# Southern California Oak Woodland Habitats

## *Climate Change Adaptation Actions Summary*

***An Important Note About this Document:*** *This document represents an initial effort to identify adaptation actions for oak woodland habitats in southern California based on stakeholder input and existing information. Specifically, the information presented below comprises stakeholder input during a two-day adaptation workshop, peer-review comments and revisions, and relevant examples from the literature or other similar efforts. The aim of this document is to expand understanding of possible adaptation actions for southern California oak woodlands in response to climate change.*

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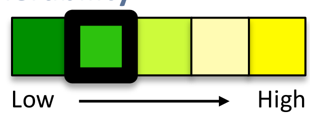
## Oak Woodland Habitat Vulnerability

**Low-Moderate Vulnerability**




The relative vulnerability of oak woodland habitats in southern California was evaluated to be low-moderate by habitat experts due to low-moderate sensitivity to climate and non-climate stressors, low-moderate exposure to projected future climate changes, and moderate adaptive capacity. Shifts in precipitation and soil moisture are likely to affect oak woodland distribution, composition, growth, and recruitment, and impacts may be compounded by shifts in temperature and drought frequency and intensity. Although adapted to wildfire, shifts in wildfire frequency and intensity may affect oak recruitment and survival. Invasive plant species compete with oak seedlings for soil moisture, while invasive insects (e.g., gold-spotted oak borer, polyphagous shot hole borer) are contributing to high oak mortality within the study region, and may expand with climate change. Land use conversion has altered the extent and continuity of oak woodland habitat, and continues to threaten this system by facilitating invasive species introductions, increasing wildfire ignition risk, and eliminating potential refugia. Oak woodland habitat has been altered and fragmented as a result of agriculture and development, and habitat structure is being affected by exotic annual grass invasions. Oaks are long-lived species with variable recruitment and limited migration potential, making it difficult for these species to keep pace with projected climate changes. Canopy diversity is fairly low, and as keystone species, loss of oak canopy species would eliminate or cause severe changes in oak woodland habitat. Oak woodland habitats provide a variety of ecosystem services including biodiversity, recreation, and carbon sequestration.

## Adaptation Strategies and Actions

Table 1 presents a summary of possible adaptation strategies and actions for oak woodland habitats, and consists of stakeholder input during an adaptation workshop as well as additional options from the literature or other similar efforts. Stakeholders identified ways in which current management actions could be modified to reduce habitat vulnerabilities as well as future management actions that are not currently implemented but could be considered for future implementation.

Adaptation strategies and actions are grouped according to one of five categories:

1. **Enhance Resistance**. These strategies can help to prevent the effects of climate change from reaching or affecting a resource.
2. **Promote Resilience**. These strategies can help a resource withstand the impacts of climate change by avoiding the effects of or recovering from changes.
3. **Facilitate Transition (or Response)**. These strategies intentionally accommodate change and/or enable resources to adaptively respond to changing and new conditions.
4. **Increase Knowledge**. These strategies are aimed at gathering more information about climatic changes, impacts, or the effectiveness of management actions in addressing climate change.

5. **Engage Coordination**. These strategies may help coordinate efforts and/or capacity across landscapes and agencies.

