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### Acronyms and Abbreviations

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACE</td>
<td>Area of Conservation Emphasis</td>
</tr>
<tr>
<td>CAL FIRE</td>
<td>California Department of Forestry and Fire Protection</td>
</tr>
<tr>
<td>CCVA</td>
<td>climate change vulnerability assessment</td>
</tr>
<tr>
<td>CDFW</td>
<td>California Department of Fish and Wildlife</td>
</tr>
<tr>
<td>CRLF</td>
<td>California red-legged frog</td>
</tr>
<tr>
<td>CTS</td>
<td>California tiger salamander</td>
</tr>
<tr>
<td>GCM</td>
<td>general circulation model</td>
</tr>
<tr>
<td>GHG</td>
<td>greenhouse gas</td>
</tr>
<tr>
<td>IPCC</td>
<td>Intergovernmental Panel on Climate Change</td>
</tr>
<tr>
<td>km/yr</td>
<td>kilometers per year</td>
</tr>
<tr>
<td>MHHW</td>
<td>mean higher high-water</td>
</tr>
<tr>
<td>NOAA</td>
<td>National Oceanic and Atmospheric Administration</td>
</tr>
<tr>
<td>OCE</td>
<td>other conservation element</td>
</tr>
<tr>
<td>OPC</td>
<td>(California) Ocean Protection Council</td>
</tr>
<tr>
<td>ppm</td>
<td>parts per million</td>
</tr>
<tr>
<td>RCIS</td>
<td>Regional Conservation Investment Strategy</td>
</tr>
<tr>
<td>RCIS area</td>
<td>Monterey County Regional Conservation Investment Strategy area</td>
</tr>
<tr>
<td>RCP</td>
<td>representative concentration pathway</td>
</tr>
<tr>
<td>SCLTS</td>
<td>Santa Cruz long-toed salamander</td>
</tr>
<tr>
<td>SWAP</td>
<td>State Wildlife Action Plan</td>
</tr>
<tr>
<td>USFWS</td>
<td>U.S. Fish and Wildlife Service</td>
</tr>
</tbody>
</table>
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1. EXECUTIVE SUMMARY

Section 1852(c)(5) of California Fish and Game Code, and Regional Conservation Investment Strategy (RCIS) Guidelines (CDFW 2018a) require that an RCIS report include a summary of historic, current, and projected future stressors and pressures in the Monterey County Regional Conservation Investment Strategy area (RCIS area), including climate change vulnerability, as available. A stressor is defined as a degraded ecological condition that results from the negative impacts of pressures, which are drivers that could result in changing ecological conditions.

This report includes a summary of historic, current, and projected stressors and pressures on focal species and non-focal species, and other conservation elements identified as part of the RCIS evaluation. These include: airborne pollutants, climate change, water management, fire, development of housing and urban areas, livestock and agriculture, habitat fragmentation, non-native species, recreation and tourism, and renewable energy. Climate change already is affecting wildlife, plants, and habitats throughout California (CDFW 2015) and is the main stressor and pressure category assessed in this document. The effects of climate change are described in further detail in the following subsections.

This summary is a result of the review of available State datasets and literature from California Department of Fish and Wildlife’s (CDFW) climate website and other supporting documents. Summary data are presented in text and table format to provide the reader with a synthesis of stressors and pressures in the RCIS area. No new analyses were conducted as part of this assessment.

Identifying projected non-climate and climate stressors and pressures in the RCIS area prioritizes conservation strategies. Stressors and pressures identified in this RCIS report can be incorporated in developing future conservation strategies. Climate vulnerability is defined as the amount of evidence that climate change is projected to negatively affect a species, asset, or system (Gardali et al. 2012). Climate vulnerability often is expressed in terms of exposure, sensitivity, and adaptive capacity:

- **Exposure** – the nature and degree to which a species, asset, or system is exposed to climate change stressors
- **Sensitivity** – the degree to which the physical condition and functionality of a species, asset, or system is affected by climate change
- **Adaptive Capacity** – the ability of a species, asset, or system to evolve in response to, or cope with the impacts of climate change

Although exposure is the greatest indicator of an asset’s susceptibility to climate change stressors, evaluating sensitivity and adaptative capacity provide valuable information on the degree to which a
species or asset would be affected or impaired and inherent characteristics that allow the species or asset to respond or be modified. Species and assets are considered to be most vulnerable if they are exposed to climate change stressors, have high sensitivity, and low adaptive capacity. The following sections describe the climate vulnerability of focal species, natural communities, and transportation assets in the RCIS area. In addition, a high-level habitat resilience assessment was conducted, using the CDFW's Areas of Conservation Emphasis dataset (CDFW 2018b) to identify and prioritize areas for conservation.

1.1 Focal Species and Natural Communities Climate Vulnerability

To assess climate change vulnerability, a literature review of regional and taxon-specific climate change vulnerability assessments, regional adaptation plans, and species-specific background research was conducted. A climate change vulnerability assessment aids in determining which fish, wildlife, and plant species may be most vulnerable to climate change, and why (CDFW 2019). To determine the climate vulnerability of focal species and natural communities in the RCIS area, several climate change vulnerability assessment reports for California species were reviewed from CDFW’s Climate Science Program (CDFW 2019). A species’ or natural community’s projected climate vulnerability can aid in identification and prioritization of conservation targets and strategies.

In general, climate change vulnerability assessments indicate that climate vulnerability of focal species and natural communities ranges from neutral to high (CDFW 2019). The following focal and non-focal species ranked as moderate and above in species-specific climate change vulnerability assessments and/or occupy natural communities that have a high combined vulnerability rank. These species are the most vulnerable to climate change in the RCIS area:

- **Amphibians and Reptiles**: California tiger salamander, Santa Cruz long-toed salamander, and Santa Lucia slender salamander
- **Mammals**: Southern sea otter and San Joaquin kit fox
- **Fish**: Steelhead and tidewater goby
- **Birds**: Western snowy plover, least Bell’s vireo, and tricolored blackbird
- **Invertebrates**: Vernal pool fairy shrimp, California brackish water snail
- **Plants**: Yadon’s rein orchid, Contra Costa goldfields, eelgrass
The following focal species are discussed and represent some of the most widespread and/or vulnerable habitats in the RCIS area: steelhead, Western snowy plover, and California red-legged frog. Some focal species, such as California red-legged frog, have relatively neutral projections of climate vulnerability (Wright et al. 2013). Continued implementation of already successful conservation measures for California red-legged frog could positively impact a variety of more climate-vulnerable focal species. Focal species that already have high present-day vulnerabilities, such as steelhead and Western snowy plover, are projected to be extremely vulnerable to climate change. Steelhead are important indicators of riparian community health, and Western snowy plover are indicators for coastline natural community health. Conservation strategies focusing on these important indicator species have the potential to affect a large number of other focal and non-focal species that are vulnerable to the impacts of climate change.

1.2 High Climate Resiliency Locations in the RCIS Area

A high-level habitat resilience assessment of locations in the RCIS area was conducted using the Area of Conservation Emphasis (ACE) dataset (CDFW 2018b). These are areas that are expected to be relatively buffered from the impacts of climate change and include Fort Ord National Monument, Fort Hunter Liggett, Northern Camp Roberts, Santa Lucia Range, Los Padres National Forest, and Cholame Valley. These areas could be prioritized for protection and are likely to remain suitable habitat for plant and wildlife species.

1.3 Transportation Vulnerability

Climate change is projected to pose increasing risk for transportation infrastructure in the RCIS area, primarily through more severe, frequent flooding, an increase in the extent and frequency of wildfires, and infrastructure damage because of more extreme heat days. Although infrastructure was designed to be adaptive to a large range of climatic conditions, the increased exposure to climate hazards is projected to affect the reliability and capacity of these transportation networks. To assess the climate vulnerability of transportation assets in the RCIS area, a high-level exposure and consequence assessment of transportation assets was conducted for the hazards of sea level rise inundation, coastal storm flooding, extreme heat, and wildfires. Previously completed and ongoing climate vulnerability and adaptation studies for the region also were reviewed and incorporated into the findings. Transportation infrastructure in Elkhorn Slough and along the oceanfront areas of the city of Monterey were identified as highly vulnerable to rising sea levels because of coastal flood exposure.
2. STRESSORS AND PRESSURES

2.1 Regional Stressors and Pressures

A stressor is a degraded ecological condition that results from the negative impacts of pressures, which are drivers that could result in changing ecological conditions (CDFW 2018a). Ten categories and eight subcategories of regional stressors and pressures were identified from two sources: the State Wildlife Action Plan (CDFW 2015); and species-specific U.S. Fish and Wildlife Service (USFWS) recovery plans in the RCIS area. Details of the stressor and pressure categories are shown in Table 2-1.

