Southern California Conifer and Subalpine Habitats

Climate Change Adaptation Actions Summary

***An Important Note About this Document:** This document represents an initial effort to identify adaptation actions for conifer and subalpine habitats in southern California based on stakeholder input and existing information.[1] Specifically, the information presented below comprises stakeholder input during a two-day adaptation workshop, peer-review comments and revisions, and relevant examples from the literature or other similar efforts. The aim of this document is to expand understanding of possible adaptation actions for southern California conifer and subalpine habitats in response to climate change.*

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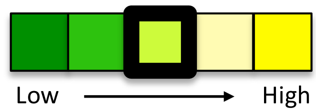
Conifer Habitat Vulnerability

Moderate Vulnerability

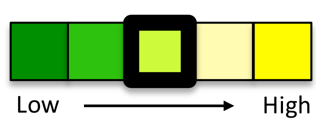


The relative vulnerability of conifer habitats in southern California was evaluated to be moderate by habitat experts due to moderate sensitivity to climate and non-climate stressors, moderate-high exposure to future climate changes, and moderate adaptive capacity. Conifer and mixed conifer habitats are sensitive to decreases in water availability, and moisture-stressed trees are more vulnerable to additional stressors, including insect outbreaks, disease, and pollution. Dead or dying trees can exacerbate wildfire by providing additional fuel, and wildfire may accelerate shifts in species composition by extirpating local populations, promoting fire-tolerant species or habitat types and creating conditions suitable for invasive species. Conifer habitats are also sensitive to non-climate stressors (e.g., air pollution) that can exacerbate the impacts of climate change. Southern California conifer habitat types vary in extent and continuity, including stands comprised of endemic species with very limited extent (e.g., Torrey pine, *Pinus torreyana*) and large tracts of forest made up of species that can be found throughout the western United States (e.g., ponderosa pine, *P. ponderosa*). Range shifts in montane forests are limited by elevation and the lack of connectivity between mountaintops, while lower-elevation forests and coastal stands are primarily limited by habitat fragmentation and human activity. The ability of conifer habitats to resist stressors and recover from disturbance varies depending on specific species requirements; however, recovery is often dependent on the rate of forest regeneration, which is generally slow (~40-60 years). Conifer habitats provide food and shelter for many wildlife species, and are highly valued for aesthetic and recreational purposes, as well as for the many ecosystem services that they provide (e.g., carbon sequestration, water supply, air quality, and flood/erosion protection).

USFS/Photo by Joseph Torok

Subalpine Habitat Vulnerability

Moderate Vulnerability



The relative vulnerability of subalpine habitats in southern California was evaluated to be moderate by habitat experts due to low-moderate sensitivity to climate and non-climate stressors, moderate-high exposure

[1] Although conifer habitat and subalpine habitat vulnerability were evaluated separately, they were combined in the discussion of adaptation strategies.

to future climate changes, and low-moderate adaptive capacity. Subalpine forests are sensitive to increasing temperatures, and older trees are especially sensitive. In young trees, warming can improve growth, contributing to a shift toward dense stands that are more vulnerable to stand-replacing fire. Moisture is the primary limiting factor in these systems, and drought stress can prevent germination and severely limit growth. In subalpine habitats, climate and non-climate stressors such as drought, air pollution, and beetle outbreaks, and disease interact with one another and increase the likelihood of further stress or tree mortality. Subalpine habitats are isolated in southern California, though they remain relatively intact due to their low accessibility. Species are somewhat resilient to the individual impacts of climate change, but climate and non-climate stressors often interact to increase the likelihood of future injury and/or mortality. Because of harsh conditions, subalpine species grow slowly and recovery from disturbance can take 100 years. Subalpine forests harbor many specialized species and/or species that depend on one another for survival (e.g., limber pine and Clark's nutcracker [*Nucifraga columbiana*]). Potential management options may focus on preventing stand-replacing wildfire, establishing nursery and seed stock, and reducing extreme disturbances.

