# Southern California Chaparral and Sage Scrub Habitats

*Climate Change Adaptation Synthesis*

## Introduction

The following section presents climate change adaptation planning results for chaparral and sage scrub habitats. The results summarize discussions and activities completed by participants during a two-day adaptation workshop as well as peer-review comments and revisions and relevant examples from the literature or other similar efforts.[1] We first present current management **goals** identified by participants. The purpose of identifying management goals is to provide a foundation for evaluating whether and how climate change might affect the ability to achieve a given goal, and to develop options for reducing vulnerabilities through revised management activities. For each management goal, participants identified potential climate change vulnerabilities. This activity was followed by the evaluation of current management actions, including whether, in their current form, they can help to reduce identified vulnerabilities and/or how they can be modified to better address climate challenges. Following the evaluation of potential vulnerabilities of current management goals and actions, participants explored potential future management goals and adaptation **strategies** and identified more specific adaptation **actions** designed to reduce vulnerabilities or increase resilience of chaparral and sage scrub habitats. For each adaptation action, participants then evaluated where, when, and how to implement those actions as well as collaboration and capacity needs. Lastly, we present a table summarizing all adaptation actions developed by participants as well as additional actions for consideration from the literature and from other similar efforts. Adaptation actions are grouped according to whether they (1) enhance resistance, (2) promote resilience, (3) facilitate transition, (4) increase knowledge, or (5) engage coordination in terms of responding to climate change.

### Defining Terms

**Goal**: A desired result for a given resource.

**Adaptation strategy**: General statements of how to reduce vulnerabilities or increase resilience of current management goals.

**Adaptation actions**: Specific activities that facilitate progress towards achieving an adaptation strategy.

## Current Management Goals and Potential Vulnerabilities

Workshop participants identified seven key current management goals for chaparral and sage scrub habitats:

[1] Workshop participants included: Bonni Corcoran, USFS; Marty Dumpis, USFS; Jeff Heys, USFS; Danielle LeFer, Palos Verdes Peninsula Land Conservancy; Dustin McLain, Riverside County Regional Park and Open-Space District; Andrea Nick, USFS; Jonathan Reinig, Riverside County Regional Park and Open-Space District; Alex Syphard, Conservation Biology Institute; and Marti Witter, NPS

(1) Improve the ability of southern California communities to limit loss of life and property and recover from the high intensity wildland fires that are a natural part of this state's ecosystem,[2]
(2) Provide ecological conditions to sustain viable populations of native and desired non-native species,[3]
(3) Reduce fire occurrence and acres burned to a natural fire return interval (40-80 year compared to 5-15 year) to increase resilience,
(4) Minimize fuel modification that can damage shrublands but is ineffective at limiting either fire spread or preventing shrubland loss,
(5) Restore disturbed areas (e.g., OHV areas) with native species to prevent establishment of non-native species and to prevent erosion,
(6) Determine risk of type-conversion from woody shrublands to exotic annual grasslands under projected climate scenarios and management regimes, as well as changes to nearby ecosystem services; prevent type-conversion of chaparral to invasive grasslands, and
(7) Create habitat by restoring five acres per year of chaparral/sage scrub.

As part of the workshop activities, participants identified potential climate and non-climate vulnerabilities to current management goals and actions for chaparral and sage scrub habitats. Potential vulnerabilities identified included:

- Increased temperature, reduced precipitation and soil moisture
- Increased drought and fires (inevitable)
- Decreased seed germination due to drought/temperature increases
- Death of plants due to drought, competition with xeriscape plants, herbivory due to loss of other food sources
- Changes in species composition and reductions in species diversity
- Increased growth of non-native plants and/or changes in composition
- Increased fire frequency, size, duration, and severity
- Progressive changes to climate, fire regime, etc. may produce response that differs qualitatively/quantitatively from historical norms
- Decreased effectiveness of fuel breaks with increasing temperatures and drought
- Altered population dynamics due to fuel treatments (introduce invasives/type conversion)
- Possible mismatch between fire suppression goals and ecological goals
- Cost of wildfire suppression efforts may not be sustainable
- Future type conversion to undesirable habitats
- Difficult to find adequate plant source
- Increased pressure from growing human population and development
- Lack of funding and resources (budget for science declining)

[2] This goal was discussed in the adaptation workshop, but was not evaluated and is not included in Table 1.
[3] This goal was discussed in the adaptation workshop, but was not evaluated and is not included in Table 1.