Table 2-1. Stressors and Pressures in the RCIS Area

<table>
<thead>
<tr>
<th>Pressure</th>
<th>Stressor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airborne pollutants</td>
<td>- Pollutants from vehicle emissions can cause harm to the environment.</td>
</tr>
<tr>
<td></td>
<td>- Carbon dioxide and methane contribute to climate change.</td>
</tr>
<tr>
<td></td>
<td>- Airborne pollutants impact amphibians that have porous skin.</td>
</tr>
<tr>
<td>Climate change</td>
<td>- Winters are projected to become warmer and wetter, and summers to become drier and hotter.</td>
</tr>
<tr>
<td></td>
<td>- Impacts may include more winter flooding, increased rates of coastal erosion, increased sedimentation in wetland habitats, higher water demands, and an increase in salinity of freshwater sources from sea level rise.</td>
</tr>
<tr>
<td>Dams and water management/use</td>
<td>- Higher water demands, because of an increasing human population in the RCIS area, may lead to the building of new dams.</td>
</tr>
<tr>
<td></td>
<td>- Dams increase the establishment of some non-native species.</td>
</tr>
<tr>
<td>Fire and fire suppression</td>
<td>- Historically, wildfire has been a naturally occurring ecological process in the RCIS area.</td>
</tr>
<tr>
<td></td>
<td>- Human-caused fires result in unnaturally high fire frequency, which has altered the natural fire regime.</td>
</tr>
<tr>
<td></td>
<td>- Fire suppression along the urban–wildland interface increases wildfire intensity in this region.</td>
</tr>
<tr>
<td>Pressure</td>
<td>Stressor</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Housing and urban areas          | • Increasing human population is causing a high demand for land and water, resulting in the conversion of natural land into urban areas and leading to habitat loss/degradation.  
+ Commercial and industrial areas | • Development associated with urban areas, including linear structures such as roads and utility lines, also restricts wildlife movement.  
+ Garbage and solid waste         | • Heavy use of pesticides negatively impacts environment health and wildlife.  
+ Roads and railroads             | • Heavy water consumption affects aquatic and riparian habitats.  
+ Utility and service lines       | • Habitat loss, degradation, and fragmentation occurs.  
+ Household sewage and urban wastewater | • Habitat fragmentation impacts plant and wildlife movement dispersal, predator–prey relationships, competitive interactions, nutrient cycling, and gene flow.  
+ Industrial and military effluents |                                                                 |
| Livestock, farming, and ranching | • Non-native species outcompete and displace native species, resulting in poor habitat quality.  
+ Annual and perennial non-timber crops | • Non-native species may alter and/or prohibit ecosystems functions.  
+ Agriculture and forestry effluents | • Increased demand for human infrastructure can cause disturbance to ecosystems and fragmentation.  
                                           | • Increased human–wildlife interactions generate negative impacts.  
| Habitat fragmentation            | • Land conversion for renewable energy facilities leads to habitat loss and fragmentation.  
                                           | • Bird and bat collisions with wind turbines occur.  
| Non-native species and disease   |                                                                 |
| Recreation and tourism           |                                                                 |
| Renewable energy                 |                                                                 |
2.2 **Species-Specific Stressors and Pressures**

A summary of stressors and pressures identified in the State Wildlife Action Plan (CDFW 2015) and species-specific USFWS recovery plans are presented next. The following stressors and pressures were identified for and apply to each focal/non-focal species and other conservation elements in RCIS area (CDFW 2015):

- Climate change
- Fire and fire supression
- Loss of habitat connectivity (habitat fragmentation)
- Non-native species and disease

The following subcategories of stressors and pressures apply to all focal/non-focal species and other conservation elements in the RCIS area:

- Housing and urban areas:
  + Commercial and industrial areas
  + Garbage and solid waste
  + Roads and railroads
  + Utility and service lines
- Livestock and farming
  + Annual and perennial non-timber crops

Stressors and pressures not listed above only affect certain species and other conservation elements. The results are shown in Table 2-1 for comparison of best available stressors and pressures data, listed by species. Species-specific stressors and pressures for non-focal species and other conservation elements are provided in Appendix A.
### Table 2-2. Focal Species-Specific Stressors and Pressures

<table>
<thead>
<tr>
<th>Species</th>
<th>Airborne Pollutants</th>
<th>Dams and Water Management/Use</th>
<th>Housing and Urban Areas</th>
<th>Livestock, Farming, and Ranching Agriculture and Forestry Effluents</th>
<th>Recreation and Tourism</th>
<th>Renewable Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>burrowing owl <em>(Athene cunicularia)</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>California brackish water snail <em>(Tryonia imitator)</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>California condor <em>(Gymnogyps californianus)</em></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X^1</td>
</tr>
<tr>
<td>California newt <em>(Taricha torosa)</em></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>California red-legged frog <em>(Rana draytonii)</em></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>California tiger salamander <em>(Ambystoma californiense)</em></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>coast horned lizard <em>(Phrynosoma blainvillii)</em></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>foothill yellow-legged frog <em>(Rana boylii)</em></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Monarch butterfly <em>(Danaus plexippus pop.1)</em></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mountain lion <em>(Puma concolor)</em></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>pallid bat <em>(Antrozous pallidus)</em></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Species</td>
<td>Airborne Pollutants</td>
<td>Dams and Water Management/Use</td>
<td>Housing and Urban Areas</td>
<td>Livestock, Farming, and Ranching</td>
<td>Recreation and Tourism</td>
<td>Renewable Energy</td>
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</tr>
<tr>
<td>San Joaquin kit fox (Vulpes macrotis mutica)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Santa Cruz long-toed salamander (Ambystoma macrodactyllum croceum)</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Smith's blue butterfly (Euphilotes enoptes smithi)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>southern sea otter (Enhydra lutris nereis)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>steelhead (South-Central California Coast steelhead Distinct Population Segment) (Oncorhynchus mykiss irideus)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tidewater goby (Eucyclogobius newberryi)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>tricolored blackbird (Agelaius tricolor)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>vernal pool fairy shrimp (Branchinecta lynchi)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>western snowy plover (Charadrius alexandrinus nivosus)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Species</td>
<td>Airborne Pollutants</td>
<td>Dams and Water Management/Use</td>
<td>Housing and Urban Areas</td>
<td>Livestock, Farming, and Ranching</td>
<td>Recreation and Tourism</td>
<td>Renewable Energy</td>
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<td>-----------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Household Sewage and Urban Waste</td>
<td>Industrial and Military Effluents</td>
<td>Agriculture and Forestry Effluents</td>
<td></td>
</tr>
<tr>
<td>Carmel Valley bush mallow (<em>Malacothrix palmeri</em>)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Lemmon’s jewelflower (<em>Caulanthus lemmonii</em>)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Hickman's onion (<em>Allium hickmanii</em>)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Monterey gilia (<em>Gilia tenuiflora</em> ssp. <em>arenaria</em>)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Monterey spineflower (<em>Chorizanthe pungens</em> var. <em>pungens</em>)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Pajaro manzanita (<em>Arctostaphylos pajaroensis</em>)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>seaside bird's-beak (<em>Cordylanthus rigidus</em> ssp. <em>littoralis</em>)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Yadon's rein orchid (<em>Piperia yadonii</em>)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

**Notes on additional stressors and pressures from focal species’ recovery plans that are not identified in the State Wildlife Action Plan:**

1. The California Condor Recovery Plan (USFWS 1996) identifies lead poisoning from recreational hunting to be a major population threat.
2. The Final Revised Recovery Plan for southern sea otter (*Enhydra lutris nereis*) (USFWS 2003) identifies offshore oil facilities and oil spills to be a major population threat to this species.
3. CLIMATE CHANGE

Climate change already is affecting wildlife, plants, and habitats throughout California, and its effects are projected to continue to increase in severity (CDFW 2015). The projections of climate change in the RCIS area and vulnerability assessments of focal/non-focal species, other conservation elements, and transportation assets presented in this chapter will help prioritize future conservation targets and actions. Species’ vulnerability assessment results are grouped by taxon or natural community.

3.1 Projections of Climate Change

This section reviews the best-available climate science for the RCIS area—including changes in temperature, precipitation, and sea level rise. It also discusses the physical impacts of these variations in the climate, including wildfires, flooding, coastal erosion, landslides, and drought.

Modeling Climate Change

To project future climate conditions, scientists rely on numerical models, known as general circulation models. These models incorporate the inter-related physical processes of the atmosphere, ocean, and land surface to simulate the response of climate systems to changing greenhouse gas and sulfate aerosol emissions. These models are based on well-established physical principles and have been demonstrated to reproduce observed changes of recent and past climates. Because the level of future emissions will be affected by population, economic development, environmental changes, technology, and policy decisions, the Intergovernmental Panel on Climate Change (IPCC) has developed a range of possible future emission scenarios, based on a combination of these driving factors.

