MIXED CONIFER FOREST

Distribution
Throughout federal and state lands, there are 3,344,960 acres of mixed conifer forest in the Sierra Nevada. Mixed conifer forests are found between 1,200-2,400 meters (4,000-8,000 feet) elevation. Major tree species in the S. Sierran mixed conifer forests are black oak, ponderosa pine, incense cedar, sugar pine, giant sequoia, white fir, Jeffrey pine, and red fir (listed in a general elevation gradient from low to high). Relative abundances vary across the S. Sierra; for example, in the Tehachapi Range to the south the conifer forest lacks sequoia and is dominated by white fir with lesser amounts of incense cedar, Jeffrey, and ponderosa pine.

Current Status and Stressors
Forest cover throughout the region is relatively intact and has a high level of contiguity. The composition and distribution of forest types has changed during the last century, however (for example, 64% decline and general upslope migration of ponderosa pine in the central Sierra Nevada). Background (non-catastrophic) tree mortality rates in southern Sierran forests have doubled in recent decades, most likely as a consequence of warming over the last century. Furthermore, the density of large-diameter trees has declined with more marked reductions occurring in higher elevation forest types, which could lead to a ‘snag famine’ in the future if new recruitment into this size class does not occur.

Additionally, fire suppression has led to higher fuel loads, forest structural homogeneity, and shifts towards areas of dense small trees dominated by shade-tolerant incense cedar and white fir. Key structural elements of late-successional forests – including large diameter trees, snags, and downed wood – are generally at low levels in Sierran forests. Only 14% of the studied state/federal mixed conifer forests had high or very high contribution to late-successional forest functions, with national parks generally earning better scores than national forests. In contrast, forests not subject to extensive fire exclusion are characterized by high structural complexity, including heterogeneity in tree spatial patterns resulting from fire.

A proxy often used to assess forest condition related to fire is the fire return interval departure (FRID). Based on the reconstructed fire regime prior to Euroamerican settlement, low FRIDs indicate that the last fire occurred within the historic FRI, and extreme FRIDs indicate that 5+ return intervals have passed. More than 70% of the forested landscape in the Sierra Nevada has not been burned since 1910, and with an average historic FRI of 14 years, most lands are in severe FRID. Less than 20% of the Sierra Nevada’s forests are receiving fuels treatments required to restore historic forest conditions.

Sugar pine is also a point of concern. In Sequoia and Kings Canyon National Parks (SEKI), most areas of sugar pine have had 2+ FRIs pass with no fire. Sugar pine is very sensitive to air pollution and the exotic pathogen white pine blister rust. Outside of the Sierra Nevada in Glacier National Park, blister rust has caused up to 90% mortality in other white pine species. Within SEKI there was a 21% incidence rate in sugar pines surveyed. For this and other stressors effecting mixed conifer forests, see Table 1.

PACIFIC FISHER

Historic Distribution
Fishers were widely distributed on the west coast until European settlement, when habitat loss and fragmentation, predator and pest control campaigns, and over-trapping drove their populations down. Their current range in California is less than half of their historical range as described in 1937 (Figure 1). The complete closure of fisher hunting in California occurred in 1946. Recent genetic studies demonstrate that the S. Sierra Nevada population has been isolated from the northern California population for 1,000 years or more, but that Euroamerican settlement caused another but smaller genetic bottleneck to occur.

Current Status and Stressors
The Pacific fisher is a species of special concern in CA and is under consideration by the USFWS to be listed as endangered.
A study conducted on habitat suitability after different kinds of them had been exposed fishers tested for rodentiicide compounds in the S. Sierra, 83% this problem has become so severe that out of a sampling of likely to succumb to predation and other mortality causes mortality or decreased fitness for fishers making them more grow sites use pesticides and rodenticides, which can cause problem, especially for breeding females formerly inaccessible fisher habitat obtain lions, and other predators that use these roads to access making them more vulnerable to predation by bobcats, mountains, and other predators that use these roads to access previously inaccessible fisher habitat. Road kill is also a large problem, especially for breeding females. Illegal marijuana grow sites use pesticides and rodenticides, which can cause mortality or decreased fitness for fishers making them more likely to succumb to predation and other mortality causes. This problem has become so severe that out of a sampling of fishers tested for rodenticide compounds in the S. Sierra, 83% of them had been exposed. See Table 1 for more details.