Adaptation Strategies and Actions

Table 1 presents a summary of possible adaptation strategies and actions for conifer and subalpine habitats, and consists of stakeholder input during an adaptation workshop as well as additional options from the literature or other similar efforts. Stakeholders identified ways in which current management actions could be modified to reduce habitat vulnerabilities as well as future management actions that are not currently implemented but could be considered for future implementation.

Adaptation strategies and actions are grouped according to one of five categories:

1. **Enhance Resistance**. These strategies can help to prevent the effects of climate change from reaching or affecting a resource.
2. **Promote Resilience**. These strategies can help a resource withstand the impacts of climate change by avoiding the effects of or recovering from changes.
3. **Facilitate Transition (or Response)**. These strategies intentionally accommodate change and/or enable resources to adaptively respond to changing and new conditions.
4. **Increase Knowledge**. These strategies are aimed at gathering more information about climate changes, impacts, or the effectiveness of management actions in addressing climate change.
5. **Engage Coordination**. These strategies may help coordinate efforts and/or capacity across landscapes and agencies.

Table 1. Summary of possible adaptation options for conifer and subalpine habitats.

Adaptation Category	Adaptation Strategy	Specific Adaptation Actions
Enhance resistance	Prevent stand-replacing wildfire	• Focus thinning activities in areas where fire is most likely to carry up from neighboring habitats (e.g., chaparral or oak woodland)[2] • Increase fire permit restrictions for recreation users during dry summers[2] • Review wilderness paradigm to allow fuel modification in mixed conifer wilderness[2] • Implement prescribed burns to prevent severe wildfires[2]

[2] Denotes adaptation action identified by workshop participants.

Adaptation Category	Adaptation Strategy	Specific Adaptation Actions
Enhance resistance (con't)	Ensure survival of seedlings after habitat restoration efforts	• Create barriers (e.g., tree tubes, K-rails) between habitat restoration areas and key human ignition points[2] • Create an Adopt-a-K-rail program, in which local artists paint K-rails to increase visibility before they are placed near possible fire ignition sources[2]
	Protect vulnerable plant and wildlife species in conifer and subalpine habitats	• Increase awareness of the need to incorporate bulldozer/retardant avoidance around rare subalpine species during fires[2] • Protect the area around rare, vulnerable, and/or endemic wildlife species from wildfire and post-fire impacts (e.g. landslides)[2]
	Minimize the impacts of recreation on conifer and subalpine habitats	• Increase signage and public education to minimize the impacts of recreation[2] • Modify and/or remove roads and trails to minimize the impacts of off-highway vehicles (OHVs)[2]
Promote resilience	Maintain big-cone Douglas fir as a component of conifer and mixed conifer forests	• Thin/underburn big-cone Douglas fir and canyon live oak stands to reduce the likelihood of crown fires and create opportunities for seedling recruitment[2] • Focus big-cone Douglas fir management and protection in identified climate refugia[2]
	Allow natural return to historical fire return intervals in coniferous forest to promote forest health and resilience	• Stop fire suppression, particularly in wilderness areas[2] • Develop a nighttime prescribed fire program[2] • Use resource advisors to avoid or minimize the impacts of bulldozers and fire retardants[2] • Apply a minimum resource decision guide to a stand in need of fuel modification to facilitate discussion of wilderness value[2]
	Facilitate regeneration of montane conifer forest	• Thin overly dense stands and/or those that are mostly single-species and uniform in age, in order to reduce competition[2] • Use nurse plants to facilitate regeneration of conifer species[2]
	Carry out post-fire restoration activities	• Re-vegetate slopes with native species that have genotypes better adapted to future conditions[2] • Plant founder stands for seed dispersal[2]
	Protect and facilitate regeneration of black oaks	• Avoid prescribed burns in areas of oak regeneration if burn conditions would be too hot for seedling survival[2]

