Southern California Subalpine Habitats

Climate Change Vulnerability Assessment Summary

An Important Note About this Document: *This document represents an initial evaluation of vulnerability for subalpine habitats based on expert input and existing information. Specifically, the information presented below comprises habitat expert vulnerability assessment survey results and comments, peer-review comments and revisions, and relevant references from the literature. The aim of this document is to expand understanding of habitat vulnerability to changing climate conditions, and to provide a foundation for developing appropriate adaptation responses.*

USFS/Photo by Joseph Torok

Habitat Description

Subalpine habitats typically occur at elevations above 2,590 m, and only cover about 8,250 acres in southern California, where they are found in the San Jacinto, San Bernardino, and San Gabriel mountains, as well as in isolated patches on the summits of Mount Pinos and Mount Abel.[1] Subalpine habitats are characterized by short growing seasons, cool temperatures, high wind, and extended periods of winter snowpack.[2] Subalpine forests are strongly dominated by lodgepole pine (*Pinus contorta*) and limber pine (*P. flexilis*), and the forest understory is often sparse.[2]

Habitat Vulnerability

Moderate Vulnerability

Low → High

Moderate Confidence

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 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 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 disturbances.

Sensitivity

Low-Moderate Sensitivity

Low → High

Moderate Confidence

Subalpine habitats are sensitive to multiple climate drivers, including air temperature, snowpack depth, timing of snowmelt/runoff, drought, and precipitation. Subalpine forests endure harsh conditions characterized by cold temperatures, low soil moisture, and rocky substrates.[2] Both energy (light and warmth) and moisture availability limit growth,[2] and the length of the short growing season is determined by the timing of snowmelt and warmth/photoperiod requirements.[3] Maximum growth rates occur when winter precipitation is high and summers are warm.[2] The primary disturbances in subalpine forests include wildfire, insects, and disease.[2,4] Non-climate stressors can decrease the ability of the habitat to recover from disturbance; however, many subalpine forests remain relatively inaccessible due to their remote location.

Habitat sensitivity factors and impacts[*]

CLIMATIC DRIVERS	Moderate-High Sensitivity; Moderate Confidence
Air temperature	Increasing temperatures may have some positive impact on subalpine habitats; however, they are likely to also cause a greater amount of precipitation to fall as rain rather than snow, reducing stored water, and to contribute to earlier snowmelt.[5] Increases in temperature may result in: • Increased mortality of large-diameter trees[6] • Transition from sparse, old-age stands to young forests with high stem density[6,7] • Longer growing seasons and potential increases in productivity for some species[3]
Snowpack depth & timing of snowmelt/ runoff	Snowmelt is a primary source of moisture for many subalpine trees and shrubs,[9] and snowpack can remain until June in good snow years, limiting the length of the annual summer drought.[10] Changes in snowpack depth and the timing of snowmelt/runoff may lead to: • Longer growing seasons limited by photoperiod requirements rather than snowmelt[3] • Reduced soil moisture and longer summer dry periods[5]
Precipitation & drought	Summer rain is infrequent in subalpine forests, and soil moisture is typically low during the growing season.[2] Shifts in the amount and timing of precipitation may cause: • Limited growth and germination, especially at dry sites or in species with higher sensitivity to water stress[8] • Increased susceptibility to insect outbreaks and other stressors[11] • Increased tree mortality, especially during drought years[11]

[*] Factors presented are those ranked highest by habitat experts. A full list of evaluated factors can be found in the Subalpine Habitats Climate Change Vulnerability Assessment Synthesis.

DISTURBANCE REGIMES	Moderate Sensitivity	High Confidence
Wildfire	Historically, fire occurred infrequently in subalpine ecosystems, and fire return intervals of greater than 200 years are common.[2,4] Fires are typically small and of low-moderate intensity with occasional torching;[2,12] and many fires are started by lightning strikes.[12] Most subalpine tree species have thin bark and fire damage is often fatal, because of this, most fires are stand-replacing.[10] Altered wildfire regimes may cause: • Increased recruitment of shade-intolerant species[10] • Possible increased fire frequency in dense stands, due to greater fuel availability[7]	
Insects	Bark beetle outbreaks in subalpine ecosystems are historically infrequent and usually confined to small clumps of trees.[4] However, with warming temperatures and increasing water stress, subalpine ecosystems are more vulnerable to insect outbreaks,[7] which may lead to: • Increased broad-scale mortality events, especially in homogeneous forests[13] • Higher rate of mortality in trees stressed by other factors (e.g., drought, air pollution[11]	
Disease	Subalpine habitats are vulnerable to pathogens, such as white-pine blister rust (*Cronartium ribicola*; affects limber pine), root diseases, and parasitic dwarf mistletoe (*Arceuthobium* spp.).[10] Little information is available on how diseases may respond to future climate conditions; however, warmer temperatures and drier conditions may limit outbreaks.[14] The impacts of disease include: • Injury and possible tree mortality, especially in trees already stressed by other factors[10,14]	
NON-CLIMATE STRESSORS	Low Sensitivity & Exposure	Low Confidence
Recreation	Recreational activities cause localized damage to sensitive soils and vegetation;[1] recreation areas can also be a source of fire ignitions.[15] In southern California, subalpine development is primarily limited to ski areas, and low accessibility in these areas limits more widespread impacts on the habitat.[16] Loss of snowpack and earlier snowmelt would have implications for winter recreation activities (e.g., ski season would become shorter).[17]	