However, the S. Sierra population is considered “stable” based on occupancy trends between 2002 and 2009. Current fisher habitat has been estimated using extensive surveys conducted during the 1990s-2000s\(^\text{30,31,32,33,34,35,36,37}\) and regional habitat modeling\(^\text{38,39}\). S. Sierra fisher population is estimated to be between 100 to 600 individuals\(^\text{39,40}\), however many researchers believe the population to be less than 300. Based on detection surveys from 2002-2006, fishers are more common on the west slope of Sequoia National Forest (SQF) than on the Kern Plateau of Sierra National Forest (SNF)\(^\text{42}\), with 23-28% of the sites on SQF having fishers.

Fishers occur in narrow elevation bands between 1,200-2,800 m (4,000-9,000 ft) elevation\(^\text{43}\), in mid-elevation conifer forests. Fishers are associated with structural characteristics of late-successional forests, but can survive in mature forests and second growth if critical structural elements, such as dense canopies, large trees, and dead wood, are present\(^\text{41-44,45,46,47,48,49,50,51}\). Large deformed limbs\(^\text{52}\), fungal infections and other decay that create cavities and susceptibility to parasites such as mistletoe (all of which are more common in older trees) support the creation of fisher resting and nesting habitat. Fire also is important for creating snags and cavities in trees for fisher use, generating damage to allow certain fungus to infect trees and create more cavities\(^\text{25,53,54,55}\), creating coarse down wood, gap creation, and age structure variation.

Stressors that affect fisher include habitat fragmentation (especially roads), rodenticide poisoning, and management activities. Forest roads encourage fishers to use them as trails, making them more vulnerable to predation by bobcats, mountain lions, and other predators that use these roads to access previously inaccessible fisher habitat\(^\text{46}\). Road kill is also a large problem, especially for breeding females. Illegal marijuana grow sites use pesticides and rodenticides, which can cause mortality or decreased fitness for fishers making them more likely to succumb to predation and other mortality causes. This problem has become so severe that out of a sampling of fishers tested for rodenticide compounds in the S. Sierra, 83% of them had been exposed\(^\text{46}\). See Table 1 for more details.

A study conducted on habitat suitability after different kinds of fuel treatments in SEKI showed that in terms of fisher resting habitat, prescribed burned areas do not differ significantly from the control plots. In the Blodgett Forest Research Station, however, mechanical only and mechanical plus fire treatments significantly reduced resting habitat features. Foraging habitat did not appear to be as affected by treatment. However, model simulations found that when considered over the scale of the S. Sierra over a 45 to 60 year timeframe, the positive effects of fuel treatments (i.e. decreasing fuel load and reducing fire severity) generally outweigh their negative effects (i.e. directly removing woody structures) on fisher habitat\(^\text{58,59}\). Severe wildfires have the potential to destroy large tracts of fisher habitat for a much longer time than fuels treatments and could isolate portions of the already small fisher population in the S. Sierra. The highest net benefits of fuel treatments to fisher were found at higher elevations (above 2,120 m; 6,950 ft)\(^\text{58}\).

### CALIFORNIA SPOTTED OWL

**Distribution and Current Status**

The California spotted owl is listed as a sensitive species by the Forest Service\(^\text{60}\). They are found in the southern Cascades, Sierra Nevada, mountains in the Southern California Province, and the central Coast Ranges\(^\text{60}\). All four subpopulations of California spotted owl were declining or remained steady from 1990-2005, with the population in SEKI showing the highest survival rates\(^\text{61}\). The Sierra population numbered over 1,865 owl sites from a 2006 survey\(^\text{62,63}\), composing the majority
### Table 1: Current stressors for the mixed conifer forest, Pacific fisher, and California spotted owl