**Table 1.** Summary of possible adaptation options for oak woodland habitats.

| Adaptation Category | Adaptation Strategy | Adaptation Action |
|---|---|---|
| **Enhance resistance** | Maintain oak woodland stands | • Practice oak seedling propagation[1]<br>• Protect native trees and stands by reducing pathogens and pests, reducing weeds, and reducing chaparral adjacent to high-value stands (can use physical removal or prescribed burns)[1] |
| | Reduce oak mortality | • Manage invasive pests (e.g., gold-spotted oak borer)[1]<br>• Remove infested/infected trees around healthy trees to prevent insect/disease spread[1]<br>• Reduce firewood movement[1]<br>• Identify critical stands for direct protection from fire and insects[2] |
| | Remove/manage invasive species | • Consider using prescribed burning to manage invasive species[1]<br>• Decrease resilience of existing non-native species with site-specific appropriate management practices[2] |
| | Prevent invasive plant establishment after disturbance | • Include invasive species prevention strategies in all projects[2]<br>• Inventory regularly to detect new populations and species[2]<br>• Implement early detection/rapid response for exotic species treatment[2]<br>• Maintain permits for aggressive treatment of invasive species (e.g., burning and herbicide)[2] |
| | Implement prescribed fire in adjacent chaparral habitats to reduce fuels and fire spread into oak woodlands | • Identify and map chaparral fuels using field data and GIS[1]<br>• Include chaparral fuels maps in forest/district climate change strategic plans[1]<br>• Communicate with private landowners regarding burn plans and Fire Safe Councils[1] |
| | Restore structure, function and composition of oak woodlands to limit high severity fires and moisture stress, both of which are predicted to increase in the future | • Plant native bunch grasses within oak woodlands to reduce spread of invasive species[2]<br>• Plant and adequately protect acorns and seedlings from browsing[2]<br>• Fence priority oak areas or individual plants to exclude browsers (to minimize synergistic effects of grazing and climate-driven changes on recruitment and survival)[2] |

[1] Denotes adaptation action identified by workshop participants.
[2] Actions were sourced from the Climate Adaptation Project for the Sierra Nevada and/or the Northern Rockies Adaptation Partnership.

| Adaptation Category | Adaptation Strategy | Adaptation Action |
|---|---|---|
| **Enhance resistance (con't)** | | • Use prescribed fire to remove non-native grasses from the understory, reducing competition for declining water resources between seedlings and invasive species[2]<br>• Create fuel breaks to limit hazard of undesirable fires[2]<br>• Take advantage of natural fire occurrence by controlling fire path and severity, helping limit future wildfire risk[2]<br>• Use other ground cover management options (mowing, spraying) to reduce non-native grasses that may increase fire risk and/or more effectively compete for soil moisture under changing climate conditions[2] |
| **Promote resilience** | Change land development/urbanization/land use planning to preserve habitat/refugia | • Develop more habitat conservation plans that are used across all levels of planning for development and conservation within a particular area[1]<br>• Update current plans to incorporate climate change[1] |
| | Plan for possible future fragmentation/increased patchiness of oak woodlands resulting from die-off after drought or wildfire | • Obtain satellite imagery to map historical range of oak woodlands and chaparral and map "age" of chaparral based on "time since burn"[1]<br>• Consider climate change in post-fire or post-drought rehabilitation (e.g., emphasize use of plant species that will be robust to climate change)[2]<br>• Anticipate increased need for seed sources and propagated plants[2]<br>• Determine where native seed may be needed for post-disturbance planting[2]<br>• Develop rapid response/assessment for post-disturbance restoration[2] |
| | Increase resilience of oak stands to disturbance | • Create buffer zones between stands and residential development[2]<br>• Influence development zoning in high fire risk areas[2]<br>• Enhance education and communication about responsible land owner actions in the Wildland-Urban Interface[2] |
| | Mitigate consequences of large disturbances by planning ahead | • Develop a gene conservation plan for *ex situ* collections for long-term storage[2]<br>• Identify areas important for *in situ* gene conservation[2]<br>• Maintain a tree seed inventory with high-quality seed for a range of species, particularly species that may do well in the future under hotter and drier conditions[2]<br>• Increase production of native plant materials for post-disturbance plantings[2] |