Adaptation Category	Adaptation Strategy	Specific Adaptation Actions
		• Plant acorns from varied genetic stocks[2] • Investigate longer-term banking or storage options for acorns and use rotating planting schedule[2]
	Improve stand resilience to improve ecosystem structure and function	• Plant resilient species intermixed with current species to reduce outbreaks associated with monocultures and consider planting outside of post-burn areas[2]
Facilitate transition	Develop seed collections to increase genetic diversity	• Collect seed from trees in lower-elevation bands[2] • Increase species and genetic diversity within seed collections[2] • Collect seeds from and monitor the species most vulnerable to climate change[2]
	Maintain biodiversity of shifting plant communities	• Facilitate migration of co-adapted species, focusing on species where one species within an association is limiting the migration of all[2] • Use monitoring results to identify threatened populations and aid efforts to increase connectivity and genetic diversity[2]
	Identify and protect refugia	• Prioritize research efforts to identify refugia and compare their ecological value other habitats[2] • Map fire refugia, identify the processes and conditions that create fire refugia, and protect fire refugia areas[3,4]
Increase knowledge	Monitor groundwater extraction both inside and outside the forest	• Determine the status of water rights[2] • Monitor groundwater extraction to quantify changes to the water table, focusing on transition zones and mesic areas where the greatest opportunities for improvement exist[2]
	Protect rare and sensitive plants in the southern California Sky Islands	• Monitor for species declines or an increase in invasive species[2] • Learn more about fire return intervals in subalpine habitat and the effects and possible necessity of fire suppression[2]
	Monitor forest to detect impacts of additional non-climate stressors	• Monitor forests for beetle outbreaks[2]
Engage coordination	Work across jurisdictions	• Coordinate management actions across land management designations to meet mutual goals[2]

[3] Mackey, B., Berry, S., Hugh, S., Ferrier, S., Harwood, T. D., & Williams, K. J. (2012). Ecosystem greenspots: Identifying potential drought, fire, and climate-change micro-refuges. *Ecological Applications*, *22*(6), 1852–1864.
[4] Kolden, C. A., Lutz, J. A., Key, C. H., Kane, J. T., & van Wagtendonk, J. W. (2012). Mapped versus actual burned area within wildfire perimeters: Characterizing the unburned. *Forest Ecology and Management*, *286*, 38–47.

Adaptation Category	Adaptation Strategy	Specific Adaptation Actions
Engage coordination (con't)		• Communicate about projects and coordinate on-the-ground activities[5]
	Track the effects of climate change and monitor forest conditions by engaging multiple entities, as well as local communities	• Implement a large-scale monitoring program designed to increase the identification, detection, and prediction of insect and disease outbreaks[2] • Develop a citizen science program to engage communities in monitoring their local forest[2]

Table 2 identifies the key conifer and subalpine habitat vulnerabilities that may be reduced and/or addressed by various adaptation actions. These linkages are based on expert opinion.

Linking vulnerabilities to adaptation options can help managers decide which actions to implement and aid prioritization based on multiple factors (e.g., habitat type, observed or projected changes, ecosystem service). However, when selecting adaptation actions for implementation it is also important to consider secondary effects on other resources, both positive and negative. For example, trail or road decommissioning may benefit aquatic systems by limiting erosion impacts but could also remove important access points to fire-prone areas. For more information about conifer and subalpine adaptation strategies and actions developed by participants during the workshop, including where and how to implement adaptation actions, implementation timeframe, collaborations and capacity required, and secondary effects on other resources (both positive and negative), please see the report *Climate Change Adaptation Strategies for Focal Habitats of Southern California*.

[5] Actions were sourced from the Climate Adaptation Project for the Sierra Nevada and/or the Northern Rockies Adaptation Partnership.