In response to these vulnerabilities, participants then evaluated whether or not existing management actions may be effective in reducing vulnerability; identified what, if any, climate and non-climate vulnerabilities the action helps reduce; and evaluated the feasibility of action implementation. Given action effectiveness and feasibility, participants then evaluated whether or not to continue implementation of the action. For those actions recommended for continued implementation, participants then identified both how and where to implement.

### Terminology

**Action effectiveness**: Identify the effectiveness of the action in reducing vulnerability.
*High*: action is very likely to reduce vulnerability and may benefit additional goals or habitats; *Moderate*: action has moderate potential to reduce vulnerability, with some limits to effectiveness; or *Low*: action is unlikely to reduce vulnerability.

**Action feasibility**: Identify feasibility of implementing the action.
*High*: there are no obvious barriers and it has a high likelihood of being implemented; *Moderate*: it may be possible to implement the action, although there may be challenges or barriers; or *Low*: there are obvious and/or significant barriers to implementation that may be difficult to overcome.

**How to implement:** Identify how to apply this action given vulnerabilities.
For example, consider planting native species that can cope with a range of future conditions or those best adapted to projected future conditions.

**Where to implement:** Identify the management, ecological, or site conditions where the action could be most appropriately implemented.
For example, is it best to implement in areas with high soil moisture holding capacity, areas projected to lose the most water supply, post-fire areas, highly roaded areas, etc.?

Table 1 below explores current management goals and actions, potential vulnerabilities, and ways to revise current actions to reduce vulnerabilities for chaparral and sage scrub habitats. The table is structured to provide:

1. A current management goal;
2. Potential climate and non-climate vulnerabilities that affect the success of achieving the management goal;
3. Multiple current management actions;
4. An evaluation of action effectiveness, feasibility, and potential vulnerabilities that the may be reduced by action implementation; and
5. A description of where and how to implement the action given climate vulnerabilities and whether or not implementation of the action may have indirect effects on other resources, either positive or negative.

## Revised Management Actions

The following list describes trends and commonalities amongst the climate-informed current management actions discussed by participants in Table 1.

- Almost half of the goals identified by workshop participants were focused on fire reduction in chaparral and sage scrub habitats, and they identified management actions related to fire suppression, fuel reduction and management, ignition prevention, mapping ignition hotspots, educating fire agencies and communities about best management practices, and land use planning. Other goals and actions fell under the following themes:
    - Managing non-climate stressors such as invasive plants and recreational use
    - Restoring disturbed habitat and/or creating new habitat by seeding and planting
    - Modeling type-conversion, both historical and under future climate scenarios
    - Quantifying ecosystem services provided by intact habitat
    - Additional research
- A majority of the management actions identified by participants fell into the category of *enhancing resistance* (e.g., fire prevention/suppression, managing non-climate stressors). However, several also fell under *increasing knowledge* (e.g., model type-conversion, quantify ecosystem services), and *promoting resilience* (e.g., education programs).
- Workshop participants identified many additional resources that would benefit from the implementation of these management actions. These included adjacent habitat types (oak woodlands, conifer forests), biodiversity (wildlife and plants such as California gnatcatcher, cactus wren, rare plant species), air and water quality, water storage, carbon sequestration, aesthetic value, safety, and recreational use.
- Workshop participants identified declines in woody shrublands (which may decrease with type-conversion) and increased water use for plantings as resources that might have conflicts if these actions are implemented.
- Several locations were suggested as priorities for action implementation. For fire prevention and suppression, workshop participants recommended focusing near population centers, in already-compromised areas, and in areas that contain focal species (e.g., Tecate cypress) and/or refugia. Planting activities should take place on north-facing or higher-elevation slopes, and in areas with higher soil moisture where plants will be more likely to succeed. Modeling past and future habitat responses could encompass all southern California forests.

