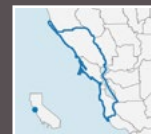


Coastal Redwood Forests

Climate Change Vulnerability
and Adaptation Strategies for the
Golden Gate Biosphere Region



Ecosystem Description

Coastal redwood forests in the Golden Gate Biosphere (GGB) region are near the southern edge of their distribution, which is limited to the coastal fog zone and extends from central California into southern Oregon. Coastal redwood forests are dominated by coast redwood (*Sequoia sempervirens*), with lower layers composed of tanoak (*Notholithocarpus densiflorus*), California bay laurel (*Umbellularia californica*), and Douglas-fir (*Pseudotsuga menziesii*). Understory vegetation is composed of species adapted to cool, moist conditions and low light. Forest structure and composition in second- and third-growth stands vary depending on site conditions and time since disturbance, but are generally denser and skewed towards younger age classes. Old-growth forest patches are present throughout the GGB region, but are less extensive than in northern areas.

Ecosystem Vulnerability - High

Sensitivity & Exposure - High

Projected Changes	Trend
Precipitation	▲▼ Varies
Coastal fog	▼ Decrease
Drought	▲ Increase
Air temperature	▲ Increase
Wildfire	▲ Increase
Disease	▲ Increase
Storms	▲ Increase

Potential Impacts:

- Increased water stress, affecting redwood growth and recruitment
- Likely range contractions within the GGB region, particularly under hotter, drier future scenarios
- Altered understory species composition due to reduced frequency of coastal fog
- Increased risk of injury and mortality to mature redwoods due to the occurrence of intense crown fires
- 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:

- *Historical timber harvesting and fire suppression/exclusion* have altered forest structure and composition and increased vulnerability to large, intense fires (especially in dense stands)
- *Invasive plants* displace native understory species; *non-native pathogens* increase mortality, altering species composition and forest structure and potentially increasing fire intensity
- *Heavy recreational use* can cause soil compaction, damaging roots and understory vegetation
- *Dams and water diversions* reduce water availability and disrupt sedimentation processes that maintain alluvial stands



Coastal redwood forests are most sensitive to factors that increase water stress and the risk of severe wildfires, and degraded second-growth forests are particularly vulnerable to impacts.

Ecosystem Vulnerability - *High*

Adaptive Capacity - *Moderate*

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

Enhance:

- High spatial and structural complexity in old-growth redwood forests
- High fire resistance, prolific sprouting after injury, and rapid growth in redwoods provides competitive advantage following disturbances

Undermine:

- Significant loss of extent and connectivity for old-growth redwood forests
- Reduced integrity and spatial complexity in degraded second- and third-growth stands, increasing vulnerability to climate changes

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

Enhance:

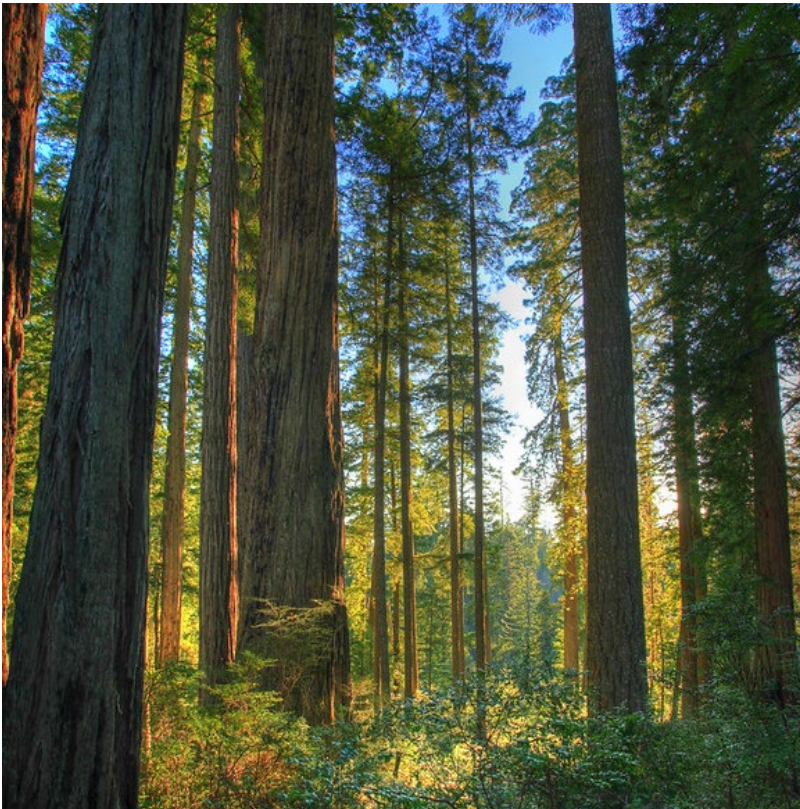
- Significant public and societal value increases support for management, especially for old-growth forests

Undermine:

- Management challenges in the context of climate change are significant and costly, particularly for landscape-scale efforts



Because they are long-lived, coastal redwoods may respond slowly to climate changes. However, their low rate of sexual reproduction makes them slow to adapt to rapid environmental change.



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GGNRA, Flickr (Public domain)

Adaptation Strategies & Actions

Adaptation strategies can reduce climate change vulnerability of a given ecosystem or species by addressing any or all of the three components of vulnerability (i.e., by reducing sensitivity, reducing exposure, and/or increasing adaptive capacity). The table below presents examples of adaptation strategies and actions, which fall within five categories, or approaches: Resistance/Resilience (**R**), Acceptance (**A**), Direct/Response (**D**), Knowledge (**K**), and Collaboration (**C**). *Please note that the strategies and actions provided here should not be considered a checklist or plan, but rather as a set of examples for land managers to consider for further study when developing site- or species-specific actions.*

Adaptation Strategies	Adaptation Actions
Move second-growth forests towards late-seral stage conditions (e.g., through thinning, managed/prescribed fire) to increase resilience to drought, wildfire, disease	<ul style="list-style-type: none"> Expand map of LIDAR forest structure mapping efforts to Sonoma and San Mateo Counties with the goal of identifying old-growth and second-growth stands across the whole region (K) Identify existing demonstration projects that have put these methods into place and/or create demonstration projects to compare and contrast methods (K) Selectively thin and/or use prescribed fire to accelerate old-growth conditions (R)
Create an early warning system to detect novel pathogens, mortality, drought stress, etc.	<ul style="list-style-type: none"> Create a central repository for existing monitoring efforts (K/C) Instrument individual trees as early warning for drought stress (K)
Restore hydrology to maintain the alluvial conditions that support coastal redwood forests	<ul style="list-style-type: none"> Decommission roads to reduce runoff and sediment inputs (R) Replace undersized culverts and/or redesign roads to remove the need for culverts to allow the passage of sediment/debris under projected flow conditions (R)
Prioritize stands for management and protection under future conditions	<ul style="list-style-type: none"> Identify and protect all remaining old-growth stands not already in conservation areas (R/K) Identify stands that should not continue to receive significant resources for management as conditions continue to become less suitable for their persistence (A)
Increase connectivity of redwood forests throughout the GGB region	<ul style="list-style-type: none"> Map potential dispersal corridors for redwood-associated species throughout the region and pursue permanent protection of these areas (R/K)
Strengthen tribal connections and co-stewardship of redwood forests	<ul style="list-style-type: none"> Work with tribal authorities to implement cultural burning of redwood stands that are characterized by relatively frequent fire (C)

Adaptation strategies and actions generated through breakout group exercises during the adaptation workshop in December 2023.