Table 2. Key vulnerabilities of conifer and subalpine habitats linked to specific adaptation actions and management activities; implementation of adaptation actions (central column) may help to directly reduce and/or address the impacts of identified climate and non-climate stressors and disturbance regimes (right columns). Actions highlighted in **red** represent adaptation strategies that enhance resistance, those highlighted in **orange** promote resilience, and those highlighted in **green** facilitate transition. Adaptation actions aimed at increasing knowledge and engaging coordination are not included in this table as they address vulnerability indirectly. Adaptation actions listed in this table include those identified by participants, in the scientific literature, and in other similar efforts.

Management Activity	Adaptation Actions	Climate Stressors: Altered precipitation (timing & amount); ↓Soil moisture; ↑Drought	Climate Stressors: ↑Air temperature	Climate Stressors: ↓Snowpack; Earlier timing of snowmelt/runoff	Disturbance Regimes: Altered wildfire regimes	Non-Climate Stressors: Fire suppression practices	Non-Climate Stressors: Insects and disease	Non-Climate Stressors: Recreation
Fire/Fuels Management Activities	Focus thinning activities in areas where fire is most likely to carry up from neighboring habitats (e.g., chaparral or oak woodland)				✔			
	Increase fire permit restrictions for recreation users during dry summers				✔			✔
	Review wilderness paradigm to allow fuel modification in mixed conifer wilderness				✔	✔		
	Implement prescribed burns to prevent severe wildfires				✔	✔		
	Increase awareness of the need to incorporate bulldozer/retardant avoidance around rare subalpine species during fires				✔			
	Protect the area around rare, vulnerable, and/or endemic wildlife species from wildfire and post-fire impacts (e.g. landslides)				✔			
	Thin/underburn big-cone Douglas fir and canyon live oak stands to reduce the likelihood of crown fires and create opportunities for seedling recruitment				✔			
	Stop fire suppression, particularly in wilderness areas				✔	✔		
	Develop a nighttime prescribed fire program				✔	✔		
	Use resource advisors to avoid or minimize the impacts of bulldozers and fire retardants				✔			
	Apply a minimum resource decision guide to a stand in need of fuel modification to facilitate discussion of wilderness value				✔	✔		
	Avoid prescribed burns in areas of oak regeneration if burn conditions would be too hot for seedling survival				✔			
Habitat Management & Restoration Activities	Create barriers (e.g., tree tubes, K-rails) between habitat restoration areas and key human ignition points				✔			
	Create an Adopt-a-K-rail program, in which local artists paint K-rails to increase visibility before they are placed near possible fire ignition sources				✔			
	Focus big-cone Douglas fir management and protection in identified climate refugia	✔	✔	✔	✔			
	Thin overly dense stands and/or those that are mostly single-species and uniform in age, in order to reduce competition	✔						
	Use nurse plants to facilitate regeneration of conifer species		✔					
	Re-vegetate slopes with native species that have genotypes better adapted to future conditions	✔	✔	✔	✔			
	Plant founder stands for seed dispersal	✔	✔	✔	✔			
	Plant acorns from varied genetic stocks	✔	✔	✔				
	Investigate longer-term banking or storage options for acorns and use rotating planting schedule	✔	✔					
	Plant resilient species intermixed with current species to reduce outbreaks associated with monocultures and consider planting outside of post-burn areas	✔	✔	✔			✔	
	Collect seed from trees in lower-elevation bands	✔	✔	✔				
	Increase species and genetic diversity within seed collections	✔	✔	✔				
	Collect seeds from and monitor the species most vulnerable to climate change	✔	✔	✔				
	Facilitate migration of co-adapted species, focusing on species where one species within an association is limiting the migration of all		✔					
	Use monitoring results to identify threatened populations and aid efforts to increase connectivity and genetic diversity	✔	✔	✔				
	Prioritize research efforts to identify refugia and compare their ecological value other habitats	✔	✔	✔	✔			
	Map fire refugia, identify the processes and conditions that create fire refugia, and protect fire refugia areas				✔			
Recreation Management Activities	Increase signage and public education to minimize the impacts of recreation							✔
	Modify and/or remove roads and trails to minimize the impacts of off-highway vehicles (OHVs)							✔

In addition to directly reducing vulnerabilities (Table 2), some adaptation actions may indirectly address vulnerabilities. For example, placing K-rails or other barriers around habitat restoration areas to protect them from fire ignitions would also reduce the impacts of recreation around those sites. Conversely, minimizing OHV use will likely reduce fire ignitions, which occur more frequently near roads and areas associated with human activity.