**Table 1.** Current management goals, potential vulnerabilities, and current management actions for chaparral and sage scrub habitats. For each current management action participants evaluated its effectiveness (likely to reduce climate vulnerability) and feasibility (likelihood of implementation), and identified climatic and non-climatic stressors the action could help to ameliorate the effects of. Given action effectiveness and feasibility, participants then evaluated whether or not the action should continue to be implemented. If the action was recommended for continued implementation, participants detailed any changes regarding where and how to implement given climate vulnerabilities. Lastly, participants evaluated whether there were potential conflicts with or benefits to other resources from action implementation.

**Current Management Goal: Reduce fire occurrence and acres burned to a natural fire return interval (40-80 year compared to 5-15 year) to increase resilience**[4]

**Potential vulnerabilities:**

- Increased drought and fires (inevitable)
- Altered population dynamics due to fuel treatments (introduce invasives/type conversion)
- Possible mismatch between fire suppression goals and ecological goals
- Increased pressure from growing human population and development
- Lack of funding

| Current Management Action | Current Effectiveness | Current Feasibility | Does Action Ameliorate Effects of Any Vulnerabilities? | Continue to Implement Action Given Climate Vulnerabilities? | Where/How to Implement Given Climate Vulnerabilities | Other Resource Considerations |
|---|---|---|---|---|---|---|
| Wildfire suppression and prevention of ignitions | Effective but expensive | High | Yes – wildfire, invasive species, air pollution, erosion | Yes | **Where**: Near population centers<br>**How**: Increase financial investment; limit human activity and traffic in fire-prone areas | **Other resources action benefits**: Adjacent habitat types may need fire (though these are small and spatially constrained)<br>**Other resources with potential conflicts**: Invasive biodiversity |

[4] This management goal and its set of corresponding actions represent a summary from the discussion and combined work of workshop participants in the chaparral and sage scrub group.

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|---|---|---|---|---|---|---|
| Fuels management | Yes – only effective under normal weather conditions (ineffective during severe fire weather); has ecosystem costs; too many acres to treat | Moderate | Yes – wildfire, air pollution, and erosion, but introduces potential invasives | Yes – with monitoring and strategic prioritization | **Where**: Keep the pristine, pristine; location of action needs to be informed<br>**How**: Bulldoze around key resources in strategic locations (e.g., around high fire-risk communities), avoid sensitive populations; use a cohesive approach across the landscape | **Other resources action benefits**: Effective fuel treatments are those that facilitate suppression efforts<br>**Other resources with potential conflicts**: No answer provided by participants. |
| Education; land use planning (wildland-urban interface); scientific knowledge | Low – political and socially driven, difficult to implement (has the potential to be highly effective) | Low – too many people (could be feasible if there were political support) | Yes – addresses all vulnerabilities If properly planned and implemented | Yes – informed planning is a necessity | **Where**: Develop in compromised regions, not intact regions (infill development patterns closer to the coast is more effective)<br>**How**: Increase investment; strategic messaging; education for elected officials | **Other resources action benefits**: Overall resiliency<br>**Other resources with potential conflicts**: People |
| **Current Management Goal: Restore areas previously damaged by OHV use** | | | | | | |
| **Potential vulnerabilities:**<br>• Difficult to find adequate plant source<br>• Future type conversion to undesirable habitats | | | | | | |
| **Current Management Action** | **Current Effectiveness** | **Current Feasibility** | **Does Action Ameliorate Effects of Any Vulnerabilities?** | **Continue to Implement Action Given Climate Vulnerabilities?** | **Where/How to Implement Given Climate Vulnerabilities** | **Other Resource Considerations** |