For the Fifth Assessment Report (AR5), the IPCC updated its scenarios—now called representative concentration pathways (RCPs)—to reflect advances in modeling approaches and additional factors that could affect future climate conditions (IPCC 2013). For climate adaptation planning, RCP4.5 and RCP8.5 are the most commonly used scenarios. The higher of the two (RCP8.5) also is referred to as a business-as-usual scenario and represents rapid economic growth, with greenhouse gas concentrations exceeding 900 parts per million (ppm) by 2100. RCP4.5 represents a more moderate scenario, with greenhouse gas emissions rising until 2040 and reaching a concentration of 550ppm, followed by stabilization.

The different RCP scenarios are incorporated into the numeric general circulation models, creating combinations of selected future conditions that can be used as input for researchers to assess the
influence of the variables on the projected climate. General circulation models provide estimates of climate change on a global level because the resolution typically is too coarse for detailed regional climate projections. Therefore, the models often are “downscaled” to allow more place-based projections on the local level. Using general circulation model results for input, downscaled models generate locally relevant data by connecting global-scale projections and regional dynamics.

**State Climate Change Guidance and Resources**

California has developed a series of guidance documents and studies, to enhance the understanding of climate change impacts on a regional scale and directly inform vulnerability assessments and adaptation strategies. Table 3-1 summarize State resources that are leveraged for assessment of climate stressors in the RCIS area.

**Table 3-1. State of California Climate Change Guidance and Resources**

<table>
<thead>
<tr>
<th>Study (Author/Date)</th>
<th>Summary</th>
</tr>
</thead>
</table>
| California’s Fourth Climate Change Assessment–Central Coast Region Report (Langridge 2018) | • The assessment is composed academic and technical reports, discussing climate change projections for a suite of climate stressors, including temperature, sea levels, snowpack, annual precipitation, precipitation intensity, frequency of drought, frequency and intensity of Santa Ana winds, marine layer clouds, and wildfire.  
  • Potential impacts also are described for a variety of sectors (e.g., land use and development, biodiversity and ecosystems, forest health, transportation, and public health).  
  • The Central Coast Regional Report, which includes Monterey County, emphasizes potential effects on natural ecosystems, agriculture, and coastal and farm communities, and it lists potential adaptations applicable to each sector. |
| Ocean Protection Council Sea Level Rise Guidance Update (California Ocean Protection Council 2018) | • This guidance update compiles, reviews, and summarizes the latest research on sea level rise.  
  • The guidance update presents the latest peer-reviewed projections of sea level rise, describes an extreme scenario for sea level rise caused by rapid ice sheet loss from the West Antarctica ice sheet, and presents scenario selections using risk-based (probabilistic) planning capabilities.  
  • The guidance update also lays out preferred approaches to planning for vulnerable assets, natural habitats, and public access. |
Cal-Adapt (Cal-Adapt 2017)

• To satisfy a key recommendation of the 2009 California Climate Adaptation Strategy, Cal-Adapt was developed to provide an interactive geospatial tool for localized climate projections in California.
• The tool allows users to explore projected changes in temperature, extreme heat, precipitation, snowpack, wildfire, and sea level rise across the state, based on a variety of climate models and future emission scenarios.
• The updated version of the tool, Cal-Adapt 2.0, also includes high-resolution, local climate projections, using downscaling methods and emission scenarios that align with the Intergovernmental Panel on Climate Change’s Fifth Assessment Report.

Sea Level Rise Projections

Since installation of the Monterey tide station in 1973, sea levels have increased at a rate of 0.06 inch per year, which equates to 0.52 foot in 100 years (NOAA 2018). Numerous studies indicate a global acceleration of local sea level rise during the turn of the twenty-first century, with rates tripling earlier observations. Based on the latest climate science, Monterey County sea levels are likely to rise between 0.5 and 1.1 feet by mid-century, and between 0.9 and 3.3 feet by end of the century. The California Ocean Protection Council (OPC) recommends using the upper limit of the likely range for projects with a high tolerance to flooding (e.g., parks or natural areas) (California OPC 2018).

Because uncertainty exists regarding future greenhouse gas emissions, sea level rise projections with lower probabilities of occurring also have been considered. In the RCIS area, a 0.5 percent probability exists that sea level rise will reach or exceed 1.9 feet by mid-century and 6.9 feet by the end of the century (California OPC 2018). OPC recommends using these projections when planning for assets with lower tolerances to flooding, such as major transportation corridors (California OPC 2018). Table 3-2 summarizes projected sea level rise ranges, based on low and high emission conditions.

Temperature Projections

Temperatures are expected to increase significantly for the RCIS area over the next century. Based on the RCP8.5 scenario, annual average temperatures are expected to increase by 4.9°F by mid-century and 7.5°F by end-of-century relative to historical period observations (1976–2005). Changes in the number of extreme heat days, defined as days with temperatures above the 98th percentile of observed daily maximum temperatures, are projected to increase by 15 days by mid-century and 30 days by end-of-century (Langridge 2018). Table 3-2 summarizes projected temperatures based on RCP4.5 and RCP8.5 conditions.
Precipitation Projections

Projections of future precipitation are associated with considerable uncertainty. Precipitation is one of the least certain aspects of climate models at the regional level, because the models do not resolve many of the fine-scale and complex interactions that occur locally. In general, a projected increase of year-to-year variability exists along the Central Coast, with fewer days of precipitation but an increase in the amount of precipitation occurring during wet days. The largest changes are expected to occur in coastal areas, where the amount of precipitation recorded in a single day may increase by up to 30 percent in Monterey County by the end of the century. The average annual precipitation, based on the RCP8.5 scenario, shows an increase of 2.1 inches by mid-century and 5.1 inches by end-of-century, when compared to historical conditions (1976–2005) (Langridge 2018). Table 3-2 summarizes projected precipitation based on RCP4.5 and RCP8.5 conditions.

Projection Summary

In general, sea levels are projected to rise at an accelerated rate through the next century. Similarly, maximum temperatures are projected to continue to increase, with greater increases experienced in inland areas. Average precipitation also is expected to increase by a relatively small amount, but annual variability in total inches is expected to increase substantially by the end of the century, with less total precipitation overall but an increase in the amount of precipitation during storm events.

Table 3-2. Summary of Climate Stressors

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea Level Rise</td>
<td>N/A</td>
<td>N/A</td>
<td>2.3–5.5 feet</td>
</tr>
<tr>
<td>Temperature (annual average)</td>
<td>70°F</td>
<td>73.7°F</td>
<td>74.9°F</td>
</tr>
<tr>
<td>Temperature (# of extreme heat days)</td>
<td>4.3</td>
<td>14</td>
<td>19</td>
</tr>
<tr>
<td>Precipitation (annual average)</td>
<td>19.3 inches</td>
<td>21.1 inches</td>
<td>21.2 inches</td>
</tr>
</tbody>
</table>

Notes:
1. For low emissions, all climate stressors are based on RCP4.5, except sea level rise, which is based on RCP2.6.
2. For high emissions, all climate stressors are based on RCP8.5.
3. Only sea level rise projections, based on RCP8.5, are provided in the Guidance prior to 2060, because emissions currently are on the RCP8.5 trajectory.
3.2 Analysis Methodology

To assess climate change vulnerability, a literature review was conducted of regional and species-specific climate change vulnerability assessments, species-specific background research, and regional adaptation plans. A high-level exposure assessment of transportation assets was conducted using inundation maps (NOAA 2015) and wildfire hazard severity maps (CALFIRE 2007). A high-level habitat resilience assessment was conducted using the ACE dataset (CDFW 2018b).

Literature Review

Regional Climate Change Vulnerability Assessments and Adaptation Plans

Monterey County and several of its communities have completed a suite of studies, to evaluate vulnerability and potential adaptation strategies in preparation for climate change impacts (Table 3-3). The studies range from reports to understanding potential climate impacts on public health, and to city-specific climate change adaptation plans, to protect built and natural public infrastructure.