<table>
<thead>
<tr>
<th>Current Stressors</th>
<th>Mechanism</th>
<th>Potential Impact to Mixed Conifers</th>
<th>Potential Impact to Fisher</th>
<th>Potential Impact to CSO</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fire Exclusion</strong></td>
<td>Homogeneous soils, forest structure shift; closed forest conditions; fewer gaps; lower shrub &amp; herbaceous plant abundance</td>
<td>Halted regeneration; increased competition for water and nutrients; reduced tree health; increased likelihood of pathogen infection</td>
<td>May temporarily increase suitability of fisher habitat, but long-term may cause more severe fires (see below); decreased cavity creation</td>
<td>Decreased survival in homogeneous forests; increased survival in high canopy closure areas; decreased nesting sites; thick stands impede foraging; decrease in key prey</td>
</tr>
<tr>
<td><strong>Fuels Management/ Timber Harvesting</strong></td>
<td>More severe wildfires from buildup of fuels</td>
<td>Severe tree mortality, including large trees; creation of large forest gaps</td>
<td>Dense canopy loss; changes in prey abundance/movement; habitat loss; decreased survival &amp; reproduction; increased competition; large gap creation/ habitat fragmentation</td>
<td>Within burned areas, strong selection for low-severity patches; decrease in certain prey; decreased survival in early successional forests</td>
</tr>
<tr>
<td><strong>Overstory reduction</strong></td>
<td>Decreased competition for water and nutrients; decreased risk of drought or insect induced mortality; accelerated growth of residual trees</td>
<td>Exposure to weather extremes; more competition; less mobility in thinned areas</td>
<td>Require high canopy closure for nesting sites, but moderate cover for foraging</td>
<td>Loss of habitat for prey species</td>
</tr>
<tr>
<td><strong>Understory reduction</strong></td>
<td>Loss in cover; reduction in prey habitat and abundance; reduction in seeds and berries</td>
<td>Increased travel time to resting/den sites, thermal refugia &amp; safe places to eat prey</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Reduction of structural elements</strong></td>
<td>N/A</td>
<td>Increased travel time to resting/den sites, thermal refugia &amp; safe places to eat prey</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Human Development</strong></td>
<td>Major highways and forest roads</td>
<td>Not assessed</td>
<td>Vehicle impact mortality; habitat fragmentation; increased predation of fishers on roads</td>
<td>Not assessed</td>
</tr>
<tr>
<td><strong>Poaching, rodenticide poisoning, drowning in water tanks, harassment by dogs, pet diseases, predator control, noise, smoke</strong></td>
<td>N/A</td>
<td>Mortality; decreased fitness; changes in behavior, prey availability, home range establishment, movement, reproduction, dispersal, predation, competition &amp; disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Urbanization, agriculture, grazing, reservoir creation, resource extraction</strong></td>
<td>Spatial and temporal changes in water availability</td>
<td>Habitat loss; fragmentation; changes in prey availability, movement, survival, reproduction, recruitment, dispersal, predation &amp; disease</td>
<td>Grazing decreases shrub cover needed for prey in foothills</td>
<td></td>
</tr>
<tr>
<td><strong>Recreational activities (tourism, hiking, camping, etc.)</strong></td>
<td>Soil compaction, loss of soil around roots; reduced regeneration, increased mortality of mature trees via root pathogens</td>
<td>Changes in nutrient cycle from fire regimes and nutrient cycling</td>
<td>Possible habitat changes</td>
<td>Possible habitat changes</td>
</tr>
<tr>
<td><strong>Invasive plant introductions</strong></td>
<td>Invasive plant introductions may lead to reduced regeneration, change in fire regimes and nutrient cycling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Disease outbreaks</strong></td>
<td>Structural failure from annosus root rot (white fir), amarillaria root disease, and carpenter ants; bark beetles; blister rust</td>
<td>Rabies; antibodies found in fisher blood for 16 pathogens; Forest disease outbreaks may change habitat structure</td>
<td></td>
<td>Possible habitat changes</td>
</tr>
<tr>
<td><strong>Increased ozone levels</strong></td>
<td>Foliar injury/lowered photosynthetic efficiency in seedlings/saplings, especially of ponderosa pine, mid-elevation conifers</td>
<td></td>
<td></td>
<td>Possible habitat changes</td>
</tr>
<tr>
<td><strong>Increased nitrogen (N) deposition</strong></td>
<td>Reduced germination; advantage for species that can rapidly utilize extra N; reduction in fine root biomass; lichen species shifts; increased nitrate in streams</td>
<td></td>
<td></td>
<td>Possible habitat changes</td>
</tr>
<tr>
<td><strong>Inter/intraspecies competition for resources and space</strong></td>
<td>Large mature trees compete for resources with dense growth of younger trees</td>
<td>N/A</td>
<td>Barred owl moving in from north competes for territory and prey</td>
<td></td>
</tr>
</tbody>
</table>

*Habitat fragmentation effects are many and include: population isolation and decreased genetic exchange; changes in how prey move across the landscape - effects prey composition, abundance, availability; additional travel time and energy needed to go around unsuitable areas and increased predation risk.*
(72%) of known nesting sites occurring in California. Within the Sierra, much of the suitable habitat and known nesting sites occur on USFS lands, with the rest being distributed between the National Park Service, Bureau of Land Management, industrial timberlands, and private ownership.

