Mixed Evergreen Forests

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

Douglas fir, Peter Stevens, Flickr (CC BY 2.0)

Ecosystem Description

Mixed evergreen forests are widely distributed across California, and are composed of a mix of hardwoods and conifers including Douglas-fir *(Pseudostuga menziesii*), tanoak (*Notholithocarpus densiflorus*), Pacific madrone (*Arbutus menziesii*), California bay laurel (*Umbellularia californica*), canyon live oak (*Quercus chrysopelis*), interior live oak (*Q. wislizenni*), coast live oak (*Q. agrifolia*), and California black oak (*Q. kelloggii)*, among others. Forest structure and composition can vary widely depending on moisture balance, disturbance history (e.g., fire), and site conditions (e.g., aspect, slope, soil properties).

Ecosystem Vulnerability - *Moderate*

Sensitivity & Exposure - *High*

Projected Changes	Trend
Precipitation	▲▼ Varies
Drought	▲ Increase
Air temperature	▲ Increase
Stream flow	▲▼ Varies
Wildfire	▲ Increase
Disease	▲ Increase
Insects	▲ Increase

Potential Impacts:

- Increased water stress, limiting growth and increasing mortality on drier sites and for species near their 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 exclusion and suppression* 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 species* compete with or degrade native vegetation and alter soil properties; non-native pathogens increase mortality, altering species composition and forest structure
- *Roads and highways* increase habitat fragmentation, enhance the risk of human ignitions, and contribute to the spread of sudden oak death

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

Ecosystem Vulnerability - *Moderate*

Adaptive Capacity - *Moderate*

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

Enhance:

- Widespread throughout the region
- High structural and species diversity, potentially supporting shifts in species composition in response to climate change

Undermine:

- Significant fragmentation and degradation increases vulnerability to disturbances and potential type conversion

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

Enhance:

- Highly valued by the public for beauty and recreational opportunities, and by tribes for the presence of many culturally-significant species

Undermine:

- Difficult to implement climate-informed management practices at larger spatial scales

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

Coastal live oak, Peggy A. Lopipero-Langmo, Flickr (CC BY 2.0)

Tanoak leaves, Sodai Gomi, Flickr (CC BY 2.0)

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
Prevent the introduction and establishment of invasive species and remove existing populations	• Remove invasive plants (e.g., annual grasses, brooms) that compete with native understory species for limited resources **(R)**
Retain biological legacies	• Protect large, healthy trees of high ecological or cultural value (e.g., oaks, maples) during forest management activities **(R)** • Protect dead and dying trees (standing or downed) for their wildlife values **(R)**
Promote spatial heterogeneity to reduce the impact of climate stressors and climate-mediated changes in disturbance regimes	• Reduce stand density where needed through frequent prescribed fire and/or variable-density thinning to increase tree vigor and structural diversity while decreasing the risk of uncharacteristically severe wildfires **(R)** • Reforest disturbed areas in patterns that promote natural development of heterogeneity (e.g., cluster planting) and prioritize planting of drought- and fire-tolerant species (e.g., oaks) **(R)**
Enhance the ability of forests to resist and/or recover from introduced pests and pathogens	• Create tanoak living collections to preserve genetic diversity and allow for future reintroduction **(R)** • Set up monitoring networks focused on early detection of sudden oak death, and manage key sites that are still uninfected **(R/K)**
Prioritize and maintain sites that may be more resistant to changes in climate	• Identify forest areas of least/slower change to support the protection and management of potential climate change refugia **(K)** • Protect mature and late-successional forests from degradation and loss (also include mid-seral and complex early-seral habitats with high structural diversity) **(R)**
Restore the role of fire as an ecological process on the landscape	• Increase education and outreach to enhance awareness of fire as a necessary and natural process in light of climate change **(C)** • Partner with local tribes to share resources and expand the use of cultural burning and managed wildfire **(C)**

Adaptation strategies and actions suggested by individual stakeholders (not discussed during the December 2023 adaptation workshop).