COASTAL REDWOOD FORESTS

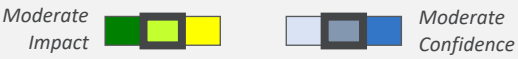
Climate Change Vulnerability and Adaptation Strategies for the Santa Cruz Mountain Region

Habitat Description

Coastal redwood forests in the Santa Cruz Mountains region are near the southern edge of their distribution, and are comprised of at least 30% coast redwood (*Sequoia sempervirens*) canopy cover, along with Douglas-fir (*Pseudotsuga menziesii*), tanoak (*Notholithocarpus densiflorus*), and a variety of other conifer and hardwood tree species. Understory vegetation is comprised of species adapted to cool, moist conditions and low light. Forest structure and composition in second-growth stands varies depending on site conditions, logging practices, and time since disturbance, but these forests are generally denser and skewed towards younger age classes. Closely-associated species include marbled murrelet (*Brachyramphus marmoratus*).

Habitat Vulnerability

Sensitivity & Exposure



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

Potential impacts:

- Increased water stress, affecting plant growth and survival
- Range contractions are possible, particularly under hotter, drier future scenarios
- Altered understory species composition due to reduced frequency of foggy days
- Greater risk of injury and mortality to mature redwoods due to the occurrence of intense crown fires, resulting in reduced extent of old-growth forest
- Shifts in understory and sub-canopy composition and structure due to changes in fire frequency and severity

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

- *Fire suppression/exclusion* has reduced fire frequency, altering forest structure and composition and increasing vulnerability to large, intense fires (especially in dense second-growth forests)

Coastal redwood forests are most sensitive to factors that increase water stress, and declines are likely under hotter, drier scenarios. Increases in wildfire may accelerate habitat loss, and degraded second-growth forests are particularly vulnerable to high-intensity fires that damage or kill mature redwoods.

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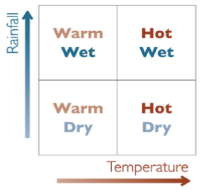
Modeled Changes in Vegetation Distribution

	San Francisco	Santa Clara Valley	Santa Cruz Mtns. North	Santa Cruz	Sierra Azul
Redwood forest					

Climate Future



Overall, redwood forest vegetation is likely to decline, particularly under hotter, drier scenarios and in the southern part of the region.

Adaptive Capacity

Moderate Adaptive Capacity   *High Confidence*

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

- ▲ High spatial and structural complexity in old-growth forests
- ▲ High fire resistance, prolific sprouting after injury, and rapid growth in redwoods provides competitive advantage following disturbances
- ▼ Significant loss of old-growth forests and altered structure/composition in logged areas
- ▼ Peninsula restricts gradual distributional shifts
- ▼ Slow to adapt to environmental change due to long lifespan and low sexual reproduction

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

- ▲ Significant public and societal value increases support for management
- ▲ Many old-growth forests are protected
- ▼ No formal federal or state protection
- ▼ Management of old-growth is costly and difficult to scale up

Because they are long-lived, coastal redwood forests may show a lagged response to climate changes. They also have low rates of sexual reproduction that limit their ability to adapt to rapid environmental change.

Key Climate Vulnerabilities: ***Marbled Murrelet***

High Vulnerability   **Moderate Confidence**

Marbled murrelets (*Brachyramphus marmoratus*) are highly dependent on structurally-complex old-growth forests that provide suitable nesting sites. As a result, climate changes that impact the extent, quality, and connectivity of old-growth redwood forests are a major driver of vulnerability for this species. Other critical impacts may include:

- Reduced availability of nesting platforms where climate change impacts moss/epiphyte growth
- Loss of mature trees or limbs used for nesting due to storm-related windthrow
- Changes in ocean conditions (e.g., temperature, acidification, currents) that reduce prey availability
- Increased presence of nest predators such as corvids due to recreational activity and habitat fragmentation, exacerbating climate-driven declines in reproductive success

Factors that enhance or undermine adaptive capacity:

- ▲ Federally-protected as a threatened species
- ▼ Very small murrelet population in the Santa Cruz Mountains region
- ▼ Low reproductive rate and high site fidelity increase vulnerability to population declines

Adaptation Strategies for Coastal Redwood Forests

Management strategies for coastal redwood forests include focusing on conserving old-growth stands as well as biologically-significant second-growth forests that increase connectivity and have the potential to develop old-growth characteristics over time. In redwood stands that have been degraded and/or are threatened by climate and anthropogenic stressors, several management strategies have demonstrated the ability to restore ecosystem functioning, enhance structural complexity, and increase resilience to future climate changes.

Management strategies for marbled murrelets primarily focus on protecting and enhancing terrestrial nesting habitat in old-growth forests. However, actions focused on reducing nest predation by corvids could also increase population stability in this species.

ADAPTATION APPROACH	ADAPTATION STRATEGIES
Resistance strategies: Maintain current conditions by limiting change *Near-term approach*	• Increase the scale of invasive species management, including early detection and rapid response efforts • Work with utilities to repair, replace, or remove dangerous infrastructure within redwood forests
Resilience strategies: Accommodate some change while enabling a return to prior conditions *Near- to mid-term approach*	• Expand the use of thinning and prescribed fire to reduce understory fuels, promote growth in overstory trees, and increase forest health and structural complexity • Restore native understory species that help retain soil moisture in redwood communities (e.g., huckleberry, forbs)* • Protect biologically-significant second-growth forests that represent the natural range of variability in this habitat type
Response strategies: Intentionally facilitate or direct change to adaptively respond to new conditions *Long-term approach*	• Protect and maintain old-growth forests that may be more resistant to changes in climate (e.g., cooler, wetter sites), as well as areas where projected climate conditions are expected to remain within or close to the suitable range for coast redwood* • Consider planting species such as Douglas-fir in areas where redwoods are highly likely to decline*
Knowledge strategies: Gather information about climate changes, impacts, and/or management effectiveness *Near- to long-term approach*	• Use genomic mapping to identify individual redwoods that are drought-tolerant and could be cloned for use in restoration efforts* • Identify species at risk of extirpation and whether there are others available to fill their functional role in the ecosystem* • 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*	• Work with private landowners and the logging industry to protect redwoods and improve stewardship practices • Increase collaboration with state parks, including expanding research, treatments, and public education* • Promote county- and agency-level policy changes that require more sustainable practices*

** 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.