| | | | | | | |
|---|---|---|---|---|---|---|
| OHV area restoration | Variable | Yes | Yes – reduces continued degradation of habitat, wildfire | No answer given by participants | **Where**: In sensitive resource areas or ignition hot-spots<br>**How**: Create education and active restoration programs, exclude OHV users with fencing if needed | **Other resources action benefits**: Habitat improvement<br>**Other resources with potential conflicts**: People |
| Reseed/planting of damaged areas | To be determined | Yes | If successful, yes<br>If not, no | Yes | **Where**: Shift to north-facing and/or higher slopes<br>**How**: Increase species diversity; increase planning phase to buffer against unfavorable years (limitation in seed stage); choose species that represent future ranges | **Other resources action benefits**: Improved water/air quality; improved aesthetic value<br>**Other resources with potential conflicts**: Displaces species associated with current habitat |
| Control non-native vegetation (via herbicide or manual removal) | Variable | No answer given by participants | Possibly not due to nitrogen deposition/ climate change | Yes | **Where**: No answer given by participants<br>**How**: No answer given by participants | **Other resources action benefits**: No answer given by participants<br>**Other resources with potential conflicts**: No answer given by participants |
| **Current Management Goal: Determine risk of type-conversion from woody shrublands to exotic annual grasslands under projected climate scenarios and management regimes, as well as changes to nearby ecosystem services; prevent type-conversion of chaparral to invasive grasslands** | | | | | | |
| **Potential vulnerabilities:**<br>• Progressive changes to climate, fire regime, etc. may produce response that differs qualitatively/quantitatively from historical norms | | | | | | |
| **Current Management Action[5]** | **Current Effectiveness** | **Current Feasibility** | **Does Action Ameliorate Effects of Any Vulnerabilities?** | **Continue to Implement Action Given Climate** | **Where/How to Implement Given Climate Vulnerabilities** | **Other Resource Considerations** |

[5] Quantifying ecosystem services provided by intact chaparral and invaded woodlands (water flow, sedimentation, nitrogen absorption, carbon sequestration) was also identified as a current management action for this goal, but was not evaluated, so it is not listed in this table.

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | **Vulnerabilities?** | | |
| Determine historical pattern of type-conversion throughout southern California forests | No direct impact | High | Yes (indirectly) | Yes | **Where**: All southern California forests<br>**How**: Model impact of changes to climate and fire regime on risk and rate of type-conversion; interpolate responses to future progressive changes based on faster historical responses | **Other resources action benefits**: Oak scrublands, conifer<br>**Other resources with potential conflicts**: Native grasslands |
| Model variability of past fire regime and climate to changes in % cover by invasive species | Moderate | High | Changes to fire history, increases to nitrogen pollution, reduction to precipitation, increases to temp | No answer given by participants | **Where**: All southern California forests<br>**How**: No answer given by participants | **Other resources action benefits**: Oak scrublands, conifer<br>**Other resources with potential conflicts**: Native grasslands |
| **Current Management Goal: Restore disturbed areas with native species to prevent establishment of non-native species and to prevent erosion** | | | | | | |
| **Potential vulnerabilities:**<br>• Increased temperature, reduced precipitation and soil moisture<br>• Increased growth of non-native plants | | | | | | |
| **Current Management Action** | **Current Effectiveness** | **Current Feasibility** | **Does Action Ameliorate Effects of Any Vulnerabilities?** | **Continue to Implement Action Given Climate Vulnerabilities?** | **Where/How to Implement Given Climate Vulnerabilities** | **Other Resource Considerations** |