Exposure[†]

Moderate-High Exposure

Low → High

Moderate Confidence

Under future climate conditions, subalpine habitats are likely to be exposed to increased air temperature, decreased snowpack, earlier snowmelt/runoff, changes in precipitation, decreased soil moisture, increased drought, and increased wildfire. Warm temperatures would lengthen the growing season and may offer some benefit to species growth and seedling

[†] Relevant references for regional climate projections can be found in the Southern California Climate Overview (http://ecoadapt.org/programs/adaptation-consultations/socal).

recruitment over the short term (10-20 years).[2,6,16] By mid- to late-century, however, increasing temperatures may cause a decline or failure in regeneration of these species, especially in harsh, dry sites. Potential refugia may occur in moist microsites or more protected microsites, where climatic water deficit and solar radiation would be lower. Overall, climate models project a decline of 75-90% for alpine/subalpine forest in California by the end of the 21st century.[4,18]

Projected climate and climate-driven changes for Southern California

CLIMATIC DRIVERS	PROJECTED CHANGE
Air temperature	+2.5 to +9°C by 2100
Snowpack depth & timing of snowmelt/runoff	Up to 50% reduction in snowfall and 70% reduction in snowpack by 2100 (greatest loss in low elevations); snowmelt and peak runoff occurring 1-3 weeks earlier
Precipitation, soil moisture, & drought	Variable annual precipitation volume and timing, with wetter winters and drier summers; decreased soil moisture; longer, more severe droughts with drought years twice as likely to occur
Wildfire	Increased fire size, frequency, and severity

Adaptive Capacity[‡]

Low-Moderate Adaptive Capacity

Low → High

Moderate Confidence

Subalpine forest is fairly rare in southern California, and is typically found on isolated mountaintops. Habitat shifts are unlikely given the slow growth and rate of succession in subalpine habitats, as well as the lack of continuity between habitat patches.[2,16] Harsh conditions make these habitats slow to recover from disturbance,[10] and both resistance and recovery are further reduced by interactions among multiple climate and non-climate stressors.[11]

Habitat adaptive capacity factors and characteristics[§]

FACTORS	HABITAT CHARACTERISTICS
Habitat extent, integrity, & continuity Low-Moderate Moderate Confidence	+ Subalpine habitats have not been substantially impacted by anthropogenic stressors (e.g., development, logging) or fire suppression tactics, and remain within their historical range of integrity[4] - Subalpine habitats are very limited in extent, and habitat patches are isolated and discontinuous in southern California - Very slow growth rates and extremely long lives further limits the ability of subalpine forest species to track climatic changes[2]

‡ Please note that the color scheme for adaptive capacity has been inverted, as those factors receiving a rank of "High" enhance adaptive capacity while those factors receiving a rank of "Low" undermine adaptive capacity.

§ Characteristics with a green plus sign contribute positively to habitat adaptive capacity, while characteristics with a red minus sign contribute negatively to habitat adaptive capacity.

FACTORS	HABITAT CHARACTERISTICS
Landscape permeability Low High Confidence	+ Some species can disperse their seeds over long distances, either by wind (e.g., lodgepole pine) or through specialized interspecies relationships (e.g., limber pine and Clark's nutcracker)[4,10] - Geologic features are a significant barrier to habitat shifts and species dispersal (e.g., mountains) - Lack of connectivity between mountaintops limit the habitat's ability to shift northward,[16] and lack of soil limits movement towards higher elevations[9]
Resistance & recovery Low-Moderate Low Confidence	+ Shade-intolerant limber and lodgepole pine species can colonize recently burned areas, taking advantage of breaks in the canopy[4,10] - Dense stands may be less resistant to stressors such as drought, fire, and insect outbreaks, and are less likely to recover following these events - Both resistance and recovery are greatly decreased by interactions between multiple climate and non-climate stressors[11] - Subalpine trees and shrubs grow slowly and must endure harsh conditions;[9,10] full recovery from disturbances can take up to 100 years[10]
Habitat diversity Low-Moderate Moderate Confidence	+ Low-moderate species diversity: dominated by two tree species (lodgepole and limber pine), as well as several understory shrubs including mountain heather and montane chaparral associations + Provides habitat for many sensitive species of wildlife including two subspecies of lodgepole chipmunk and Clark's nutcracker (the latter plays a vital role as seed disperser, especially for limber pine)[1,2] - Low-moderate species and functional group diversity, moderate physical/topographic diversity
Management potential Moderate Low Confidence	+ High societal value: Valued for aesthetics, recreational opportunities, and water storage + Subalpine habitats provide a variety of ecosystem services: biodiversity, water supply/quality/sediment transport, recreation, air quality, and flood and erosion protection - Low-moderate opportunity to alleviate the impacts of climate change through management actions, due to limited options for management of subalpine habitats

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

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