MIXED EVERGREEN/MONTANE HARDWOOD FORESTS

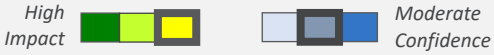
Climate Change Vulnerability and Adaptation Strategies for the Santa Cruz Mountain Region

Habitat Description

Mixed evergreen/montane hardwood forests are comprised of a mix of hardwoods and conifers including Pacific madrone (*Arbutus menziesii*), tanoak (*Notholithocarpus densiflorus*), Douglas-fir (*Pseudostuga menziesii*), canyon live oak (*Quercus chrysopelis*), interior live oak (*Q. wislizenni*), California black oak (*Q. kelloggii*), coast redwood (*Sequoiadendron sempervirens*), and California buckeye (*Aesculus californica*). Forest structure and composition can vary widely across sites depending on moisture balance, disturbance history, soil conditions, and topography.

Habitat Vulnerability

Sensitivity & Exposure



Projected Changes	Trend
Precipitation	▲▼
Coastal fog	▼
Soil moisture	▼
Air temperature	▲
Drought	▲
Disease	▲
Wildfire	▲
Storms	▲

Potential impacts:

- Increased water stress, limiting growth and increasing mortality on drier sites or near southern range limits
- Possible increases in seedling recruitment and productivity for some hardwoods due to warmer air temperatures
- Increased tree mortality due to drought, wildfire, and sudden oak death, especially in stands where increased competition for soil moisture has reduced tree vigor
- Likely shifts in species composition and forest structure due to species-specific impacts of water stress, mortality, and post-disturbance regeneration

Non-climate stressors may interact with climate stressors and disturbance regimes:

- *Fire suppression/exclusion* has reduced fire frequency, increasing tree and understory density that enhances the likelihood of uncharacteristically intense fires
- *Timber harvest* has caused fragmentation and loss of old-growth forests, reducing structural complexity and exacerbating changes that drive altered fire regimes
- *Invasive plants* compete with or degrade native vegetation and alter soil properties
- *Roads, highways, and recreational trails* increase habitat fragmentation, enhance the risk of human ignitions, and contribute to the spread of sudden oak death
- *Residential development* has resulted in significant forest loss and fragmentation, particularly in and around the wildland-urban interface

Mixed evergreen/montane hardwood forests are sensitive to climate changes that impact water availability, alter fire regimes, or influence patterns of disease. These changes affect patterns of tree growth and mortality, resulting in shifts in species composition and forest structure.

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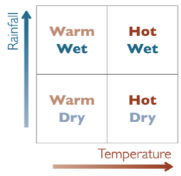
Modeled Changes in Vegetation Distribution

Dramatic Decline | Moderate Decline | Relative Stability | Increase

	San Francisco	Santa Clara Valley	Santa Cruz Mtns. North	Santa Cruz	Sierra Azul
Douglas fir forest					
Tanoak forest					
Montane hardwood					
California bay forest					

Trends for mixed evergreen/montane hardwood forests are highly variable across landscape units, though Douglas fir forest was projected to be consistently stable or increase in all areas except under hot/dry conditions. Similarly, tanoak forest was projected to remain stable or undergo declines in most areas and scenarios.

Climate Future



Adaptive Capacity

Moderate Adaptive Capacity   *High Confidence*

Intrinsic factors (i.e., inherent characteristics) that enhance or undermine adaptive capacity:

- ▲ Extensive within the region
- ▲ High structural/species diversity
- ▼ Significant habitat fragmentation/degradation slows forest recovery from disturbance

Extrinsic factors (i.e., management potential) that enhance or undermine adaptive capacity:

- ▲ Highly productive and valued for carbon sequestration, hydrological function, recreation
- ▼ Management efforts unlikely to stop the spread of sudden oak death

Forests with high structural and species diversity have high potential for coping with climate changes, however degraded stands are less able to resist stressors and disturbances.

Key Climate Vulnerabilities: ***Salamanders***

High Vulnerability   **High Confidence**

Salamanders are dependent on cool, moist forest microclimates, and many species also utilize aquatic habitats. As a result, they are sensitive to factors that increase physiological stress or alter habitat availability and quality (e.g., temperature, moisture/drought). Increases in direct mortality and habitat loss/fragmentation due to wildfire, disease, or non-climate stressors (e.g., roads, poisons) can cause additional direct and indirect impacts.

Factors that enhance or undermine adaptive capacity:

- ▲ Diverse behavioral/phenotypic responses and life history strategies within the group
- ▲ Some species receive regulatory protection
- ▼ Unable to migrate/disperse long distances, so are heavily impacted by habitat fragmentation
- ▼ Declines and low genetic diversity in some species

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Adaptation Strategies for Mixed Evergreen/Montane Hardwood Forests

Changing climate conditions are likely to make the management of mixed evergreen/montane hardwood forests more complex due to the increased potential for stressed forests to experience drastic shifts in species composition and/or large-scale dieback. In forests that have been degraded and/or are threatened by climatic and anthropogenic stressors, management strategies may include reducing stem density, reintroducing fire onto the landscape, and supporting forest regeneration. These strategies are designed to enhance forest resilience by increasing spatial heterogeneity and structural complexity, which reduces vulnerability to large-scale disturbances such as uncharacteristically severe wildfire, insects, and disease.

Management strategies for salamanders are likely to focus on maintaining or increasing the availability of cool, moist forest microsites and restoring connectivity between habitat patches, as well as reducing the impacts of non-climate stressors.

ADAPTATION APPROACH	ADAPTATION STRATEGIES
Resistance strategies: Maintain current conditions by limiting change *Near-term approach*	• Remove invasive plants (e.g., annual grasses, scotch broom) that compete with native understory species for limited resources • Protect large, healthy trees of high ecological or cultural value (e.g., oaks, sugar pine) during forest management activities
Resilience strategies: Accommodate some change while enabling a return to prior conditions *Near- to mid-term approach*	• Reduce stand density through frequent prescribed fire and/or variable-density thinning to increase tree vigor and structural diversity while decreasing the risk of uncharacteristically severe wildfires • Reforest disturbed areas in patterns that promote natural development of heterogeneity (e.g., cluster planting) • Create tanoak seed banks and living collections to preserve genetic diversity and allow for future reintroduction*
Response strategies: Intentionally facilitate or direct change to adaptively respond to new conditions *Long-term approach*	• Plant a greater proportion of drought- and fire-tolerant species (e.g., oaks) when restoring disturbed areas • Protect mature and late-successional forests, as well as mid-seral and complex early-seral habitats with high structural diversity
Knowledge strategies: Gather information about climate changes, impacts, and/or management effectiveness *Near- to long-term approach*	• Set up monitoring networks focused on early detection of sudden oak death in order to support proactive site management • Expand research on hardwood silviculture techniques, particularly for drought- and heat-tolerant species* • Identify forest areas of least/slower change to support the protection and management of potential climate change refugia*
Collaboration strategies: Coordinate management efforts and/or capacity across boundaries *Near- to long-term approach*	• Increase education and outreach to enhance awareness of fire as a necessary and natural process in light of climate change* • Partner with local tribes to share resources and expand the use of cultural burning and managed wildfire*

** Future management strategies (not currently occurring)*

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Further information and citations can be found in the source reports of the Santa Cruz Mountains Climate Adaptation Project, available online at http://ecoadapt.org/programs/awareness-to-action/santa-cruz-mountains.