Table 3-3. Previous and Ongoing Climate Change Vulnerability Assessments and Adaptation Plans for Monterey County/Monterey Cities

<table>
<thead>
<tr>
<th>Study/Lead Agency (Date)</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>City of Monterey Transportation Adaptation Plan</td>
<td>• Identifies transportation infrastructure vulnerable to climate change and develops adaptation strategies to preserve the transportation network by building on the findings of the City’s Sea Level Rise and Vulnerability Analyses, Existing Conditions, and Issues Report.</td>
</tr>
<tr>
<td>Monterey–Salinas Transit, Transportation Agency for Monterey County, Association of Monterey Bay Area Governments (2018)</td>
<td>• Focuses on benefits to regional disadvantaged communities, local businesses, homes, and schools relying on the network.</td>
</tr>
<tr>
<td>City of Monterey Sea Level Rise and Vulnerability Analyses, Existing Conditions and Issues Report City of Monterey (2016)</td>
<td>• Examines existing conditions and climate stressor projections for sea level rise, temperature, precipitation, and wildfire in a series of planning horizons through 2100.</td>
</tr>
<tr>
<td>City of Monterey Multi-Jurisdictional Hazard Mitigation Plan The Monterey County Hazard Mitigation Planning Team (2015)</td>
<td>• Evaluates coastal flood hazards based on wave flooding, barrier beach flooding, tidal inundation, and short and long-term erosion.</td>
</tr>
<tr>
<td></td>
<td>• Serves as a guide for State and local efforts to reduce disaster losses of life, property, and infrastructure, including transportation assets.</td>
</tr>
<tr>
<td></td>
<td>• Identifies trends and vulnerabilities associated with county-wide hazards, including sea level rise flooding, precipitation flooding, wildfires, landslides, and coastal erosion.</td>
</tr>
<tr>
<td></td>
<td>• Offers county-wide and jurisdiction-specific recommendations to reduce future risks.</td>
</tr>
<tr>
<td>Study/Lead Agency (Date)</td>
<td>Summary</td>
</tr>
<tr>
<td>-------------------------</td>
<td>---------</td>
</tr>
</tbody>
</table>
| City of Pacific Grove Climate Change Vulnerability Assessment City of Pacific Grove (2015) | • Discusses potential climate change impacts, including temperatures, sea level rise, ocean acidification, extreme storms, and wildfires.  
• Evaluates the adaptive capacity of existing city assets.  
• Provides recommendations to assist the City in addressing identified climate change impacts. |
| Monterey Bay Sea Level Rise Vulnerability Assessment  
The Monterey Bay Sanctuary Foundation (2014) | • Presents the methods used to map erosion and coastal flood hazards, based future climate scenarios for the Monterey Bay coastline.  
• Presents the results at the planning horizons of 2030, 2060, and 2100.  
• Creates hazard zones for the 100-year tide, wave run-up, overtopping, and seasonally closed lagoons. |

**Focal/Non-Focal Species Climate Change Vulnerability Assessments**

Literature reviewed for this assessment included climate change assessments that have been developed or supported by State and federal agencies for all taxa except invertebrates, which do not have a species-specific climate change vulnerability assessment in California (CDFW 2019) and the State Wildlife Action Plan (CDFW 2015). Additional data reviewed included climate change assessments developed by non-governmental agencies, along with species-specific background information for focal/non-focal species and natural communities. Table 3-4 summarizes the climate change vulnerability assessments that were reviewed for focal/non-focal species.

**Table 3-4. Climate Change Vulnerability Assessments for Focal/Non-Focal Species**

<table>
<thead>
<tr>
<th>Study (Author/Date)</th>
<th>Summary</th>
</tr>
</thead>
</table>
| Assessing Climate Change Impacts on Vernal Pool Ecosystems and Endemic Branchiopods (Pyke 2005) | • Models future climate change effects on vernal pools in the California Central Valley using author-developed climate scenarios.  
• Identifies three scales of responses: regional, local, and individual pools. |
| Terrestrial Climate Change Resilience—Area of Conservation Emphasis (CDFW 2018b) | • Summarizes information on areas in California that are expected to be buffered from the impacts of climate change.  
• Uses modeled exposure of natural habitats (vegetation) to climate change. |
<table>
<thead>
<tr>
<th>Study (Author/Date)</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A Climate Change Vulnerability Assessment for Twenty California Mammal Taxa</strong></td>
<td>• Assesses vulnerability using three approaches:</td>
</tr>
<tr>
<td>(Stewart et al. 2016)</td>
<td>• models geographic response;</td>
</tr>
<tr>
<td></td>
<td>• considers the ratio of climatic exposure to climatic niche breath; and</td>
</tr>
<tr>
<td></td>
<td>• considers expert-assessed qualitative vulnerability categories for 2070–2099.</td>
</tr>
<tr>
<td><strong>A Climate Change Vulnerability Assessment of California's At-Risk Birds</strong></td>
<td>• Develops a new framework for assessing climate change vulnerability of California's at-risk birds for 2070.</td>
</tr>
<tr>
<td>(Gardali et al. 2012)</td>
<td>• Integrates the results into the existing California Bird Species of Concern list.</td>
</tr>
<tr>
<td><strong>A Climate Change Vulnerability Assessment of California's Terrestrial Vegetation</strong></td>
<td>• Determines climate change vulnerability of vegetation communities by mapping spatial patterns and examines how climate conditions are projected to change at those locations in 2070–2099.</td>
</tr>
<tr>
<td>(Thorne et al. 2016)</td>
<td>• Identifies the biological traits of the dominant plant species and explains that different types have different levels of sensitivity and adaptive capacity to climate change.</td>
</tr>
<tr>
<td><strong>California Amphibian and Reptile Species of Future Concern: Conservation and Climate Change</strong></td>
<td>• Builds ecological niche models for all amphibian and reptile species in California and forecasts the distribution of suitable habitat under four future climate scenarios and eleven general circulation models for 2050.</td>
</tr>
<tr>
<td>(Wright et al. 2013)</td>
<td><strong>Carpe Noctem: The Importance of Bats as Bioindicators</strong> (Jones et al. 2009)</td>
</tr>
<tr>
<td><strong>Climate Change Vulnerability Assessment for the North-Central California Coast and Ocean</strong></td>
<td>• Identifies bats as having a big potential to act as bioindicators for climate change and habitat loss worldwide.</td>
</tr>
<tr>
<td>(Hutto et al. 2015)</td>
<td>• Discusses several climate factors, such as drought and increasing temperatures, and their effects on bats.</td>
</tr>
<tr>
<td></td>
<td>• Identifies focal marine and coastal resources that were assessed by federal and State agencies, non-governmental organizations, and academic institutions.</td>
</tr>
<tr>
<td><strong>Climate Change Vulnerability Assessment of Rare Plants in California</strong></td>
<td>• Uses the Nature Serve Climate Change Vulnerability Index to determine the most at-risk of California's rare plant species for 2050.</td>
</tr>
<tr>
<td>(Anacker and Leidholm 2012)</td>
<td>• Presents predicted species' distribution maps.</td>
</tr>
<tr>
<td><strong>Dispersal will Limit Ability of Mammals to Track Climate Change in the Western Hemisphere</strong></td>
<td>• Models velocities at which species will need to move to keep pace with projected changes in suitable climates and compares them to dispersal velocities of mammal species.</td>
</tr>
</tbody>
</table>
Projected Effects of Climate Change in California: Ecoregional Summaries Emphasizing Consequences for Wildlife (PRBO Conservation Science 2011)
- Assembles available literature relative to the twelve ecoregions in California.
- Supplements lacking information with regional climate models to synthesize information about climate change as related to wildlife habitat.

Projected Effects of Future Climates on Freshwater Fishes of California (Moyle et al. 2012)
- Presents methodology that allows a systematic evaluation of climate change impacts on freshwater fishes in California.
- Uses expert opinion and literature review to score both the status of each species and likely impact of climate change for 2100.
- Does not consider specific climate change models or emission scenarios.

- Identifies specific stressors and pressures, including climate change, in the Bay–Delta and Central Coast regions

The Impact and Implications of Climate Change for Bats (Sherwin et al. 2013)
- Identifies observed impacts of climate change on bats and identified risk factors allowing species-specific predictions.

Twenty-Five Years of Monitoring a Townsend’s Big-Eared Bat (Corynorhinus townsendii) Maternity Roost (Fellers and Halstead 2015)
- Describes the results of a 25-year monitoring project of a Townsend’s big-eared bat maternity roost in central California and documents how the species has reacted to different effects of climate change.

### Species-Specific and Natural Community Climate Change Vulnerability Assessments Methodologies

Species-specific and natural community climate change vulnerability assessments that were reviewed use a variety of methodologies. The specific variables for exposure and sensitivity used to model responses to climate stressors differ depending on the taxa, which makes directly comparing vulnerability between taxa challenging.

Table 3-5 shows the climate change vulnerability assessment methodologies that were reviewed for each focal/non-focal species assessed in the RCIS area. Each assessment uses different, specific ranking systems but present a vulnerability ranking for each species or community to climate change. Some of the reviewed assessments use the following additional modeled variables:

- **Species’ distribution models:** measures of habitat suitability or probability of occurrence for each taxon;
• **Adaptive capacity:** the ability of a species, asset, or system to evolve in response to, or cope with the impacts of climate change; and

• **Representative concentration pathways (RCPs):** a range of possible future emission scenarios based on population, economic development, environmental changes, technology, and policy decisions.

