by 2012; and all six cells within Balch, Deer, and Obelisk fires that were unsuitable in 1990 became suitable by 2012.

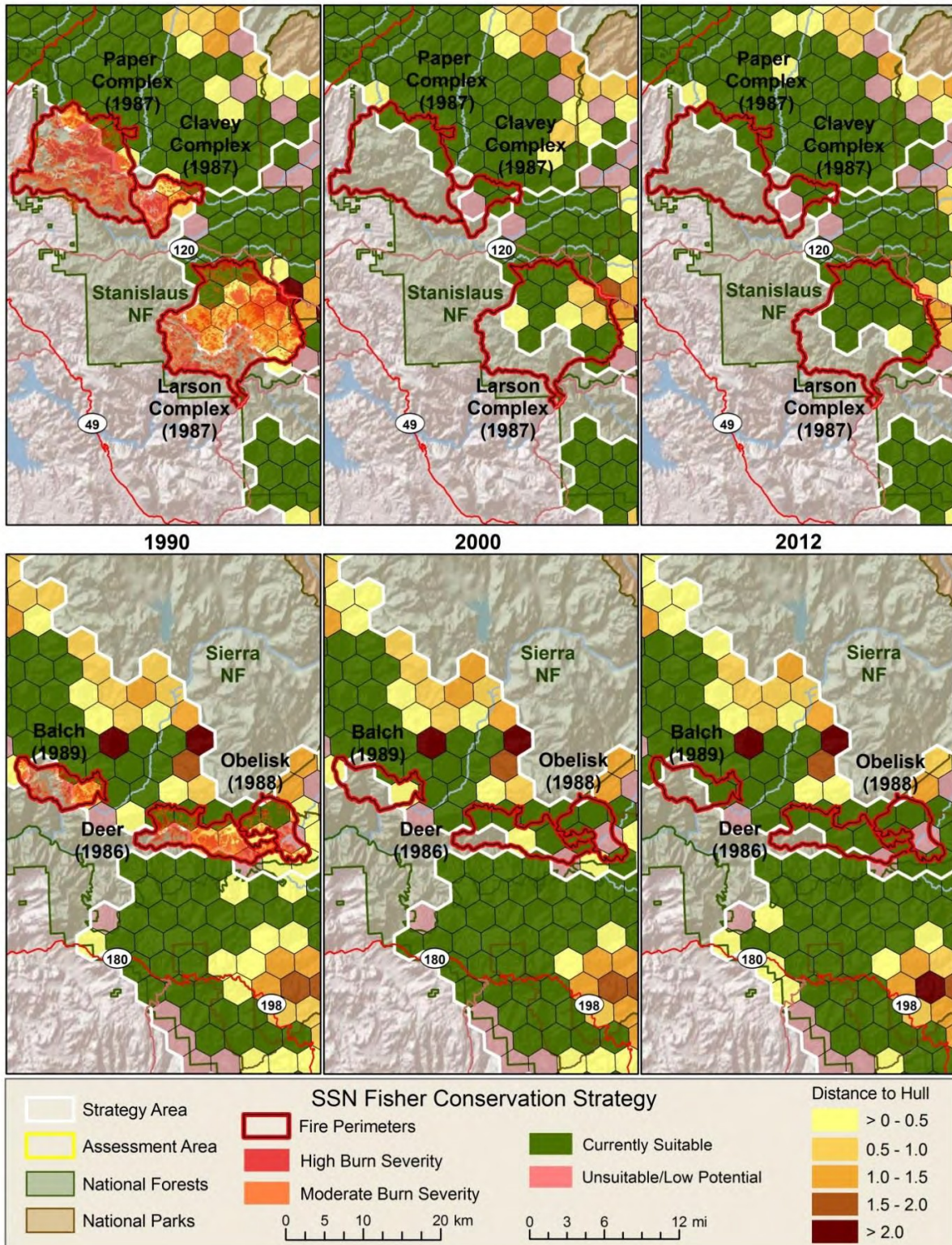
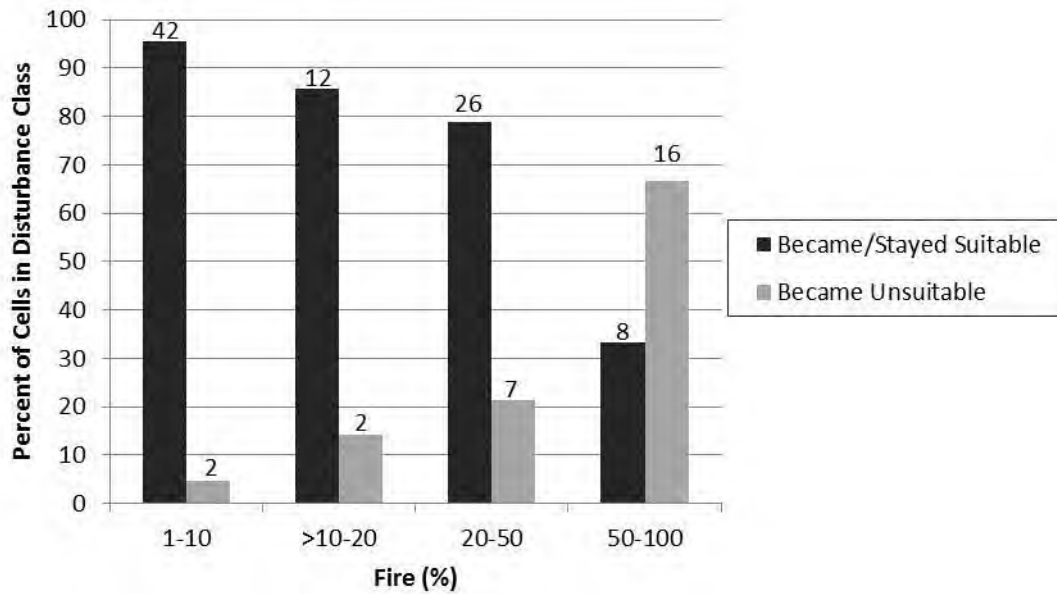