| Adaptation Category | Adaptation Strategy | Adaptation Action |
|---|---|---|
| **Facilitate transition** | Identify and protect refugia | • Establish extra protection for priority refugia areas using management designations, management action plans, and by excluding humans and browsers[2]<br>• Designate conservation easements[2]<br>• Monitor and evaluate the stands that successfully regenerate, and promote these stands to serve as future potential refugia[2]<br>• Identify areas where relict plants could be established[2] |
| | Facilitate change to desired assemblages | • Plant seedlings expected to thrive in new climate conditions[2]<br>• Monitor for management action effectiveness and communicate effective techniques to partners and stakeholders[2]<br>• Consider planting desired species (assisted migration) rather than relying on natural regeneration and migration[2]<br>• Prioritize monitoring and management of desired species where predicted to survive and establish in future[2]<br>• Relax seed zone guidelines to include genotypes from warmer locations; use a variety of genotypes rather than just one[2] |
| **Increase knowledge** | Develop resistant oak strains that are more tolerant of drought and perhaps increased pest resistance (similar to white pine blister rust program) | • Conduct genetic studies on oak variability and environmental tolerances[1]<br>• Conduct genetic surveys of oaks and collect data on environmental conditions[1] |
| | Enhance certainty of current oak associations | • Correlate species with static/dynamic conditions (soil vs. weather)[1] |
| | Determine priority areas by understanding biological response to environmental change | • Monitor wildlife long-term to identify response to habitat change[1] |
| | Improve understanding of future distribution of individual species to assist with management action and restoration planning and implementation | • Utilize species distribution models under current climate regime and future climate conditions to identify suitable areas in the future (major core areas and microrefugia)[1] |
| | Increase knowledge of patterns, characteristics, and rates of change in species distributions | • Expand long-term monitoring programs; track regeneration and species distribution at the fine-scale[2] |
| | Address information gaps in order to maintain viable populations | • Address information gaps – identify current locations, potential future habitat, and stand condition[2]<br>• Address genetic gaps – establish breeding program[2] |

| Adaptation Category | Adaptation Strategy | Adaptation Action |
|---|---|---|
| **Engage coordination** | Engage the public in stewardship of oak woodlands to improve understanding about ecosystem value and potential climate impacts | • Increase education on the intrinsic value and ecosystem services of oak woodlands and how they may change in light of climate change impacts[2]<br>• Encourage climate-smart restoration activities and volunteer work days to improve understanding about potential climate impacts and enhance the ability of oaks to cope with climate change effects[2]<br>• Engage community service organizations to improve understanding about climate impacts to oak woodlands and the services people depend on[2]<br>• Enhance oak stewardship on private lands to improve the ability of oaks to cope with changing climate conditions[2]<br>• Hold town-halls and invite community leaders to improve understanding about climate impacts to oak woodlands and services people depend upon[2]<br>• Create accessible forms of information (webpages, fact sheets, etc.) on the value of oak woodlands now and in the future[2]<br>• Facilitate and build capacity in communities to protect/enhance/restore grasslands and oak woodlands[1] |
| | Work across jurisdictions | • Align budgets and priorities for program of work with neighboring lands[2]<br>• Communicate about adjacent projects and coordinate on the ground action[2]<br>• Coordinate invasive species management, funding and support between agencies[2] |

Table 2 identifies the key oak woodland habitat vulnerabilities that may be reduced and/or addressed by various adaptation actions. These linkages are based on expert opinion.

Linking vulnerabilities to adaptation options can help managers decide which actions to implement and aid prioritization based on multiple factors (e.g., habitat type, observed or projected changes, ecosystem service). However, when selecting adaptation actions for implementation, it is also important to consider secondary effects on other resources, both positive and negative. For example, trail or road decommissioning may benefit aquatic systems by limiting erosion impacts but could also remove important access points to fire-prone areas. For more information about oak woodland adaptation strategies and actions developed by participants during the workshop, including where and how to implement adaptation actions, implementation timeframe, collaborations and capacity required, and secondary effects on other resources (both positive and negative), please see the report *Climate Change Adaptation Strategies for Focal Habitats of Southern California.*

**Table 2.** Key vulnerabilities of oak woodland habitats linked to specific adaptation actions; implementation of adaptation actions (central column) may help to directly reduce and/or address the impacts of identified climate and non-climate stressors and disturbance regimes (right columns). Actions highlighted in **red** represent adaptation strategies that enhance resistance, those highlighted in **orange** promote resilience, and those highlighted in **green** facilitate transition. Adaptation actions aimed at increasing knowledge and engaging coordination are not included in this table as they address vulnerability indirectly. Adaptation actions listed in this table include those identified by participants, in the scientific literature, and in other similar efforts.