| | | | | | | |
|---|---|---|---|---|---|---|
| Immediately plant or seed with native species after disturbance | High | Moderate | Maintains native ecosystems and habitats | Yes | **Where**: More effective in areas where higher chance of success such as high soil moisture, elevation ranges<br>**How**: Combination of continuing to plant some species but also look into planting other natives which may be more hardy | **Other resources action benefits**: Habitat restoration to improve water storage, maintains native habitat, prevents conversion<br>**Other resources with potential conflicts**: Do not foresee negative conflicts |
| Remove non-native species as soon as they are detected | High | High | Yes – prevents conversion to non-natives | Yes | **Where**: This action can be applied most everywhere<br>**How**: Continue to remove invasives and explore other methods which may be more effective | **Other resources action benefits**: Prevents conversion and establishment of non-natives, helps improve water storage<br>**Other resources with potential conflicts**: Do not foresee negative conflicts |
| Water plants to ensure establishment | Moderate | Moderate | Yes – helps to ensure success and establishment of native species | Maybe | **Where**: North slopes or shaded areas to maintain soil moisture<br>**How**: Continuing to water may not be feasible or effective | **Other resources action benefits**: Helps habitat restoration<br>**Other resources with potential conflicts**: Do not foresee negative conflicts |
| **Current Management Goal: Create habitat by restoring five acres per year of chaparral/sage scrub** | | | | | | |
| **Potential vulnerabilities:**<br>• Decreased seed germination due to drought/temperature increases<br>• Death of plants due to drought, competition with xeriscape plants, herbivory due to loss of other food sources<br>• Changes in species composition and reductions in species diversity<br>• Increased growth of invasive plants and/or changes in composition<br>• Future type conversion | | | | | | |

| Current Management Action | Current Effectiveness | Current Feasibility | Does Action Ameliorate Effects of Any Vulnerabilities? | Continue to Implement Action Given Climate Vulnerabilities? | Where/How to Implement Given Climate Vulnerabilities | Other Resource Considerations |
|---|---|---|---|---|---|---|
| Clear weeds | Moderate | High | Yes – invasive weed control, prevents weed expansion, reduces weed seed bank for natural plant germination in good years | Yes | **Where**: Weed areas that currently have some coastal sage scrub to enhance rather than restore from ground up<br>**How**: Continue or increase weed control | **Other resources action benefits**: Clearing weeds will decrease impact on habitat<br>**Other resources with potential conflicts**: No answer provided by participants |
| Install plants | Moderate | High | Yes – reduces fragmentation, and erosion, increases soil moisture and species diversity | Yes | **Where**: Select restoration areas that are less likely to dry out/less likely to suffer from heat (slopes, along coast, in canyons)<br>**How**: Increase species in plantings that are hardy; focus on longer scale restoration (but possibly less intensively) | **Other resources action benefits**: California gnatcatcher, cactus wren, rare plant species<br>**Other resources with potential conflicts**: Water use |
| Seed | Moderate | High | Yes – creates seed bank for germination in good years | Yes | **Where**: Select restoration areas that are less likely to dry out/less likely to suffer from heat (slopes, along coast, in canyons)<br>**How**: Increase species in plantings that are hardy; increase species that germinate well | **Other resources action benefits**: Increases seed bank<br>**Other resources with potential conflicts**: No answer provided by participants |

## Future Management Goals and Adaptation Actions

Workshop participants identified the following possible future management goals and adaptation actions for chaparral and sage scrub habitat:[6]

**Management Goal/Adaptation Strategy:** Restore/manage habitat to reflect future climate conditions, not historical, while still benefitting native species and mirroring current ecological function.

Adaptation action: During restoration activities, focus resources on particularly resilient species and possibly incorporate species that are not currently on site (assisted migration).

**Management Goal/Adaptation Strategy:** Increase connectivity and limit recreational trails/roads to decrease disturbance patterns.

Adaptation action: Provide greater regulation, enforcement, and education, and increase rehabilitation of disturbed areas.

Adaptation action: Centralize recreation impacts to areas with easy access.

Adaptation action: Implement an education campaign on OHV impacts.

**Management Goal/Adaptation Strategy:** Protect vulnerable species and habitats, restore habitat/prevent wildfire, and educate fire/elected officials.

Adaptation action: Conduct spatial analysis of vulnerable species and habitats (output should include overlays of high biodiversity and high threat, functional type diversity) to inform protection.

Adaptation action: Create a training video for fire/elected officials and the public.

**Management Goal/Adaptation Strategy:** Move all power lines underground to reduce fire risk and improve scenic integrity from high to very high.

Adaptation action: Move power lines next to road underground.