Figure A-16—Cell recovery following moderate and high severity fires during the 1980s. Post-fire recovery of affected cells in Cores 4 (bottom row) and 6 and 7 (top row).

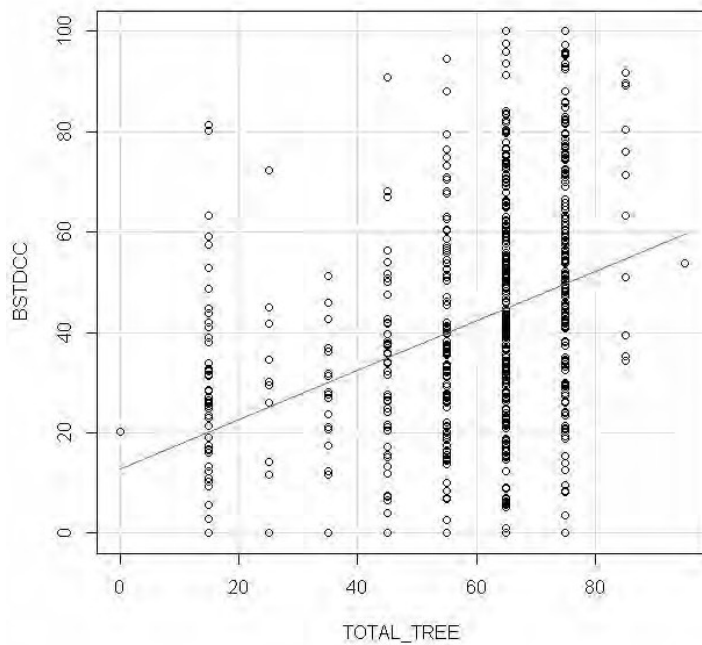
Figure A-17 illustrates how the proportion of a cell impacted by moderate-severe fire affects predicted cell suitability in the next decade for all cells in the Strategy Area that experienced moderate-severe fire. In general, the greater the amount of fire experienced, the more likely a cell is to become unsuitable; and a majority of suitable cells impacted over >50% of their area become unsuitable during the following decade.



**Figure A-17—Changes in cell suitability for cells that experienced >0% moderate-severe fire during the preceding decade.** Numerals above bars indicate number of cells in each category.