Climate change vulnerability assessments require a large amount of species-specific information, and the vulnerability to climate change of many focal and non-focal species have not been assessed directly in the reviewed literature. In these cases, the vulnerability of the natural communities with which the focal/non-focal species are associated are used to assess the species current and future vulnerability to climate stressors.

Table 3-5. Climate Change Vulnerability Assessments Methodology for Focal/Non-Focal Species

<table>
<thead>
<tr>
<th>Study (Author/Date)</th>
<th>Species Distribution Models</th>
<th>Adaptive Capacity</th>
<th>IPCC 4th Assessment Report Representative Concentration Pathways (RCPs)</th>
<th>IPCC 5th Assessment Report Representative Concentration Pathways (RCPs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Climate Change Vulnerability Assessment for twenty California Mammal Taxa</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>(Stewart et al. 2016)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A Climate Change Vulnerability Assessment of California's At-Risk Birds</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>(Gardali et al. 2012)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A Climate Change Vulnerability Assessment of California's Terrestrial Vegetation</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Thorne et al. 2016)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>California Amphibian and Reptile Species of Future Concern: Conservation and Climate</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change (Wright et al. 2013)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climate Change Vulnerability Assessment for the North-central California Coast and</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Ocean (Hutto et al. 2015)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climate Change Vulnerability Assessment of Rare Plants in California</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Anacker and Leidholm 2012)</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Ecological Climate Resilience Assessment

The RCIS guidelines require identification of areas that may be resilient to the impacts of climate change (CDFW 2018a). A high-level habitat resilience assessment for the RCIS area was conducted using the ACE dataset (CDFW 2018b). This dataset is a suite of conservation information and summarizes areas expected to be relatively buffered from the impacts of climate change (CDFW 2018b). It includes summaries of the following:

- **Species Biodiversity**: This summary is based on species’ occurrence and distribution information for amphibians, aquatic macroinvertebrates, birds, fish, mammals, plants, and reptiles. It combines information from the Terrestrial Biodiversity Summary and the Aquatic Biodiversity Summary. These summaries combine three measures of biodiversity: native species richness, rare species richness, and a weighted measure of endemism (the ecological state of a species being unique to a defined geographic location).

- **Significant Habitats**: The terrestrial significant habitat and aquatic significant habitat summaries provide information to help determine significant habitat areas that are essential to the survival of specific species of conservation concern. Information on vegetation, land cover, and species-specific habitat information is used in these determinations.

- **Habitat Connectivity**: This summary uses mapped corridors or linkages, distance from large, contiguous, natural areas, and a relative intactness score for terrestrial habitats. An aquatic equivalent dataset has not been developed yet.

- **Climate Resilience**: This summary uses a climate change vulnerability assessment of vegetation communities done by Thorne et al. (2016) to summarize the probability that a given location may function as refugia from climate change at mid-century and end-of-century. An aquatic equivalent dataset has not been developed yet. Areas with higher resiliency rankings are projected to remain...
as suitable habitat, with ecological functions continuing as usual. Locations with lower resiliency rankings are projected to not continue to support current species diversity, and ecological functions may diminish or be eliminated.

Scores in each category ranged from 1 to 5, where 1 is low projected climate resilience and 5 is high projected resilience.

**Transportation Infrastructure Vulnerability Assessment**

A high-level exposure assessment was conducted for Monterey County’s transportation infrastructure, to provide insight on risk and timelines for intervention. Climate stressors that were assessed included flooding from rising sea levels, and wildfires, which are directly influenced by increases in temperature and changes in the precipitation cycle. A high-level evaluation of potential impacts from extreme heat exposure also was conducted, through a review of previously completed and ongoing climate studies for the region; the findings are discussed in Section 3.3. Evaluated infrastructure included existing and planned projects under the following three asset categories: highways, main roads, and rail lines.

**Sea Level Rise Inundation Mapping**

Inundation maps are a valuable tool for evaluating the potential exposure of habitats, infrastructure, and assets to future water-level conditions. The maps are used to evaluate the timing and extent of potential flooding, based on projections of sea level rise. Inundation maps also help planners to identify critical flooding thresholds, where an entire area may be compromised.

Three sea level rise amounts—1, 3, and 7 feet—were selected for flood exposure. The scenarios represent projections for 2050 and 2100, based on the State’s latest sea level rise guidance (California OPC 2018). The maps show areas vulnerable to flooding, based on two future flood conditions: daily tidal inundation, and temporary storm flooding. Daily tidal inundation conditions are represented by mean higher high-water (MHHW) level, and temporary storm flooding is represented by the 100-year storm tide. The 100-year storm tide is a statistically-derived water elevation that has a 1 percent chance of occurring in any given year. It includes the effects of the astronomical tide and storm conditions (because of atmospheric pressure and meteorological effects, precipitation, and El Niño conditions).

Future inundation layers for sea level rise scenarios that are available from the National Oceanic and Atmospheric Administration (NOAA 2015) were downloaded and used to understand potential future flood exposure of the transportation infrastructure in the RCIS area. NOAA sea level rise inundation layers provide the geographical extent and depth of inundation using 1-foot increments up to 10 feet above the average high-tide conditions, represented by MHHW elevation. The inundation maps do not account wave height, rainfall, or other potential variations in conditions that could affect the depth or extent of inundation at any given location.
The assessment of the exposure in sea level rise to the transportation infrastructure in the RCIS area involved conducting a spatial analysis to estimate the timing and extent of temporary storm flooding and daily tidal inundation. Sea level rise layers for 2050 and 2100 conditions were overlaid on the locations of transportation features to estimate exposure to future water-level conditions.

**Wildfire Threat Mapping**

The California Department of Forestry and Fire Protection (CAL FIRE) identifies wildfire hazard severity zones for the RCIS area (CAL FIRE 2007). A suite of physical factors characterizing the local environment, including existing and potential vegetation sources, flame length, blowing embers, topography, and typical weather for the area, was used to develop zones that estimate fire frequency and potential fire behavior. A science-based and field-tested computer model was used to assign hazard scores, based on each factor. The resulting zones were ranked Very High, High, or Moderate Fire Hazard Severity. Areas designated as being Very High or High Fire Severity zones are the most likely to experience wildfire, and transportation structures likely to be affected are identified in each zone.

The assessment of wildfire threat involved conducting a spatial analysis to estimate the extent of transportation infrastructure that may be affected directly by wildfires. Layers of potential fire hazard severity were overlaid on the locations of transportation features to estimate exposure of infrastructure in fire-prone areas.

### 3.3 Results

**Focal/Non-Focal Species and Natural Communities Results**

The results of the climate change vulnerability assessments and species-specific background studies for focal and non-focal amphibians and reptiles, mammals, fish, vernal pool species, and plants are described next. Where the assessments include results from different emission scenarios, those from RCP4.5 and RCP8.5 are presented because these are the commonly used emission scenarios for climate adaptation planning. Tables are used to summarize the data where applicable.

**Focal and Non-Focal Amphibian and Reptile Species Climate Change Vulnerability Assessment**

Wright et al. (2013) conducted a climate change vulnerability assessment for all Californian amphibian and reptile species for 2050 (Table 3-6). Species vulnerability was ranked by two different measures:

- **Point Ranking**: a projection of currently occupied areas remaining, and
• **Area Ranking:** projected change of suitable habitat remaining.

All focal and non-focal amphibian and reptile species, with the exceptions of California tiger salamander and Santa Lucia slender salamander, had Point Rankings of Stable or Slightly Reduced for both emission scenarios, meaning that current population distributions are likely to remain the same as present-day, experience a less than 20 percent reduction in area, or experience an increase in area. These species had an Area Ranking of Neutral for both emission scenarios, meaning that the amount of suitable habitat is projected to change no more than 20 percent.

Under the RCP4.5 scenario, California tiger salamander had a Point Ranking of Moderately Reduced, meaning currently occupied areas are projected to be reduced by 20 to 40 percent, and an Area Ranking of Somewhat Increase Vulnerability, meaning the amount of suitable habitat is projected to decrease by 20 to 50 percent. Under the RCP8.5 scenario, California tiger salamander had a Point Ranking of Greatly Reduced, meaning currently occupied areas are projected to be reduced by 40 to 80 percent, and an Area Ranking of Increased Vulnerability, meaning the amount of suitable habitat is projected to decrease by 50 to 99 percent.