After identifying possible future management goals and actions for chaparral and sage scrub habitat, participants were asked to evaluate action effectiveness and feasibility; identify the timeframe for action implementation; describe where and how to implement the action; and identify collaboration and capacity needs. Timeframe, collaboration and capacity needs are defined below.

- **Implementation timeframe:** Identify when the action could feasibly be implemented.
  - *Near*: <5 years; *Mid*: 5-15 years; or *Long*: >15 years.
- **Collaboration:** Identify any other agencies, organizations, or people – both internal and external – needed to collaborate with in order to implement this tactic.
- **Capacity needed**: Identify capacity needed for implementation such as data, staff time and resources, funding, or policy changes, among others.

[6] Additional management goals and actions were identified but not explored in detail, therefore are not included here or the table below.

Table 2 below explores the future management goals/adaptation strategies, actions, and implementation recommendations developed by workshop participants for chaparral and sage scrub habitat. The table is structured to provide:

1. A future management goal/adaptation strategy;
2. Adaptation actions for each goal/strategy;
3. An evaluation of action effectiveness, feasibility, and implementation timeframe; and
4. A description of where and how to implement and collaboration and capacity needed to move forward with implementation.

This workshop activity was intended to generate a range of recommended adaptation actions that could be implemented both now and in the future. The resulting actions are not comprehensive, and users of this report are encouraged to explore additional adaptation actions that may help reduce vulnerabilities, increase resilience, or capitalize on opportunities presented by climate change for chaparral and sage scrub habitats.

### Future Management Actions

The following list describes trends and commonalities amongst the future management actions discussed by participants in Table 2.

- The workshop participants identified goals and actions across a number of themes, including reducing non-climate stressors (e.g., the impacts of recreation and powerlines), reducing wildfire, habitat restoration, and spatial analysis of vulnerable species, habitats, and available resources. Wildfire reduction and prevention was mentioned several times, with specific activities focused on land management, education, and infrastructure improvements.
- The management actions identified by workshop participants focused on either *enhancing resistance* to climate change (e.g., wildfire prevention, reducing impacts of off-highway vehicles, moving powerlines underground) or *promoting resilience* (e.g., restoring habitat with a focus on resilient species, spatial analysis of water resources, biodiversity, etc.).
- Workshop participants suggested many possible collaborations that would help to implement these actions, including academic and research institutions, neighboring organizations, Sierra Club, The Nature Conservancy, USGS, NGOs, local fire departments and fire safe councils, city and county officials, and volunteers. Funding, staffing, data, political will, and societal buy-in are all necessary to build capacity.
- Workshop participants recommended that these actions be taken either in high quality/low use sites (which could include refugia), or in highly impacted or vulnerable areas.

**Table 2.** Potential future management goals, adaptation actions, and action implementation details including where and how to implement and collaboration and capacity needs for chaparral and sage scrub habitats. Action effectiveness (likelihood of reducing vulnerability), feasibility (likelihood of implementation), and timeframe (near: <5 years; mid: 5-15 years; long: >15 years) were also evaluated for each adaptation action.

| **Management Goal: Restore/manage habitat to reflect future climate conditions, not historical, while still benefitting native species and mirroring current ecological function** | | | | | |
|---|---|---|---|---|---|
| **Adaptation action** | **Effectiveness** | **Feasibility** | **Timeframe** | **Implementation (where/how)** | **Collaboration & Capacity** |
| During restoration activities, focus resources on particularly resilient species and possibly incorporate species that are not currently on site (assisted migration) | Moderate | High | Mid | **Where**: Highly impacted but less resilient areas<br>**How**: Conduct research to assure future plant communities will perform similar function as historical communities, and that restoration decisions make sense in the context of future climate projections | **External collaboration**: Academic and research institutes, neighboring organizations with knowledge/experience in communities that could shift into our area<br>**Internal collaboration**: No answer provided by participants<br>**Capacity needed**: Current capacities need to shift to incorporate modified goals; increased collaboration with other organizations |
| **Management Goal: Increase connectivity and limit recreational trails/roads to decrease disturbance patterns** | | | | | |
| **Adaptation action**[7] | **Effectiveness** | **Feasibility** | **Timeframe** | **Implementation (where/how)** | **Collaboration & Capacity** |
| Provide greater regulation, enforcement, and education, and increase rehabilitation of disturbed areas | Moderate | Moderate | Mid | **Where**: In highly impacted areas and overused areas; habitat refugia and low-use areas<br>**How**: Identify overused/impacted areas (by mapping resources and threats), conduct visitor counts on busy weekends, identify overlapping stressors, increase interpretive signage | **External collaboration**: Volunteers; NGOs and non-profits; county, city, and correctional people<br>**Internal collaboration**: All scientific staff<br>**Capacity needed**: Staff/funding, societal buy-in/tolerance, education (erosion, trash, etc.) |
| **Management Goal: Protect vulnerable species and habitats, restore habitat/prevent wildfire, and educate fire/elected officials** | | | | | |