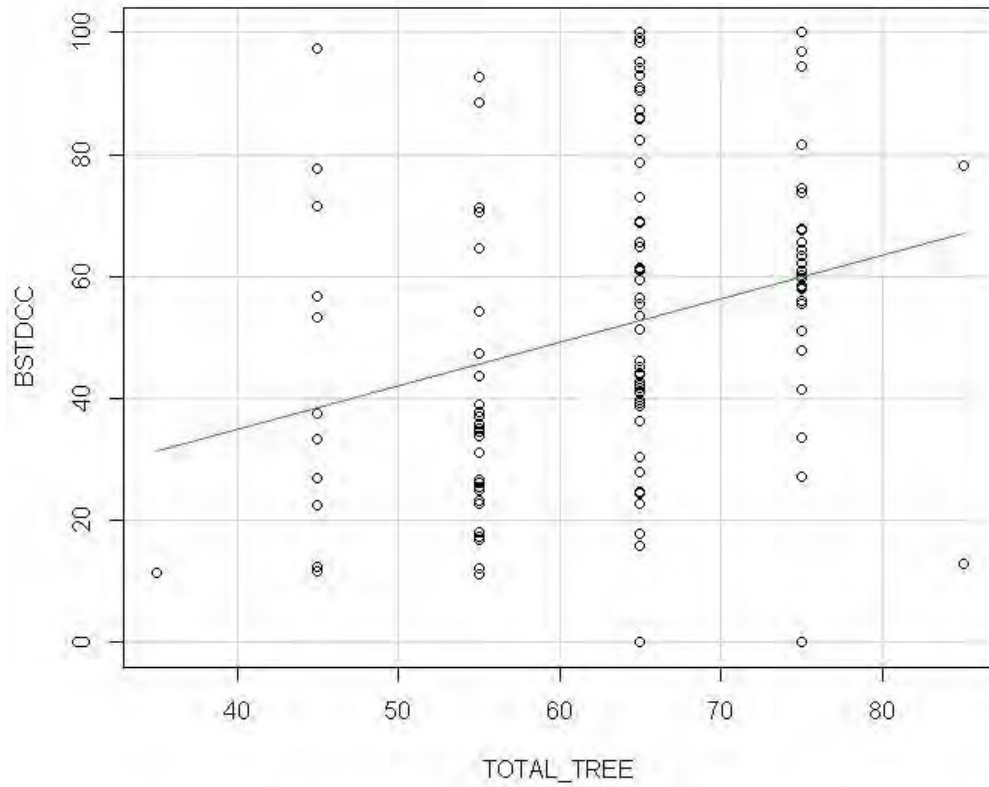
## A-4 Canopy Cover Comparisons for FVS and EVEG

We compared canopy cover estimates from EVEG (*Total Tree Cover From Above*, 10% classes) to those derived using FVS applied to stand exam plot data on two vegetation management project areas: 691 plots on Exchequer, Sierra National Forest, and 122 plots on Rancheria, Sequoia National Forest. On average, EVEG and FVS estimates are similar at low canopy cover (<40%), but FVS outputs tend to be lower than EVEG at moderate and higher canopy covers (>40%) (Figures A-18 and A-19,  $r = 0.37$  and  $0.26$ , respectively).



**Figure A-18—Comparison of percent canopy cover estimates from EVEG (total tree canopy cover from above, x axis) vs estimated using FVS (plot corrected, FVS output, y axis) at Exchequer plots on Sierra National Forest.** EVEG estimates represent the midpoint of 10% classes. The linear regression line has slope 0.49 and y intercept 12.9.





**Figure A-19— Comparison of percent canopy cover estimates from EVEG (total tree canopy cover from above, x axis) vs estimated using FVS (plot corrected, FVS output, y axis) at Rancheria plots on Sequoia National Forest. EVEG estimates represent the midpoint of 10% classes. The linear regression line has slope 0.71 and y intercept 6.31.**

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# Appendix B—Southern Sierra Nevada Working Group Charter

This charter identifies the mission, principles, goals and general organization structure for the Southern Sierra Nevada Fisher Working Group (SSNFWG). Objectives listed in Appendix A will be updated annually.