Under the RCP4.5 scenario, Santa Lucia slender salamander had a Point Ranking of Greatly Reduced (40 to 80 percent decrease in currently occupied areas) and an Area Ranking of Somewhat Increase Vulnerability (20 to 50 percent decrease in suitable habitat). Under the RCP8.5 scenario, the Point Ranking for the species was Severely Reduced, meaning currently occupied areas are projected to be reduced by more than 80 percent, and it had an Area Ranking of Increased Vulnerability (50 to 99 percent decrease in suitable habitat). No specific analysis exists for Santa Cruz long-toed salamander; it has a smaller current range than Santa Lucia slender salamander and likely is similarly very vulnerable to climate change.
Table 3-6. Focal and Non-Focal Reptile and Amphibian Species Climate Change Vulnerability Assessment

<table>
<thead>
<tr>
<th>Species1</th>
<th>Type of Analysis</th>
<th>Low Emissions (RCP4.5)</th>
<th>High Emissions (RCP8.5)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Focal</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>California red-legged frog</td>
<td>Point Ranking</td>
<td>Slightly Reduced</td>
<td>Slightly Reduced</td>
</tr>
<tr>
<td></td>
<td>Area Ranking</td>
<td>Neutral</td>
<td>Neutral</td>
</tr>
<tr>
<td>California tiger salamander</td>
<td>Point Ranking</td>
<td>Moderately Reduced</td>
<td>Greatly Reduced</td>
</tr>
<tr>
<td></td>
<td>Area Ranking</td>
<td>Slightly Reduced</td>
<td>Neutral</td>
</tr>
<tr>
<td>coast horned lizard</td>
<td>Point Ranking</td>
<td>Slightly Reduced</td>
<td>Slightly Reduced</td>
</tr>
<tr>
<td></td>
<td>Area Ranking</td>
<td>Neutral</td>
<td>Neutral</td>
</tr>
<tr>
<td>foothill yellow-legged frog</td>
<td>Point Ranking</td>
<td>Slightly Reduced</td>
<td>Slightly Reduced</td>
</tr>
<tr>
<td></td>
<td>Area Ranking</td>
<td>Neutral</td>
<td>Neutral</td>
</tr>
<tr>
<td>California newt</td>
<td>Point Ranking</td>
<td>Slightly Reduced</td>
<td>Slightly Reduced</td>
</tr>
<tr>
<td></td>
<td>Area Ranking</td>
<td>Neutral</td>
<td>Neutral</td>
</tr>
<tr>
<td><strong>Non-Focal</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>northern California legless lizard</td>
<td>Point Ranking</td>
<td>Slightly Reduced</td>
<td>Slightly Reduced</td>
</tr>
<tr>
<td></td>
<td>Area Ranking</td>
<td>Neutral</td>
<td>Neutral</td>
</tr>
<tr>
<td>Santa Lucia slender salamander2</td>
<td>Point Ranking</td>
<td>Greatly Reduced</td>
<td>Severely Reduced</td>
</tr>
<tr>
<td></td>
<td>Area Ranking</td>
<td>Slightly Reduced</td>
<td>Neutral</td>
</tr>
<tr>
<td></td>
<td>Area Ranking</td>
<td>Somewhat Increase Vulnerability</td>
<td>Increased Vulnerability</td>
</tr>
<tr>
<td>two-striped garter snake</td>
<td>Point Ranking</td>
<td>Stable</td>
<td>Stable</td>
</tr>
<tr>
<td></td>
<td>Area Ranking</td>
<td>Neutral</td>
<td>Neutral</td>
</tr>
<tr>
<td>western spadefoot</td>
<td>Point Ranking</td>
<td>Slightly Reduced</td>
<td>Slightly Reduced</td>
</tr>
<tr>
<td></td>
<td>Area Ranking</td>
<td>Neutral</td>
<td>Neutral</td>
</tr>
</tbody>
</table>

**Notes:**
1. Projected future range maps were created for each species for every combination of future greenhouse gas trajectories (RCP)
2. Santa Cruz long-toed salamander likely has similar climate change projections as the Santa Lucia slender salamander
Focal and Non-Focal Mammal Species Climate Change Vulnerability Assessments

Stewart et al. (2016) conducted a climate change vulnerability assessment for 20 Californian mammal species for the 2080s. Species were assessed under two emission scenarios, RCP4.5 and RCP8.5, and two general circulation models: Warm and Wet, and Hot and Dry. Overall Climate Change Vulnerability Scores are calculated using each taxon’s projected geographic response score, exposure/niche breadth score, and qualitative vulnerability score. Species distribution models used occurrence locations and seven climatic and hydrological variables to project future climatic suitability at present-day occurrence locations. Although many areas this species currently occupies are projected to become unsuitable, it is likely to benefit from newly climatically suitable areas. Results for the San Joaquin kit fox are described in Table 3-7.

Table 3-7. San Joaquin Kit Fox Climate Change Vulnerability Assessment

<table>
<thead>
<tr>
<th>Species Distribution Model Results</th>
<th>Climate Change Vulnerability Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate Change Scenario</td>
<td>Percent Occurrence Locations Remaining Suitable</td>
</tr>
<tr>
<td>Low Emission (RCP4.5) Warm and Wet</td>
<td>99.13%</td>
</tr>
<tr>
<td>High Emission (RCP8.5) Warm and Wet</td>
<td>75.73%</td>
</tr>
<tr>
<td>Low Emission (RCP4.5) Hot and Dry</td>
<td>92.15%</td>
</tr>
<tr>
<td>High Emission (RCP8.5) Hot and Dry</td>
<td>26.01%</td>
</tr>
</tbody>
</table>

Hutto et al. (2015) conducted climate change vulnerability assessments for a variety of focal marine habitats and species. Species and habitats were assessed for Sensitivity, Exposure, and Adaptive Capacity. These results were combined to create an Overall Vulnerability Score. Variables used in the Sensitivity and Exposure analysis include climate and climate-driven factors, disturbance regimes, future climate exposure, life history, dependencies (generalist/specialist), and non-climate stressors. Variables
used in the Adaptive Capacity analysis include: extent, status, and dispersal ability, intraspecific/life history diversity, and management potential. Results for the southern sea otter are shown in Table 3-8.

Table 3-8. Southern Sea Otter Climate Change Vulnerability Assessment

<table>
<thead>
<tr>
<th>Sensitivity to Climate and Climate Driven Change</th>
<th>Sensitivity of Change in Disturbance Regimes</th>
<th>Sensitivity and Current Exposure to Non-Climate Stressors</th>
<th>Overall Vulnerability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salinity</td>
<td>Wind</td>
<td>Predation</td>
<td>Exposure</td>
</tr>
<tr>
<td>Sea Surface Temperature</td>
<td>Storms</td>
<td>Harvest of Prey</td>
<td>Sensitivity</td>
</tr>
<tr>
<td>Dynamic Ocean Conditions</td>
<td>Disease</td>
<td>Pollution and Poisons</td>
<td>Adaptive Capacity</td>
</tr>
<tr>
<td>Coastal Erosion</td>
<td></td>
<td></td>
<td>Overall Vulnerability</td>
</tr>
<tr>
<td>Dissolved Oxygen Levels</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wave Action</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Precipitation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Although no specific climate change vulnerability assessments exist for the focal and non-focal bat species, studies have been made to predict bat species responses to various climate stressors. An increase in the number of severe storms (Fellers and Halstead 2015) and increased periods of drought (Jones et al. 2009) may have detrimental effects on insect populations, leading to lower prey availability. An increase in overall winter temperatures could lead to negative effects during hibernation, by increasing energy needs, depleting fat reserves, and making bats more susceptible to fungal infections (Jones et al. 2009). Increasing temperatures (Jones et al. 2009) may cause some species to move farther north and increasing incidences of heat waves may threaten bats with direct and mass mortality (Sherwin et al. 2013).

No specific climate change vulnerability assessments exist for mountain lion and American badger. Mountain lion occurs in all habitat types and all regions in the RCIS area. Because of its use of a large variety of habitat types, it is less susceptible to changes in any one habitat type. Analysis conducted by Schloss et al. (2012) predicted the response of mammals based on their dispersal ranges (kilometers per year [km/yr]). Species with larger dispersal were predicted to be less vulnerable to climate change effects (Schloss et al. 2012). Mountain lion had one of the highest dispersal ranges (48.92 km/yr) and likely is able to keep pace with large-scale climate changes (Schloss et al. 2012). American badger also had a relatively high dispersal range (12.03 km/yr) and also is likely to be able to keep pace with large-scale climate changes (Schloss et al. 2012).
Focal Fish Species Climate Change Vulnerability Assessments

Moyle et al. (2012) conducted a climate change vulnerability assessment for all 121 native Californian fish species and 43 non-native species. Results for focal fish species are shown in Table 3-9. Three measures of vulnerability were assessed:

- **Baseline (present-day) vulnerability**: includes a variety of metrics, including current population size (in last 10 years), long-term population trends, and current vulnerability to stressors other than climate change,

- **Climate change vulnerability**: includes metrics such as physiological/behavioral tolerances to temperature increase nad precipitation changes, dispersal capability, and habitat specialization and,

- **Combined Vulnerability Ranking**: a score that indicates the overall likelihood of each species persistence into the next century.