| Management Activity | Adaptation Actions | Climate Stressors | | Disturbance Regimes | | | Non-Climate Stressors | |
|---|---|---|---|---|---|---|---|---|
| | | ↑ Air temperature | Altered precipitation (timing & amount); ↓ Soil moisture; ↑ Drought | Altered wildfire regimes | Insects | Disease | Invasive & problematic species | Land use conversion |
| Habitat Management and Restoration Activities | Practice oak seedling propagation | | ✔ | | | | | |
| | Protect native trees and stands by reducing pathogens and pests, reducing weeds, and reducing chaparral adjacent to high-value stands (can use physical removal or prescribed burns) | | ✔ | ✔ | ✔ | ✔ | ✔ | |
| | Manage invasive pests (e.g., gold-spotted oak borer) | | | | ✔ | | ✔ | |
| | Remove infested/infected trees around healthy trees to prevent spread | | | | ✔ | ✔ | ✔ | |
| | Reduce firewood movement | | | | ✔ | | ✔ | |
| | Identify critical stands for direct protection from fire and insects | | | ✔ | ✔ | | ✔ | |
| | Decrease resilience of existing non-native species with site-specific appropriate management practices | | ✔ | ✔ | ✔ | | ✔ | |
| | Prevent invasive plant establishment after disturbance[3] | | ✔ | | | | ✔ | |
| | Plant native bunch grasses within oak woodlands to reduce spread of invasive species | | | | | | ✔ | |
| | Fence priority oak areas or individual plants to exclude browsers (to minimize synergistic effects of grazing and climate-driven changes on recruitment and survival) | | ✔ | | | | | |
| | Plant and adequately protect acorns and seedlings from browsing | | ✔ | | | | | |
| | Use other ground cover management options (mowing, spraying) to reduce non-native grasses that may increase fire risk and/or more effectively compete for soil moisture under changing climate conditions | | ✔ | ✔ | | | ✔ | |
| | Consider climate change in post-fire or post-drought rehabilitation (e.g., emphasize use of plant species that will be robust to climate change) | ✔ | ✔ | ✔ | | | | |
| | Anticipate increased need for seed sources and propagated plants | | ✔ | ✔ | | | | |
| | Determine where native seed may be needed for post-disturbance planting | | ✔ | ✔ | | | | |
| | Develop rapid response/assessment for post-disturbance restoration | | ✔ | ✔ | | | | |
| | Mitigate consequences of large disturbances by planning ahead (e.g., gene conservation, maintain seed inventory)[3] | | ✔ | ✔ | | | | |
| | Establish extra protection for priority refugia areas using management designations, management action plans, and by excluding humans and browsers | ✔ | ✔ | ✔ | | | | |
| | Monitor and evaluate the stands that successfully regenerate, and promote these stands to serve as future potential refugia | ✔ | ✔ | | | | | |
| | Identify areas where relict plants could be established | ✔ | ✔ | ✔ | | | | |
| | Facilitate change to desired assemblages[3] | ✔ | ✔ | ✔ | | | | |
| Fire Management Activities | Identify and map chaparral fuels using field data and GIS | | | ✔ | | | | |
| | Include chaparral fuels maps in forest/district climate change strategic plans | | | ✔ | | | | |
| | Communicate with private landowners regarding burn plans and Fire Safe Councils | | | ✔ | | | | |
| | Use prescribed fire to remove non-native grasses from the understory, reducing competition for declining water resources between seedlings and invasive species | | ✔ | ✔ | | | ✔ | |
| | Create fuel breaks to limit hazard of undesirable fires | | | ✔ | | | | |
| | Take advantage of natural fire occurrence by controlling fire path and severity, helping limit future wildfire risk | | | ✔ | | | | |
| | Obtain satellite imagery to map historical range of oak woodlands and chaparral and map "age" of chaparral based on "time since burn" | | | ✔ | | | | |
| | Create buffer zones between stands and residential development | | | ✔ | | | | |
| | Influence development zoning in high fire risk areas | | | ✔ | | | | |
| | Enhance education and communication about responsible land owner actions in the Wildland-Urban Interface | | | ✔ | | | | |
| Land Use Planning | Develop more habitat conservation plans that are used across all levels of planning for development and conservation within a particular area | ✔ | ✔ | ✔ | | | | ✔ |
| | Update current plans to incorporate climate change | ✔ | ✔ | ✔ | | | | ✔ |
| | Designate conservation easements | | ✔ | | | | | ✔ |