## Mission

The mission of the Southern Sierra Nevada Fisher Working Group is to provide a forum for wildlife biologists, scientists, and managers to collaboratively identify, review, develop, and communicate research, management, and conservation information and recommendations that promote the long-term viability of the fisher (*Martes pennanti*) in the Southern Sierra Nevada.

## Principles

The Southern Sierra Nevada Fisher Working Group members agree:

1. Conservation of the fisher and its habitat are important land and wildlife stewardship goals.
2. Forest vegetation management (e.g. prescribed fire, mechanical thinning) is necessary to achieve some goals and objectives, including maintaining, enhancing, or restoring fisher habitat in some areas.
3. A viable fisher population requires managing for both short-term and long-term needs.
4. SSNFWG members agree to work cooperatively to achieve the working group's goals and objectives.
5. SSNFWG's acquisition and free exchange of fisher information, such as habitat requirements, responses to habitat modifications, and population dynamics, will better allow managers and biologists to plan and implement resource management projects in a manner that helps them maintain the long-term viability of the fisher in the Sierra Nevada.

## Goals

1. **Information Collection, Review, and Dissemination:** Promote the sharing of fisher ecological and management information.
2. **Research:** Provide a collaborative forum for identifying, promoting, prioritizing, reviewing, and sharing fisher ecological and management research.
3. **Technical Assistance:** Provide technical assistance to managers and policy directors for fisher management and conservation.
4. **Partnerships:** Develop collaborative relationships among government and private individuals and organizations that promote the long-term viability of fishers in the Southern Sierra Nevada.

## Organization

The SSNFWG will be facilitated by a leadership team representing the diverse membership. Duties of the leadership team will include: (1) directing and guiding the SSNFWG members in a manner that helps them achieve the working group's goals and objectives; and (2) establishing and guiding subgroups to work on specific projects and issues. Membership of the leadership team will include researchers and managers from state and federal agencies, universities, nongovernmental organizations, or other individuals having relevant experience with fishers and forest management in the Sierra Nevada.

Subgroup membership and activities will vary depending on needs and issues. These subgroups may work as advisory teams for the leadership team, or for the entire SSNFWG, or they may be asked to accomplish specific tasks without general consensus of the entire SSNFWG, such as developing meetings or technical assistance products. Potential subgroups include: Technical Assistance, Research, and Communication/Outreach.

## Attachment A (Updated Annually)

# Objectives of the Southern Sierra Nevada Fisher Working Group

### Information **Collection, Review, and Dissemination**

**Goal:** Promote the sharing of fisher ecological and management information.

**Objectives:**

- Annually provide a conference where research and management results are presented and discussed.
- By 2011, produce, or contribute to, an information data base or other system for fisher literature, that will be updated annually. Such a system could be a comprehensive compilation of all past and present research on fishers in the Pacific States, possibly including research dates, locations, abstracts, and potentially a tabular matrix summarizing results, segregated by key elements, such as habitat use, movements, demographics, and population threats.
- By 2016, publish, or assist with publishing, a comprehensive document (monograph or major manuscript) summarizing the status, ecology and management of fishers in the Southern Sierra Nevada.
- The group will contribute a presentation or paper to the International *Martes* Symposium (2014, 2019...).

### Research

**Goal:** Provide a collaborative forum for identifying, promoting, prioritizing, reviewing, and sharing fisher ecological and management research.

**Objectives:**

- Promote collaboration and coordination among research projects to answer questions most efficiently and effectively.
- Define, and annually update, the needs and priorities for short and long-term research and population monitoring of fishers in the Southern Sierra Nevada, such as,
- Research to assess: (1) habitat composition of home ranges and core use areas at multiple scales throughout the Southern Sierra fisher range; (2) daily movements and habitat use; (3) the effects of various management activities on fisher and their use of habitats; and (4) the effects of wildfire and climate change on fisher populations.
- Determine limiting factors for the Southern Sierra Nevada fisher population.
- Long-term population monitoring.



- Assess and promote new technologies, strategies, and procedures that may provide improved effective and efficient fisher population monitoring, and habitat management.
- Investigate new funding sources for fisher research.