Table 3-9. Focal Fish Species Climate Change Vulnerability Assessment

<table>
<thead>
<tr>
<th>Species</th>
<th>Baseline Vulnerability</th>
<th>Climate Change Vulnerability</th>
<th>Combined Vulnerability Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>steelhead (South-Central California Coast DPS)</td>
<td>Approaching Extinction</td>
<td>Highly Vulnerable</td>
<td>On Path to Extinction</td>
</tr>
<tr>
<td>tidewater goby</td>
<td>Approaching Extinction</td>
<td>Highly Vulnerable</td>
<td>On Path to Extinction</td>
</tr>
</tbody>
</table>

Hutto et al. (2015) also conducted a climate change vulnerability assessment on tidewater goby (Table 3-10). The analysis produced a ranking of Moderate-High for Sensitivity, High for Exposure, and Moderate-High for Adaptive Capacity. The species had a Final Rank Vulnerability (weighted score) of Moderate-High. The climate factors to which this species is most sensitive were determined to be precipitation and displacement from extreme storm events (Hutto et al. 2015).

Table 3-10. Tidewater Goby Climate Change Vulnerability Assessment

<table>
<thead>
<tr>
<th>Sensitivity to Climate and Climate Driven Change</th>
<th>Sensitivity of Change in Disturbance Regimes</th>
<th>Sensitivity and Current Exposure to Non-Climate Stressors</th>
<th>Overall Vulnerability</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH Sea Level Rise</td>
<td>Flooding</td>
<td>Invasive Species</td>
<td>Sensitivity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Land Use Change</td>
<td>Exposure</td>
</tr>
<tr>
<td>Coastal Erosion</td>
<td></td>
<td></td>
<td>Adaptive Capacity</td>
</tr>
<tr>
<td>Precipitation</td>
<td></td>
<td></td>
<td>Overall Vulnerability</td>
</tr>
</tbody>
</table>
Focal and Non-Focal Vernal Pool Species Climate Change Vulnerability Assessment

Limited climate change vulnerability assessments have been done for vernal pool species, and many have been region-specific. An analysis conducted by Anacker and Leidholm (2012) on a subset of rare California plants included the Lost Hills crownscale (*Atriplex coronata* var. *vallicola*), which is a vernal pool species found in Monterey County. This analysis concluded that the species is Highly Vulnerable, meaning the abundance and range extent within the geographical area that was assessed is likely to decrease significantly by 2050. Because many vernal pool species can be affected by climate stressors in similar ways, Lost Hills crownscale can be used as a likely indicator of how focal vernal pool species, Contra Costa goldfields and vernal pool fairy shrimp, may be affected by climate change.

Focal and Non-Focal Plant Species Climate Change Vulnerability Assessments

The 2012 analysis by Anacker and Leidholm on a subset of rare California plants included Yadon’s rein orchid. Using distributional and natural history information to obtain vulnerability scores, this species was given a score of Extremely Vulnerable. This means that the abundance and/or range extent within the assessed geographical area would be extremely likely to substantially decrease or disappear by 2050. Anacker and Leidholm also created modelled range maps, which project a near total range loss for Yadon’s rein orchid. (Anacker and Leidholm 2012).

No specific climate change vulnerability assessment exists for eelgrass. Because eelgrass is a keystone species in estuarine habitats, climate change vulnerability assessments of this habitat type can be used as a likely indicator of how eelgrass may be affected by climate change. An analysis by Hutto et al. of estuarine habitats produced a rank of Moderate-High for Sensitivity, High for Exposure, and Moderate-High for Adaptive Capacity (Table 3-11). Estuarine habitats had a Final Rank Vulnerability (weighted score) of Moderate-High. Key factors for eelgrass health included water clarity and quality, greatly affected by human activities and land use pressures (Hutto et al. 2015).
Table 3-11. Estuarine Habitat Climate Change Vulnerability Assessment

<table>
<thead>
<tr>
<th>Sensitivity to Climate and Climate Driven Change</th>
<th>Sensitivity of Change in Disturbance Regimes</th>
<th>Sensitivity and Current Exposure to Non-Climate Stressors</th>
<th>Overall Vulnerability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic Ocean Conditions</td>
<td>Storms</td>
<td>Coastal Roads/Armoring</td>
<td>Sensitivity</td>
</tr>
<tr>
<td>Salinity</td>
<td>Flooding</td>
<td>Invasive Species</td>
<td>Exposure</td>
</tr>
<tr>
<td>Turbidity</td>
<td>Disease</td>
<td>Overwater/Underwater Structures</td>
<td>Adaptive Capacity</td>
</tr>
<tr>
<td>Air Temperature</td>
<td></td>
<td>Land Use Change</td>
<td>Overall Vulnerability</td>
</tr>
<tr>
<td>Dissolved Oxygen Levels</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coastal Erosion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sea Surface Temperature</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wave Action</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Precipitation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sea Level Rise</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

No specific climate change vulnerability assessments exist for the other focal/non-focal plant species. The climate change vulnerability assessment of natural terrestrial communities (Thorne et al. 2016; Appendix B) can be used for indicators of how these species may fare with climate change.

**Focal and Non-Focal Avian Species Climate Change Vulnerability Assessments**

Gardali et al (2012) conducted climate change vulnerability assessments for 358 at-risk California bird species and identified those vulnerable to climate change (Table 3-12). Sensitivity factors that were assessed included:

- **Habitat specialization**: defined by nesting requirements in California;
- **Physiological tolerances**: using theoretical approaches (e.g., thermal range normally experienced by species);
- **Migratory status**: classified as long-distance (migrations between temperate and tropical zones), short-distance (migrations restricted to North American/northern Mexico), or resident (do no migrate); and
• **Dispersal ability**: classified as being high (nomadic or migratory), medium (generally non-migratory, although possessing the ability to move moderately long distances), or low (generally non-migratory, sedentary species).

Exposure factors that were assessed included:

• **Changes in habitat suitability**: using habitat suitability models developed for California species;

• **Changes in food availability**: showing the relationship between climate and food for most species as being very complicated and generating scores of low confidence; and

• **Changes in extreme weather**: relying on literature to inform what extreme weather each taxon may experience throughout its range.

Habitat specialization is the primary sensitivity factor negatively affected by climate change. Most focal and non-focal species have High vulnerability in this category, meaning that the species are dependent on specific habitat types or elements. The Western snowy plover, least Bell’s vireo, and yellow-billed magpie are included in the Climate Change Vulnerability Priority list, meaning that they were among the group of taxa with the highest rank (25 percent) of all scores. These taxa then were ranked into levels of climate change priority by identifying natural breaks in the distribution of vulnerability scores. A summary of all the results is shown in Table 3-12.
### Table 3-12. Focal and Non-Focal Avian Species Climate Change Vulnerability Assessments

<table>
<thead>
<tr>
<th>Species</th>
<th>Exposure</th>
<th>Sensitivity</th>
<th>Climate Vulnerability Priority List</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Habitat Suitability</td>
<td>Food Availability</td>
<td>Extreme Weather</td>
</tr>
<tr>
<td>Focal species</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>burrowing owl¹</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>California condor</td>
<td>Low</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>tricolored blackbird¹</td>
<td>Moderate</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>western snowy plover</td>
<td>Moderate</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Non-Focal species</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>least Bell’s vireo</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>little willow flycatcher</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>yellow-billed magpie¹</td>
<td>High</td>
<td>Low</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

**Notes:**
1. Gardali et al. (2012) created projected future species range maps for two different climate models.
2. Analysis conducted by Hutto et al. (2015) addressed sensitivity, exposures, and adaptive capacity for this species, which resulted in a final vulnerability ranking (weighted score) of Moderate-High.
Natural Communities Climate Change Vulnerability Assessment

Because some species do not have specific climate change vulnerability assessments, the natural communities in which they occur can be used as a likely indicator of the species’ responses to climate change. Thorne et al. (2016) conducted climate change vulnerability assessments for 31 terrestrial vegetation macrogroups in California. The results from vegetation communities occurring in the RCIS area are provided in Appendix B. Montane chaparral and vernal pool natural communities were not included due to lack of adequate spatial data, and marine communities were not included the study scope. The analysis included a variety of measures of vulnerability:

- **Sensitivity and Adaptability Rank**: Scores for individual species that made up each macrogroup were derived from life history traits. Scores from each species were combined to create a single Sensitivity and Adaptability Rank for the vegetation community.

- **Climate Exposure and Spatial Disruption Rank**: Climate exposure assessed how the area each vegetation community occupies is expected to change under various future climate projections and used nine hydro-climatic variables. Spatial disruption modeled the expected shifts in area currently occupied by each group using six hydro-climatic variables.