### Stressors

Like the fisher, these owls also are strongly associated with late-successional forests\(^6\). The owls tend to select remnant trees from the late-successional conifer forest (200-400 years old) for roosting and nesting sites. Territory occupancy has been associated with the amount of forest dominated by large trees (>61 cm dbh) with high canopy cover (>70%) around the nest area\(^6\). Foraging habitat is much more varied\(^6\). Loss of late-successional habitat is the most important stressor affecting these owls today. Additionally, encroachment of the competitively dominant barred owl (native to eastern North America) has resulted in displacement of northern spotted owls over large areas of their range\(^6\). The barred owl has been detected in the S. Sierra (first reported in 2004)\(^6\),\(^66\), and may be an increasing concern for California spotted owl in the Sierra Nevada.

Fire exclusion has affected the spotted owl in a similar way to the fisher – loss of large trees, higher risk of high-severity wildfires, more homogenous forests, and more (see Table 1)\(^6\). Unlike the fisher studies described above, no study has assessed fuels treatment effects on owl vigor. Modeling suggests that landscape-scale fuels treatments can minimize detrimental habitat changes\(^63,67,68\) and reproductive effects\(^63,69\) and that the long-term benefits of reducing wildfire severity outweigh short-term treatment effects on spotted owls\(^63,70\). Furthermore, many studies indicate that low to moderate severity fires do not affect spotted owls\(^63,71,72,73\).

### POSSIBLE FUTURE CHANGES AND ADAPTIVE CAPACITY

Although predicting future climates is extremely complex, the climate models driven by the three main Intergovernmental Panel on Climate Change (IPCC) emission scenarios agree that temperature in the S. Sierra Nevada will warm, with predictions between +2.6-3.9°C by 2100\(^74\). Less certain is the change in precipitation – of the 18 general circulation models that include California, about half predict decreases and half predict increases for the Sierra region\(^74\). Even with little change in precipitation, effective drought will increase as snow melts earlier and evaporative demand increases, and could cause changes in wildfire regimes, snowmelt patterns, and more (Table 2).

Synergistic effects of climate change with other stressors, such as fire exclusion and air pollution, are likely to cause scenarios of increased drought stress, more frequent, larger, and more severe wildfires (Figure 3), more insect and pathogen outbreaks, and increased invasions by non-native species including at higher elevations than observed today\(^75\). The observed increase in tree mortality rates\(^6\) likely will accelerate. Eventually, major shifts in species composition are expected, including new assemblages without modern analogs, with general upslope movement limited by dispersal and soil conditions. These compositional changes may be gradual or potentially more rapid following disturbances such as high severity fires; insect outbreaks; or mass wasting events. Conifer forests are predicted to decrease by up to a half of current extent by 2099 under three climate models. In these projections mixed conifer is replaced by a mixed evergreen forest dominated by ponderosa pine and black oak\(^76\) (Figure 4). Another way of projecting potential change is shown in Figure 5, which shows oak woodlands areas predicted to be at “high risk soonest” and “most resilient longest” (potential climate refugia) under two future scenarios.

Fisher and California spotted owl may be affected directly by changes in temperature, precipitation, and snowpack or indirectly by affects to their habitat, competitors, and prey. One potentially beneficial outcome for fishers is a reduction in snowpack, as deep snow restricts travel for fishers\(^5,37,77\), but this could increase competition with marten\(^7\). Predicted shifts in the composition and locations of the mixed conifer forest raise the question of whether enough overlap of required temperature, snowpack, and habitat conditions will exist in the future for Pacific fisher and California spotted owl. Life history patterns also will affect a species ability to react to a changing environment – owls have large spatial requirements, low population densities, are habitat specialists, and sporadically reproduce when environmental conditions are favorable\(^63\), and fisher have slow maturation and low reproductive rates\(^78\). Overall, a decrease in the structural elements required for fishers and owls is expected\(^83\), with the largest impacts occurring in the S. Sierra\(^78\).
Figure 4: Vegetation class distribution for historical period (1961-1990), PCMI-A2 future (no change in precipitation and an intermediate temperature increase of less than 3 degrees), GFDL-A2 (moderately dry with intermediate temperature increases), and GFDL-B1 (hottest and driest of the scenarios) for 2070-2099. Note the encroachment of the light green mixed evergreen forest over the dark green mixed conifer forest in all scenarios. Adapted from Lenihan et al. 2008.
Table 2: Potential climate change impacts and vulnerability characteristics for the mixed conifer forest, Pacific fisher, and California spotted owl