### Technical Assistance:

**Goal:** Provide technical assistance to managers and policy directors for fisher management and conservation.

#### Objectives:

- Contribute to the development of a Conservation Strategy for the Southern Sierra Nevada Fisher Population.
- Provide reviews and recommendations, on request and ability to respond, for fisher habitat management and fisher conservation issues, including habitat management guidelines, recommendations, and regulations, based on best available science.
- Provide technical reviews and recommendations for unique conservation, research, and management issues and needs, such as a policy for the care and dispersal of rescued fishers.

### Partnerships

**Goal:** Develop collaborative relationships among government and private individuals and organizations that promote the long-term viability of fishers in the Southern Sierra Nevada.

#### Objectives:

- Work to develop formal and informal partnerships with agencies, organizations, and individuals to facilitate funding, support, and implementation of research, conservation, and communication that promotes long-term viability of fishers in the Southern Sierra Nevada.
- Facilitate communication and understanding among government agencies, universities, organizations, private land owners, and others pertaining to fishers and fisher research, management, and conservation.

## Appendix C--Fisher Management and Research Questions

Management Question	Research Questions	Approach/Technique	Current state of knowledge/existing data	Feasibility (see Read Me)	Priority (see Read Me)	Cost (see Read Me)	
1 Where should vegetation treatments (e.g., fuel modifications) be prioritized or avoided?	1.1 How do different types of vegetation treatments affect individual fishers (e.g., behavioral)?	Field (telemetry)	Data being collected (SNAMP, KRFP, and Thompson JFSP). Analyses still needed.	High	High	Already funded	
		a. Immediate, within-home range effects					
		b. Intermediate (e.g., over several years) effects (home range use patterns)					
	1.2 How do different treatments affect fisher habitat value?	c. Longer term effects	Field and modeling	a-d: Data & models available; more analysis needed?	High	High	Already funded
		a. Fine-resolution denning habitat					
		b. Fine-resolution resting habitat					
		c. Stand-scale					
	d. Home range scale	c-d: Thompson et al. home range composition model and Before/After probability of use models linked to habitat (SNAMP, KRFP)					
	1.3 How does post-fire management (salvage logging, restoration, rehabilitation, hazard tree removal) affect fisher habitat and its recovery following fire?	Field and modeling: Before/After use of areas with Hazard Tree logging associated with burn/fires (SNAMP, KRFP?)	No data	Low-mod?	Mod	\$\$\$?	
	2 How should treatments be phased in fisher habitat?	2.1 How long following various treatments is habitat value affected?	Modeling w/ field sampling	a-b: Available, but more field sampling needed? c-d: Available, but more field sampling needed?	High	High	Partially funded; modest additional analysis costs?
a. Fine-resolution denning habitat							
b. Fine-resolution resting habitat							
c. Stand-scale							
d. Home range scale		c-d: Thompson FVS home range habitat trajectory model					
2.2 How long are treatments effective at reducing fire risks?		Changes in risk of fire before/after treatments with modeling	Some results already published; SNAMP Forest Health modeling underway	Mod?	High	Already funded	
2.3 What proportion of the landscape can be altered per unit time to minimize effects on fishers (fine to intermediate scales)?	Analyses to derive rules-of-thumb using Thompson and Zielinski FVS trajectory models.	Analyses underway (Thompson and Zielinski)?	High	High	Already funded		
2.4 What proportion of the landscape can be altered per unit time to minimize risks to the fisher population (regional to range-wide scales)?	HEXSIM population modeling coupled with LANDIS-II (similar to Sheller et al. 2011) to investigate population viability under alternative fire/management scenarios.	Future effort by CBI using updated habitat models and demographic data from field studies?	Mod?	Mod?	\$\$		
3 Will implementing GTR 220/237 have the desired outcome?	3.1 How would implementing GTR220/237 affect fire regime and fisher populations at the landscape scale?	Field research (DFLP & KRFP) coupled with HEXSIM/LANDIS-II modeling?	DFLP currently implementing; KRFP will assess. Future habitat & population modeling efforts?	Mod?	High	\$\$	