[7] Additional current management actions identified by participants were: 1) Centralize impacts to easy access areas, and 2) Implement an education campaign on OHV impacts. These were not evaluated, so they are not listed in this table.

| Adaptation action[8] | Effectiveness | Feasibility | Timeframe | Implementation (where/how) | Collaboration & Capacity |
|---|---|---|---|---|---|
| Conduct spatial analysis of vulnerable species and habitats to inform protection | High | Moderate | Near – Long | **Where**: A particular management unit: county, national forest, watershed, So Cal-wide; the most vulnerable areas<br>**How**: Target species selection/hotspots of biodiversity; output should include an overlay of high biodiversity, high threat, and functional type diversity. Explore Jeff Tracy's approach to evaluating species ranges (Tracey et al. 2014); map connectivity and fragmentation, expected future conditions (climate, development, fire-prone areas, nitrogen deposition), and species distribution models. | **External collaboration**: Conservation Biology Institute, The Nature Conservancy, USGS, Universities<br>**Internal collaboration**: PSW research station, U.S. Forest Service biologists, research and development (genetics lab/storage for restoration purposes)<br>**Capacity needed**: Money (Landscape Conservation Cooperatives), field verification of modeled data, reliable data |
| **Management Goal: Move all power lines underground to reduce fire risk and improve scenic integrity from high to very high** | | | | | |
| **Adaptation action** | **Effectiveness** | **Feasibility** | **Timeframe** | **Implementation (where/how)** | **Collaboration & Capacity** |
| Move power lines next to road underground | High | No answer provided by participants | No answer provided by participants | **Where**: Anywhere they cross-cut wild areas<br>**How**: Through NEPA requirements | **External collaboration**: Economists, ecologists, recreation groups<br>**Internal collaboration**: LMP and permit staff<br>**Capacity needed**: Data, staff, funding, policy change |

[8] Creating a training video for fire/elected officials/public was also identified as a future management action for this goal, but was not evaluated, so it is not listed in this table.

## Additional Adaptation Actions for Consideration

Table 3 summarizes all of the adaptation actions generated by workshop participants for chaparral and sage scrub habitats and includes additional actions for consideration; additional actions comprise those from the literature as well as those identified by land and resource managers during other workshops. These strategies and actions are grouped according to one of five categories:

1. **Enhance Resistance**. Implementation of these strategies can help to prevent the effects of climate change from reaching or affecting a resource. One common type of resistance actions are those designed to reduce non-climate stressors.
2. **Promote Resilience**. These strategies can help a resource weather the impacts of climate change by avoiding the effects of or recovering from changes.
3. **Facilitate Transition (or Response)**. Transition or response strategies intentionally accommodate change and enable resources to adaptively respond to changing and new conditions.
4. **Increase Knowledge**. These strategies are aimed at gathering more information about climate changes, impacts, and/or the effectiveness of management actions in addressing the challenges of climate change.
5. **Engage Coordination**. Coordination strategies may help align budgets and priorities for program of work across lands or establish or expand collaborative monitoring efforts or projects, among others.