[3] This adaptation strategy includes many specific adaptation actions (Table 1).

In addition to directly reducing some vulnerabilities (Table 2), some adaptation actions may indirectly address other vulnerabilities. For example, designating conservation easements may indirectly reduce vulnerability to hotter air temperatures if areas of thermal refugia are prioritized for protection. Similarly, planting native bunch grasses to prevent the spread of invasive species may indirectly reduce moisture competition and vulnerability to shifting fire regimes, as non-native invasive species typically perpetuate more frequent fires and compete with oak seedlings for soil moisture.

Two other important considerations when selecting adaptation actions for implementation include feasibility (action capable of being implemented) and effectiveness (action reduces vulnerability). An adaptation action with high feasibility has no obvious barriers and a high likelihood of implementation whereas an action with low feasibility has obvious and/or significant barriers to implementation that may be difficult to overcome. An adaptation action with high effectiveness is very likely to reduce associated vulnerabilities (listed in Table 2) and may benefit additional management goals or resources whereas an action with low effectiveness is unlikely to reduce vulnerability and may have negative impacts on other resources.

Figure 1 plots adaptation actions listed in Table 1 according to feasibility and effectiveness. This figure can help managers prioritize actions for implementation (e.g., actions with high feasibility and high effectiveness), better target management efforts toward specific challenges (e.g., actions with low or moderate feasibility but high effectiveness), and/or evaluate whether to proceed with implementation (e.g., actions with high feasibility but low effectiveness). For the latter two purposes, managers may consider the following questions:

- **Low or Moderate Feasibility/High Effectiveness Actions**: What steps can be taken to increase the likelihood of this action being implemented in the future?
    - *Example*: Would improving public outreach and education or enhancing public/private collaboration facilitate the removal of dikes or recharge basins with the goal of restoring fluvial processes?
- **High Feasibility/Low or Moderate Effectiveness Actions**: Does this action still make sense given projected climate changes and impacts?
    - *Example*: If conditions are projected to become drier, should grazing continue in areas with drought-sensitive vegetation?

Alternatively, there may be some actions that do not reduce vulnerability directly but could provide important information, tools, or support to address vulnerability down the line. For example, actions aimed at increasing knowledge through monitoring or modeling could provide key information for future restoration activities (e.g., creating detailed species genetic profiles to select genetically and ecologically suitable plant species for future conditions). Managers may want to weigh the costs and benefits of implementing actions with the timeframe required to reduce vulnerability directly. Additionally, actions focused on coordination and collaboration may not directly address vulnerabilities, but these remain important steps toward better planning and management.