# Southern Sierra Nevada Fisher Conservation Strategy

Management Question	Research Questions	Approach/Technique	Current state of knowledge/existing data	Feasibility (see Read Me)	Priority (see Read Me)	Cost (see Read Me)		
4	Are fisher populations increasing, decreasing, or stable (range-wide or sub-regionally)?	4.1 What is lambda for southern SN population (and subpopulations)?	Occupancy based on regional monitoring and demographic data from SNAMP and KRFP	Already estimated using occupancy models (Zielinski et al. 2013); analyses in progress, SNAMP & KRFP	High	High	Already funded	
		4.2 Is mortality limiting to population size and potential for expansion?	Field mortality estimates coupled with HEXSIM modeling	KRFP and SNAMP data; potential future modeling?	High	High	\$\$	
		4.3 Is fecundity limiting to population size and potential for expansion?	Field fecundity estimates coupled with HEXSIM modeling	KRFP and SNAMP data; potential future CBI modeling?	High	High	\$\$	
5	What are the of primary mortality factors, their relative magnitudes, and are there effective mitigation measures?	5.1 What are the class-specific mortality rates from predation, disease, poisoning, road-kill, interacting factors?	Field research (telemetry data, post-mortems, roadkill and road-crossing monitoring)	KRFP and SNAMP data UC Davis Veterinary Pathology Lab and IERC	High	High	Partially funded; modest additional costs?	
		5.2 What are the impacts of rodenticide exposure and how long do the effects last?		Gabriel et al. 2012. More data and analyses needed?	Mod?	High	\$\$\$?	
		a. Half-life in the field, with/without site cleanup	a. Field research and laboratory analyses					
		b. Degree and duration of effects on prey	b. Not known; information from USDA APHIS on toxicity of different AR compounds on rodents may be useful			b. Mod?		
	c. Degree and duration of effects on fishers	c. Thompson et al, submitted manuscript			c. High			
		5.3 Are there relationships between predation rates and habitat structure? Is predation higher in areas with more roads, fragmented habitat, more open forest, or fuels treatments relative to other areas?	Field research on predation sites; field research on predator species; "risky habitat" models.	R. Green dissertation; G. Wengert bobcat work/dissertation. Need to extend from Hoopa to SSN.	Mod?	High	Partially funded; modest additional costs (\$\$)?	
	5.4 How do mortality factors interact (e.g., compensatory vs. additive factors, or "natural" vs. "human-linked" factors)?	Field research and perhaps modeling/analytical support?	KRFP and SNAMP data UC Davis Veterinary Pathology Lab and IERC	Mod?	Mod?	Partially funded; modest additional costs?		
	5.5 Do fishers use culverts or other road-crossing structures, and can adding/improving crossing structures and/or fencing reduce roadkill?	Cameras at crossing structures, roadkill surveys, and adaptive management experiments with fences and structures.	Research occurring in Yosemite and SNAMP; longer term work needed.	High	High	Partially funded; modest additional costs? Caltrans should be involved.		
6	What factors are limiting population size and potential for expansion?	6.1 Which habitat features/resources are most restrictive in limiting fisher populations?	Field research coupled with population modeling and statistical analysis.	KRFP and SNAMP data; more analysis needed? Future HEXSIM modeling?	Mod	High	Partially funded; modest additional costs?	
		6.2 What topographic features act as barriers or corridors? To what extent are barriers permeable?	Field and genetic research, coupled with landscape modeling	Tucker analyses of genetic connectivity vs. landscape variables currently underway.	High (genetic analyses & modeling)	Mod?	Already funded?	
		6.3 Are fishers using least-cost corridors for dispersal?	Field research with GPS	Need to analyze SNAMP GPS data with models	Mod	Mod-High?	Partially funded; modest additional costs?	
		6.4 What forest conditions (e.g., canopy closure) limit fisher movements; will they move through recent fuels treatments or openings?	Field research	KRFP and SNAMP movements data; analysis needed.	Low, except with GPS?	High	Partially funded; modest additional costs?	
		6.5 Are denning or resting habitat or structures limiting? Does lack of sufficient denning habitat/structures explain absence of fishers from some areas (e.g., north of Merced River)?	Field evaluation of habitat conditions?		Mod	High	\$\$	
		6.6 Are prey limiting? Would more large prey like porcupines help the fisher population?	Field research (scat collection, prey surveys)	Scat analysis; SSNFWG discussions re: potential for porcupine reintroduction. Historical/Recent assessment of distribution of	Mod	Mod	\$\$\$ if new field studies; \$ with existing data and meta-analysis?	