**Table 3.** Summary of possible adaptation goals and actions for chaparral and sage scrub habitats, grouped by category (enhance resistance, promote resilience, facilitate transition, increase knowledge, and engage coordination). Adaptation goals and actions include those generated by workshop participants for chaparral and sage scrub habitats, as well as additional actions identified from the literature and by land and resource managers during other workshops.

| CHAPARRAL AND SAGE SCRUB HABITATS | | |
|---|---|---|
| **Category** | **Adaptation Goal** | **Adaptation Action** |
| **Enhance resistance** | Restore disturbed areas with native species to limit erosion and prevent establishment of non-native species | • Remove non-native species as soon as they are detected<br>• Create a seed collection for disturbance-adapted species<br>• Immediately plant or seed with native species after disturbance<br>• Supplement water to ensure establishment of restored native plants<br>• Exclude off-highway vehicles (OHVs) from restored sites |
| | Practice rapid, effective fire suppression to minimize fire frequency and restore appropriate fire return intervals | • Practice effective types of fuels management in strategic locations, particularly around at-risk human communities or key resources<br>• Conduct patrols during high wind events for early detection of fire<br>• Prevent or reduce fine fuel growth at road margins<br>• Use physical barriers to block sparks from igniting vegetation on roadsides |
| | Increase public education and wildfire prevention efforts | • Limit human activity and traffic in fire-prone areas to prevent ignitions<br>• Move roadside power lines underground to reduce fire risk<br>• Map ignition hotspots and reduce access to those areas<br>• Increase fire prevention efforts in heavily used sites<br>• Incorporate fire risk into land use planning (e.g., plan for defensible space, focus on the wildland-urban interface) |
| | Consider limiting recreational use to decrease disturbance and risk of wildfire | • Identify overused areas and consider whether limits on recreational trails/roads and OHV use are appropriate<br>• Centralize recreation impacts to easy-access areas<br>• Collaborate with law enforcement to regulate and enforce recreational and access restrictions<br>• Create an education campaign for OHV users that emphasizes potential impacts<br>• Improve public education and interpretive signage to increase understanding of impacts |

| | | |
|---|---|---|
| **Promote resilience** | Promote occurrence and vigorous growth of native shrubs and other perennial species | • Promote the occurrence and growth of early-season native species<br>• Reduce grazing in July and August to encourage perennial growth<br>• Revise grazing policies, and review and evaluate grazing allotment plans<br>• Focus habitat restoration activities on sites that are less likely to experience very warm or dry conditions |
| | Restore/manage habitat to reflect future climate conditions while still benefitting native species and mirroring current ecological function | • Conduct common garden experiments to determine which species may succeed under future conditions<br>• During restoration activities, focus resources on resilient species and possibly incorporate species that are not currently on site (assisted migration)<br>• Reseed/replant disturbed sites with species expected to do well under future climate conditions<br>• Increase planting phase of restoration activities to buffer against years with unfavorable conditions |
| **Facilitate transition** | Identify vulnerable species and natural resources to inform protection efforts | • Conduct spatial analysis to identify vulnerable species, incorporating observed mortality, climate and non-climate threats and functional diversity<br>• Identify overused/impacted areas by conducting visitor counts during heavy use periods to inform development of regulation and/or education programs<br>• Use fire history and occurrence maps to identify vulnerable natural resources and prioritize restoration efforts with disturbance tolerant native species |
| **Increase knowledge** | Determine risk of type-conversion from woody shrublands to exotic annual grasslands under projected climate scenarios, changes in fire regime, and management regimes | • Determine historical pattern of type-conversion in southern California<br>• Model impact of changes in climate and fire regime on risk of type-conversion and possible rate of conversion<br>• Model variability of past fire regime and climate and link with changes in percent cover of invasive species<br>• Quantify ecosystem services provided by woody shrublands under past and future conditions (water flow, sedimentation, nitrogen absorption, carbon sequestration) |
| **Engage coordination** | Coordinate with fire agencies and communities to reduce risk of wildfire | • Educate fire agencies and communities about Best Management Practices for fuels treatments<br>• Work with firefighters to determine most strategic locations for fuels management<br>• Engage land use planners to reduce leapfrog development patterns and increase infill |