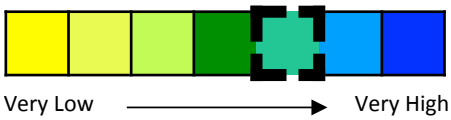
Alpine/Subalpine Ecosystems

Climate Change Vulnerability, Adaptation Strategies, and Management Implications

General Information:

The alpine/subalpine ecological zone of the Sierra Nevada forms a wide band across the top of the mountain range in the southern Sierras but narrows progressively north through Tahoe National Forest, after which it becomes discontinuous islands. The subalpine zone of the Sierra Nevada includes both forested and non-forested vegetation, although non-forested vegetation may dominate the landscape in higher elevation sections of the range. East of the Sierra crest, species composition differs from slopes west of the crest including, for example, absent or restricted red fir and the presence of limber pine. Bristlecone pine, although not in the Sierra Nevada, is included in the bioregion (i.e., White and Inyo Mountains). Subalpine forests are thought to be within the natural range of variation, although there have been some shifts in structure due to climate warming and 19th century logging. Additionally, some species have migrated upward into alpine zones (e.g., bristlecone pine), likely due to increased temperatures. Component species of the alpine/subalpine ecosystem include: mountain hemlock (*Tsuga mertensiana*), whitebark pine (*Pinus albicaulis*), western white pine (*P. monticola*), lodgepole pine (*P. contorta*), red fir (*Abies magnifica*), bristlecone pine (*P. longaeva*), limber pine (*P. flexilis*), and foxtail pine (*P. balfouriana*).

Ecosystem Vulnerability: **Moderate-High**



Alpine/subalpine habitats are sensitive to a variety of climate and climate-driven factors, including increased temperature, decreased water supply (e.g., precipitation and snowpack), and increased climatic water deficit. Water availability is likely the most important factor affecting this system, as it controls tree growth, survival, and susceptibility to insects and disease. Alpine/subalpine response to regional change will likely vary by species, tree age and size, stand density, and microclimate, and responses could include uphill migration, range constriction, and/or increased subalpine extent and diversity. Non-climate stressors, including development (e.g., ski resorts), insects (mountain pine beetle), and disease (white pine blister rust), can degrade this system, prevent uphill migration, and/or exacerbate climate impacts.

Projected Climate and Climate-Driven Changes	Impacts on Alpine/Subalpine Ecosystems
Increased air temperature (+2.4 to +3.4˚C), with largest increases during summer	• Increased growth rates and productivity, especially for lodgepole, foxtail, and western white pines near treeline • Increased wildfire risk, especially for dense stands at lower elevations • Increased pine beetle outbreaks • Increased potential evaporation
Changes in precipitation and snowpack: – Decreased summer and fall precipitation – Decreased snowpack (-64% to -87%), especially in northern range – Earlier snowmelt	• Reduced water availability and storage, potentially increasing drought-related tree mortality and/or susceptibility to pine beetle infestations • Increased wildfire risk, especially for dense stands at lower elevations
Increased climatic water deficit (+44%), especially in northern range	• Reduced soil moisture, leading to drought stress if accompanied by warming temperatures

With limited ability to migrate vertically and slow species establishment and growth, alpine/subalpine ecosystems likely have a limited ability to adapt to changing climate conditions. In particular, alpine systems are strongly constrained by geographic isolation and limited soil productivity. Some species may be better able to adapt to changing conditions (e.g., foxtail pine, limber pine, and mountain hemlock).

The more continuous alpine/subalpine habitats in the southern Sierra Nevada may be more resilient compared to the fragmented and elevationally isolated habitats in the northern Sierra Nevada

Adaptation Strategies for Alpine/Subalpine Ecosystems

Adaptation Strategy	Specific Management Actions
Maintain or improve ability of forests to resist insects, disease, and invasive species both now and in the future	• Implement large-scale, coordinated monitoring program (including "citizen science" groups) in wilderness and non-wilderness areas to improve ability to identify, detect, and predict future outbreaks • Targeted non-wilderness areas: – Use thinning to reduce soil moisture deficits, which may increase tree resilience – Promote diversity of age classes to increase overall system resistance and resilience
Restore fire to fire-adapted ecosystems to minimize fuel loading and reduce the potential for high severity fires	• Increase use of managed wildfires to restore stand structure, promote seral diversity, and re-engage key ecosystem processes, especially in wilderness areas • Reduce stand densities with available management tools • Maintain refugia to provide suitable habitat for populations under changing climate conditions • Use prescribed burning in lower elevation subalpine forests (non-wilderness) • Take advantage of natural fire occurrences by managing fire path and severity
Increase diversity of nursery stock and maintain seeds of desired species for use after severe disturbances and to protect species from insect and disease outbreaks	• Complete gene-screening for blister rust and, where feasible, identify and plant disease-resistant strains of white pine species (e.g., in stands already impacted by blister rust and areas that are already losing individuals) to reduce susceptibility of forests to disease that may be exacerbated by or exacerbate climate impacts

Restoring natural forest structure through various management actions (e.g., managing natural fires in wilderness areas, using silvicultural treatments in non-wilderness areas) can increase the resilience of the alpine/ subalpine ecosystem to large, severe fires, moisture stress, and insect and disease outbreaks

Management Implications

This information can be used in a variety of ways:

✔ Forest Plan Revisions

✔ U.S. Forest Service Climate Change Performance Scorecard: Element 6 - "Assessing Vulnerability" and Element 7 - "Adaptation Actions"

✔ National Park Service Resource Stewardship Strategies, Fire and Fuel Management Plans, General Management Plans, Strategic Plans, and Wilderness Stewardship Plans

Further information and citations can be found in source reports, *A Climate Change Vulnerability Assessment for Focal Resources of the Sierra Nevada* and *Climate Change Adaptation Strategies for Focal Resources of the Sierra Nevada*, available online at the EcoAdapt Library: http://ecoadapt.org/library.

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