<table>
<thead>
<tr>
<th>Climate Scenario</th>
<th>Potential Results</th>
<th>Potential Impact to Mixed Conifers</th>
<th>Potential Impact to Fisher</th>
<th>Potential Impact to Owl</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>“Much Warmer/ Much Drier” Scenario</strong></td>
<td>Earlier snow melt\textsuperscript{113,114}, decreased snow pack\textsuperscript{115,116}; changes in hydrology; increased summer soil evaporation\textsuperscript{118}</td>
<td>More intense/longer summer drought; trees weakened and more susceptible to insect attack, disease, air pollution, etc.\textsuperscript{4}</td>
<td>Detrimental change in conifer forest structure; other trees beneficial to fisher, like hardwoods, may expand\textsuperscript{76,120}</td>
<td>Detrimental change in forest structure\textsuperscript{123}; decreased prey abundance; decreased adult survival &amp; reproduction; weather during incubation affects reproductive output\textsuperscript{123}</td>
</tr>
<tr>
<td><strong>Expanding ranges of pathogens</strong></td>
<td>Increased mortality\textsuperscript{4}</td>
<td>Detrimental change in forest structure\textsuperscript{120}</td>
<td>Unknown</td>
<td>Detrimental change in forest structure\textsuperscript{120}</td>
</tr>
<tr>
<td><strong>Increased fires at all elevations except lowest foothills\textsuperscript{71,115}; increase area burned\textsuperscript{119}</strong></td>
<td>Increased large tree mortality - homogenized forest structure with loss of LSOG\textsuperscript{4}</td>
<td>Reduced connectivity and extent of LSOG will pose migration issues; decrease in habitat</td>
<td>Decrease in habitat</td>
<td></td>
</tr>
<tr>
<td><strong>Range shifts</strong></td>
<td>Conifers may move higher and northward</td>
<td>Loss of required overlap in habitat &amp; climate</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td><strong>Shift in plant species composition</strong></td>
<td>New assemblages without modern analogs</td>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>“Moderately Warmer/ Same Precip” Scenario</strong></td>
<td>Increased fire probability at almost all elevations\textsuperscript{118}</td>
<td>Increased large tree mortality - homogenized forest structure with loss of LSOG</td>
<td>Reduced connectivity and extent of LSOG will pose migration issues; decrease in habitat</td>
<td>Decrease in habitat</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vulnerability</th>
<th>Explanation</th>
<th>Potential Impact to Mixed Conifers</th>
<th>Potential Impact to Fisher</th>
<th>Potential Impact to Owl</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Moisture Requirements</strong></td>
<td>Moisture requirements vary by species (and potentially by genotype)</td>
<td>Regeneration failure and mortality of weakened adult trees</td>
<td>Decreased habitat</td>
<td>Decreased habitat</td>
</tr>
<tr>
<td><strong>Low Genetic Diversity</strong></td>
<td>More susceptible to disease, mutation, stochastic event; less adaptive capacity</td>
<td>N/A</td>
<td>SSN population already has lower genetic diversity than other populations\textsuperscript{121,122}</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Spatial Isolation</strong></td>
<td>Isolated populations could lead to further decreases in genetic diversity</td>
<td>N/A</td>
<td>Isolated populations in California</td>
<td>Isolated local populations, low density areas, and gaps/bottlenecks in distribution</td>
</tr>
<tr>
<td><strong>Reproductive Methods &amp; Ability to Disperse</strong></td>
<td>Slow maturation/low reproductive success can cause population decline; suitable environment may move and reproduction and dispersal is required to shift range</td>
<td>Ponderosa Pine: mature at 7-350yr, heavy crops every 8yr, low dispersal; Incense Cedar: med seed crops every 4yr, far wind-dispersal, 30% germination; Jeffrey Pine: mature at 8yr, large crop every 5yr, dispersal=tree height, animal dissemination, low germination; Sugar Pine: low seed production, low dispersal, animal dissemination, high germination; White Fir: mature at 40-300yr, heavy crop every 6yr; limited wind dispersal &lt;2X tree height; Red Fir: mature at 35yr, heavy crop every 3yr, wind dispersal &lt;2.5X tree height</td>
<td>Maturation at 2 yrs\textsuperscript{79,90}; ~25% of females reproduce and wean at least 1 kit annually\textsuperscript{81,82,83,84,85}; most individuals die &lt;8 yrs; 50 km (30 mi) dispersal\textsuperscript{94}; unable to cross transecting landscape features such as steep river canyons</td>
<td>Maturation at 2 years, but often do not nest for 1+ yrs after this\textsuperscript{109}; owls may not nest every year\textsuperscript{109}; Juveniles disperse &lt; 13km (8 mi) from nesting sites\textsuperscript{90}; adults can fly to find new habitat</td>
</tr>
</tbody>
</table>