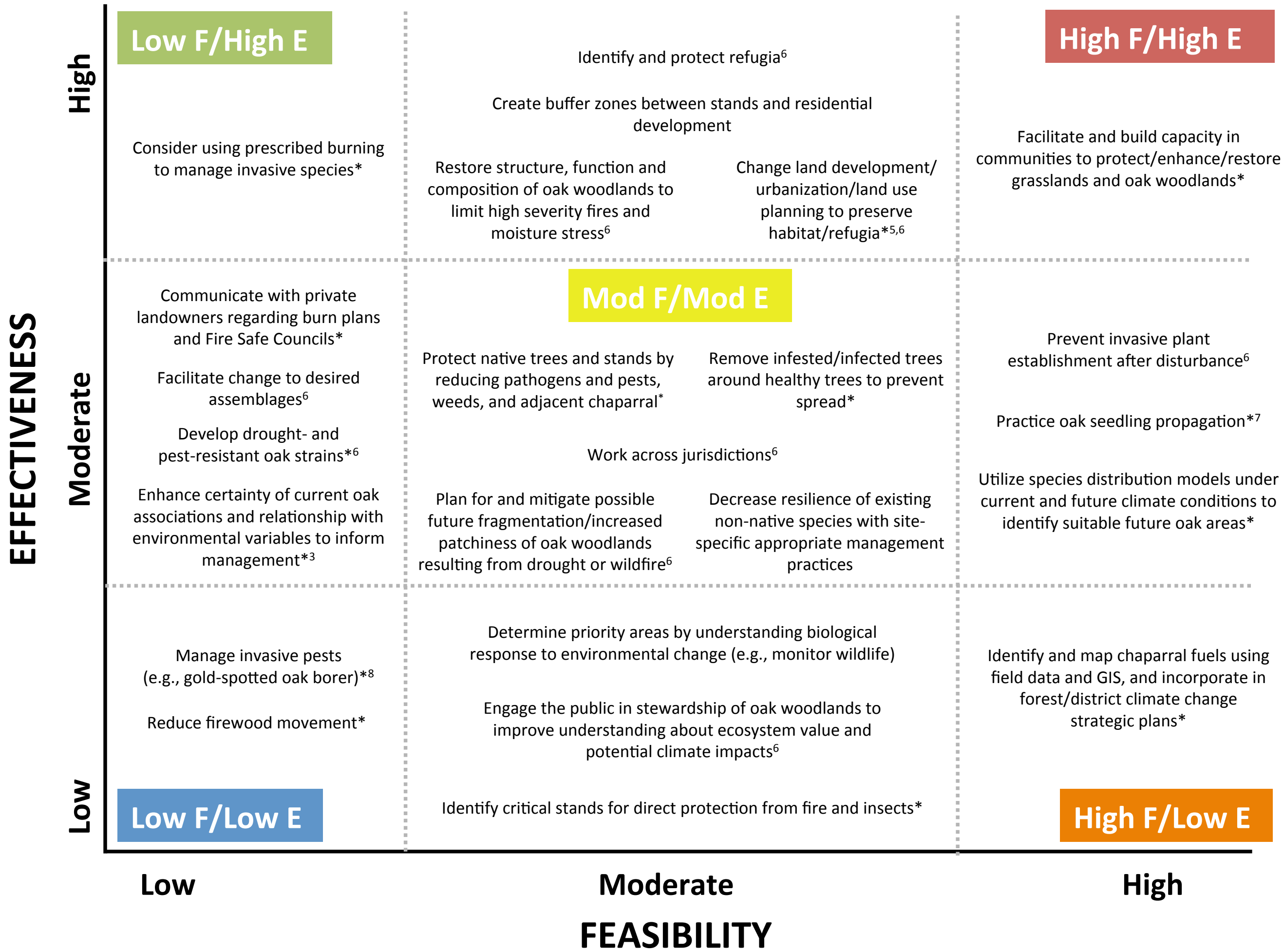



**Figure 1.** Oak woodland adaptation actions plotted according to implementation feasibility (action capable of being implemented) and effectiveness (action reduces vulnerability). Those actions having high feasibility and effectiveness appear in the upper right corner and low feasibility and effectiveness in the bottom left corner. An asterisk (*) denotes adaptation actions evaluated for feasibility and effectiveness by workshop participants, although in some cases the ranking was shifted based on expert opinion. All other adaptation action evaluations are based on expert opinion.

## Recommended Citation

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[4] Workshop participants noted that the feasibility of this action will depend on available funding.
[5] Workshop participants noted that the feasibility of this action may increase with funding and/or political support.
[6] This adaptation strategy includes many specific adaptation actions (Table 1).
[7] Workshop participants noted that the effectiveness of this action could decrease under future climate changes, particularly drier conditions.
[8] Workshop participants noted that the feasibility and effectiveness of this action may improve as research enhances understanding of pest life cycles and effective control treatments.