Two other important considerations when selecting adaptation actions for implementation include feasibility (action capable of being implemented) and effectiveness (action reduces vulnerability). An adaptation action with high feasibility has no obvious barriers and a high likelihood of implementation whereas an action with low feasibility has obvious and/or significant barriers to implementation that may be difficult to overcome. An adaptation action with high effectiveness is very likely to reduce associated vulnerabilities (listed in Table 2) and may benefit additional management goals or resources whereas an action with low effectiveness is unlikely to reduce vulnerability and may have negative impacts on other resources.

Figure 1 plots adaptation actions listed in Table 1 according to feasibility and effectiveness. This figure can help managers prioritize actions for implementation (e.g., actions with high feasibility and high effectiveness), better target management efforts toward specific challenges (e.g., actions with low or moderate feasibility but high effectiveness), and/or evaluate whether to proceed with implementation (e.g., actions with high feasibility but low effectiveness). For the latter two purposes, managers may consider the following questions:

- **Low or Moderate Feasibility/High Effectiveness Actions**: What steps can be taken to increase the likelihood of this action being implemented in the future?
    - *Example*: Would improving public outreach and education or enhancing public/private collaboration facilitate the removal of dikes or recharge basins with the goal of restoring fluvial processes?
- **High Feasibility/Low or Moderate Effectiveness Actions**: Does this action still make sense given projected climate changes and impacts?
    - *Example*: If conditions are projected to become drier, should grazing continue in areas with drought-sensitive vegetation?

Alternatively, there may be some actions that do not reduce vulnerability directly but could provide important information, tools, or support to address vulnerability down the line. For example, actions aimed at increasing knowledge through monitoring or modeling could provide key information for future restoration activities (e.g., creating detailed species genetic profiles to select genetically and ecologically suitable plant species for future conditions). Managers may want to weigh the costs and benefits of implementing actions with the timeframe required to reduce vulnerability directly. Additionally, actions focused on coordination and collaboration may not directly address vulnerabilities, but these remain important steps toward better planning and management.