# Southern Sierra Nevada Fisher Conservation Strategy

Management Question	Research Questions	Approach/Technique	Current state of knowledge/existing data	Feasibility (see Read Me)	Priority (see Read Me)	Cost (see Read Me)	
7	7.1	What are the specific habitat structures used for resting/denning?	Field research	KRFP and SNAMP data on den sites, KRFP data on resting sites. Zielinski et al. 2004; Purcell et al. 2009	Done or in progress (dens)	High for dens	Already funded
	7.2	What are the biotic and abiotic features associated with resting/denning sites at micro to stand scales?	Field research and modeling	Same as above	Done or in progress (denning habitat)	High for dens	Already funded
	7.3	Does removal of hazard trees limit the availability of rest/den structures for fishers?	Field research and modeling	SNAMP will examine	Mod	Mod	Already funded
	7.4	How are denning females affected by disturbance factors (e.g., thinning/harvest) as a function of distance (to establish den buffers)? How long do effects last?	Field research	Thompson JFSP and DLRP doing some monitoring.	Mod.	High	Partially funded; modest additional costs?
8	8.1	How will fisher habitat (forest composition and structure) and populations change over time?	Modeling (MC1 global vegetation model coupled with Maxent occupancy models)	CBI Yale Framework climate-effects assessment; first-cut results suggest strong negative effects on forest conditions and fisher populations.	First-cut analyses done; more analyses needed.	Mod	Partially funded; modest additional costs?
	8.2	How will climate factors (temperatures, precipitation, snow cover) change conditions for fishers?	Modeling (MC1 coupled with Maxent occupancy models)	CBI Yale Framework climate-effects assessment; first-cut results suggest strong negative effects on fisher populations.	First-cut analyses done; more analyses needed.	Mod	Partially funded; modest additional costs?
	8.3	Are fishers physiologically/behaviorally limited by climate?	Field research? Modeling with existing data?	Krohn et al. (2004) relationships with snow.	Mod	Mod	\$\$?
9	9.1	How do fishers relate to habitat factors on the Kern Plateau?	Field research on fisher habitat selection on Kern Plateau.		Mod	Mod	\$\$\$
	9.2	Can the CBI den habitat model be confidently extrapolated to the rest of the SSN?	Field validation of model predictions with telemetry and/or GPS.		Low	High	\$\$\$
	9.3	Do existing habitat models accurately predict habitat quality in areas not currently supporting fishers (or in recent introduction sites)?	Field validation of model predictions	Facka and Powell to test models in reintroduction site.	Mod	High	\$\$
	9.4	Can demographic results from KRFP and SNAMP be applied elsewhere?	Modeling? Compare occupancy trends between regions coupled with HEXSIM model sensitivity tests?		Mod?	Mod?	\$\$
	9.5	Can treatment effects observed at KRFP and SNAMP be extrapolated elsewhere?	FVS modeling using Zielinskis (FIA resting habitat), Thompson (home range composition) and Purcell (substand) models calibrated using field measurements of stands following treatments?		Mod?	Mod?	\$\$
10	10.1	Within a post-fire landscape, how do fisher respond to low intensity fire, moderate intensity fire, and/or high-intensity fire areas?	Field	data being collected (Kern Plateau); analysis in progress	Mod?	High	\$\$\$?
	10.2	How do post-fire management actions (e.g., salvage logging or replanting) affect post-fire fisher response to fire effects?	Field		Mod?	High	\$\$\$?
	10.3	Does pre-fire forest condition influence post-fire use (e.g., pre-fire 5D (CWHR)) following fires of differing severity and size?	Field	data being collected (Kern Plateau); analysis in progress	Mod?	High	\$\$\$?
	10.4	How does time since fire influence use of post-fire landscapes?			Mod	High	\$\$\$?