| **Synergistic Effects** | Already weakened flora and fauna may become more vulnerable to new stressors and new combinations of stressors brought on by climate change | |

*Habitat fragmentation effects are many and include: population isolation and decreased genetic exchange\textsuperscript{120}; changes in how prey move across the landscape - effects prey composition, abundance, availability\textsuperscript{46,94,90}; additional travel time and energy needed to go around unsuitable areas and increased predation risk\textsuperscript{44}.*

**Authorship Note**
This information brief was created by Katy Cummings (NPS) and Koren Nydick (NPS), with review and contributions from John Battles (UC-Berkeley), Marc Meyer (USFS), Tom Munton (USFS), Mark Schwartz (UC-Davis), and Wayne Spencer (Conservation Biology Institute). Additional thanks to Erika Williams (NPS for graphic design assistance.)
Figure 5. Two scenarios of future climate exposure for mixed conifer forests in the southern Sierra Nevada study area. Maps show grove area predicted to be at risk soonest (high exposure in 2010-2039) in red and orange; resilient longest (low exposure in 2070-2099) in dark and light green; and at risk later (high exposure by 2070-2099) in gray. Blue borders = NPS; yellow shading = USFS. Bar graphs show percent of study area falling within different climate exposure score categories over time (1971-2000; 2010-2039; 2040-2069; 2070-2099) for NPS, other, and USFS lands. Exposure score percentiles are based on projected future climate conditions compared to the baseline (1971-2000) climate envelope for mixed conifer forests, which include mixed conifer-fir and mixed conifer-pines CalVeg types. These results use the IPCC A2 emissions scenario. Adapted from Schwartz et al. In Prep.
POTENTIAL MANAGEMENT STRATEGIES (WORK IN PROGRESS)

• Manage for persistence (resist change or build resilience):
  - Restore/maintain structural complexity of forests
  - Restore a natural fire regime to avoid high severity fires
  - Minimize mechanical disturbances in late-successional forests; if mechanical disturbances are necessary, limit them to areas outside high-quality late-successional forests (includes shaded fuel breaks, removal of small/medium sized trees, and other fuel reduction activities)
  - Encourage harvesting practices that retain structural features and large-diameter trees
  - Install artificial snags as nesting and resting habitat
  - Prioritize protection of late successional forests in known fisher and California spotted owl habitat
  - Close and remediate old roads
  - Protect known and modeled potential fisher denning habitat from significant modification
  - Protect known owl nest stands from significant modification
  - Manage forests for high quality, large area, contiguous blocks of late seral/old growth forests
  - Identify problem road crossing areas for fishers (and other wildlife) and add road-crossing structures where needed.
  - Locate and remediate marijuana grow sites by removing all chemicals.
  - Capture and translocate/kill barred owls that ingress into spotted owl territory

• Manage for change (facilitate transformation):
  - Create seeds banks for use in assisted migration efforts for vulnerable tree and herbaceous species
  - Anticipate and plan for large disturbance events - do compliance ahead of time and have a planting plan that includes experimentation
  - Reduce barriers to species movement; protect contiguous migration corridors
  - Capture-release programs/assisted migration for fisher and California spotted owl

• Delay deciding (monitor and research):
  - Monitor fisher and California spotted owl populations, reproductive success, and mortality
  - Monitor large tree mortality rate, distribution, and causes of death
  - Monitor shifts in range for conifer forest
  - Monitor spread of white pine blister rust
  - Conduct studies to assess before-and-after-control-impact of fuels treatments, prescribed burning, and wildfire for fisher and California spotted owl
  - Model how California spotted owl populations may respond to future climate scenarios
  - Monitor spread of barred owl

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