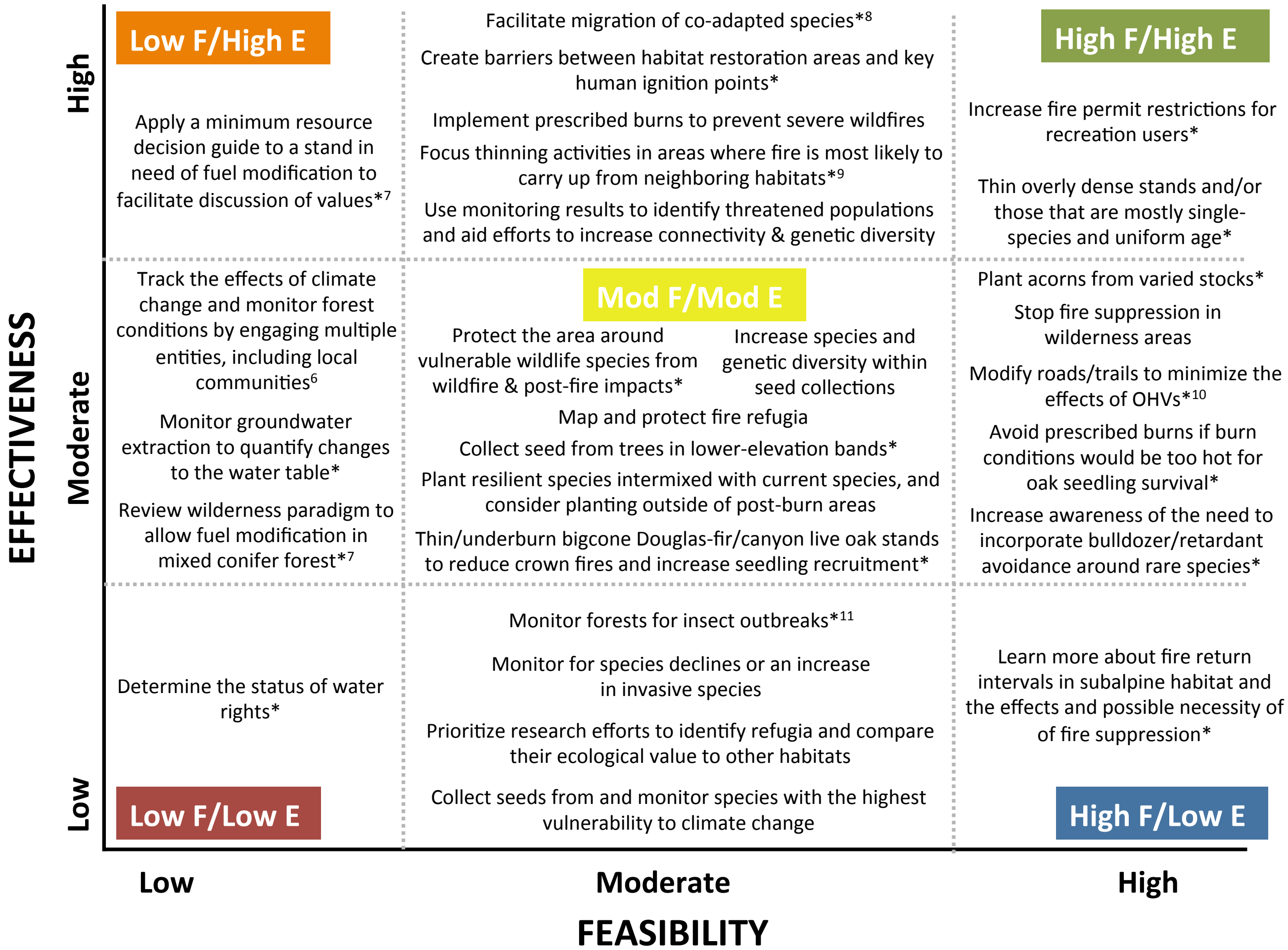


Figure 1. Conifer and subalpine habitat adaptation actions plotted according to implementation feasibility (action capable of being implemented) and effectiveness (action reduces vulnerability). Those actions having high feasibility and effectiveness appear in the upper right corner and low feasibility and effectiveness in the bottom left corner. An asterisk (*) denotes adaptation actions evaluated for feasibility and effectiveness by workshop participants, although in some cases the ranking was shifted based on expert opinion. All other adaptation action evaluations are based on expert opinion.

Recommended Citation

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This document is available online at the EcoAdapt website (http://ecoadapt.org/programs/adaptation-consultations/socal).

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[6] This overall goal includes several specific adaptation actions (see Table 1).
[7] Workshop participants noted that the feasibility of this action may be higher than noted, depending on perceived wilderness values and what people believe the natural fire regime is.
[8] Workshop participants noted that the feasibility of this action is limited by the need to first identify expected range shifts.
[9] Workshop participants noted that the feasibility of this action is limited by access and cost, but no policy change is needed since this is already directed implemented.
[10] Workshop participants noted that this action only minimizes impacts and does not directly address species' declines.
[11] Workshop participants noted that the effectiveness of this action is limited because it is unclear whether anything could be done if an outbreak was detected.