- **Mean Combined Vulnerability Rank**: Measures of sensitivity, exposure, and spatial disruption were combined into an index of vulnerability, for comparison of macrogroups.

The assessment also included the results from different future climate models, and many results were the same for both models. Where differences occurred, the specific model is identified.

Ecological Climate Resilience

As shown in Figure 3-1, most of the RCIS area has an ACE Climate Resilience Score of either 4 or 5, indicating high resiliency potential to projected climate changes. Coastal areas, such as Elkhorn Slough, Monterey Bay, and San Jose Creek south to the Santa Lucia Range, as well as inland patches within Los Padres National Forest, Northern Camp Roberts, and the Carmel Valley, show low-medium to medium resiliency potential. No locations in the RCIS area have the lowest resiliency potential.

Areas that have high scores for species biodiversity, significant habitats, terrestrial connectivity, and climate resilience include Fort Ord National Monument, Fort Hunter Ligget, and areas in the Santa Lucia Range.
Areas of Conservation Emphasis (ACE), CDFW (2018)

Transportation Agency for Monterey County
Monterey County Regional Conservation Investment Strategy

Climate Resilience
Transportation Infrastructure Results

This section describes the results of a high-level vulnerability assessment, focused on potential exposure and climate change impacts on the transportation infrastructure in the RCIS area. The results are the culmination of climate vulnerabilities that were identified in previous studies and the findings of a high-level mapping evaluation of infrastructure in areas vulnerable to sea level rise, from flooding and wildfire exposure.

Sea Level Rise

A high-level assessment of the exposure to sea level rise was performed using inundation maps to evaluate the potential vulnerability of transportation infrastructure to daily tidal inundation and temporary storm flooding (Figure 3-2, Figure 3-3, Figure 3-4, Figure 3-5, Figure 3-6). A “no action” scenario was assumed to examine the effect of not implementing strategies to protect existing assets.

Sea level rise inundation exposure of all transportation infrastructure would be limited to Elkhorn Slough (Figure 3-5) and the portion of the city of Monterey adjacent to Del Monte Beach (Figure 3-6). By mid-century, large portions of Elkhorn Slough’s low-lying salt marshes are projected to be flooded, exposing numerous stretches of highways, primary arterials, main roads owned and maintained by the Transportation Agency for Monterey County, and rail lines. By end-of-century, flooded areas of Elkhorn Slough are projected to expand and cover a larger region, and to begin to expose waterfront roadways in the city of Monterey from overtopping along the low-lying shoreline of Del Monte beach. Table 3-7 summarizes the analysis of sea level inundation exposure by transportation asset type (i.e., highways, major roads, and rail lines), with approximate mileage of the exposed network.
FIGURE 3-2

2050 (RCP8.5) Sea Level Rise Scenario

Transportation Agency for Monterey County
Monterey County Regional Conservation Investment Strategy
FIGURE 3-3
2100 (low risk aversion, RCP8.5)
Sea Level Rise Scenario
FIGURE 3-4
2100 (medium-high risk aversion, RCP8.5)
Sea Level Rise Scenario
Elkhorn Slough Sea Level Rise Detail

2050 (RCP8.5) Sea Level Rise Scenario
- 2 ft - Sea Level Rise
- 5 ft - Sea Level Rise + 100-yr Storm Tide

2100 (low risk aversion, RCP8.5) Sea Level Rise Scenario
- 3 ft - Sea Level Rise
- 6 ft - Sea Level Rise + 100-yr Storm Tide

2100 (medium-high risk aversion, RCP8.5) Sea Level Rise Scenario
- 7 ft - Sea Level Rise
- 10 ft - Sea Level Rise + 100-yr Storm Tide
FIGURE 3-6
City of Monterey Sea Level Rise Detail

2050 (RCP8.5)

2100 (low risk aversion, RCP8.5)

2100 (medium-high risk aversion, RCP8.5)

2050 (RCP8.5) Sea Level Rise Scenario
- 2 ft - Sea Level Rise
- 5 ft - Sea Level Rise + 100-yr Storm Tide

2100 (low risk aversion, RCP8.5) Sea Level Rise Scenario
- 3 ft - Sea Level Rise
- 6 ft - Sea Level Rise + 100-yr Storm Tide

2100 (medium-high risk aversion, RCP8.5) Sea Level Rise Scenario
- 7 ft - Sea Level Rise
- 10 ft - Sea Level Rise + 100-yr Storm Tide

Planned Railroad
- Planned Transportation Projects
- Monterey County RCS Area
- Existing Railroad
- Existing Roadway
- Main Roads

Monterey Bay
Seaside
Sand City
Pacific Grove
Monterey
Monterey County (2019)
Association of Monterey Bay Area Governments (2019)
Caltrans (2019)
National Oceanic and Atmospheric Administration (2017)
Table 3-13. Summary of Transportation Infrastructure Exposure to Sea Level Rise Impacts

<table>
<thead>
<tr>
<th>Transportation Assets in the RCIS area</th>
<th>Sea Level Rise Scenarios</th>
<th>2-feet Sea Level Rise (Mid-Century)</th>
<th>3-feet Sea Level Rise (End-of-Century)</th>
<th>7-feet Sea Level Rise (End-of-Century)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Daily Tidal Inundation</td>
<td>Temporary Storm Flooding</td>
<td>Daily Tidal Inundation</td>
<td>Temporary Storm Flooding</td>
</tr>
<tr>
<td>Highways</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>State Route 156 (Elkhorn Slough area)</td>
<td>0.2 mile</td>
<td>0.9 mile</td>
<td>0.2 mile</td>
<td>1.6 miles</td>
</tr>
<tr>
<td>State Route 183 (Elkhorn Slough area)</td>
<td>0.1 mile</td>
<td>0.1 mile</td>
<td>0.1 mile</td>
<td>0.1 mile</td>
</tr>
<tr>
<td>State Route 1 (Elkhorn Slough area)</td>
<td>2.7 miles</td>
<td>7.2 miles</td>
<td>4.5 miles</td>
<td>8.1 miles</td>
</tr>
<tr>
<td>Main Roads</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lighthouse Ave (City of Monterey)</td>
<td></td>
<td></td>
<td></td>
<td>0.2 mile</td>
</tr>
<tr>
<td>Franklin St (City of Monterey)</td>
<td></td>
<td></td>
<td></td>
<td>0.4 mile</td>
</tr>
<tr>
<td>Del Monte Ave (City of Monterey)</td>
<td></td>
<td></td>
<td></td>
<td>0.7 mile</td>
</tr>
<tr>
<td>Fremont St (City of Monterey)</td>
<td></td>
<td></td>
<td></td>
<td>0.03 mile</td>
</tr>
<tr>
<td>Del Monte Ave: planned future projects (City of Monterey)</td>
<td></td>
<td></td>
<td></td>
<td>0.2 mile</td>
</tr>
<tr>
<td>Rail Lines</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amtrak-Coast Starlight (Elkhorn Slough area)</td>
<td>8.7 miles</td>
<td>13.7 miles</td>
<td>11.3 miles</td>
<td>13.7 miles</td>
</tr>
<tr>
<td>Amtrak-Coast Starlight: planned future projects (Elkhorn Slough area)</td>
<td>6.5 miles</td>
<td>8.5 miles</td>
<td>6.5 miles</td>
<td>0.5 mile</td>
</tr>
</tbody>
</table>

Potential impacts on roadways (highways and main roads) include the following.

**Temporary Storm Flooding:**
- Temporary road closure during large storm events;
- Scour of road banks from high velocity storm flows;
- Limited access to neighborhoods or commercial areas during storm events;
Extended travel time for passengers required to drive inland around the Elkhorn Slough area;

Large-scale effects on commercial shipping dependent on corridors;

Repeated flooding, which may decrease the useful life and increase the maintenance frequency/costs;

Increased emergency response times from road closure

Increased erosion of coastal bluffs, creating the potential for local road failure and transporation infrastructure damage; and

Coastal storm events that may undercut coastal bluffs, creating landslides that can cause local roadways failure and transporation infrastructure damage.

Daily Tidal Inundation:

Long-term inundation, interrupting the roadway network, affecting access to housing, jobs, tourism, commercial areas, shipping, and emergency response;

Erosion of roadway infrastructure, with prolonged inundation of the base of coastal bluffs that may increase erosion, creating the potential for local road failure and transporation infrastructure damage; and

Higher water levels at the base of coastal bluffs that may increase the chance of landslides, creating the potential for local road failure and transporation infrastructure damage.

Potential impacts on rail lines include the following.

Temporary Storm Flooding:

Delayed or canceled passenger and freight service during large storm events;

Power switches, derails, and signals associated with railways may be damaged; and

Scour of railway foundations from high velocity storm flows.

Daily Tidal Inundation:

Long-term inundation, leaving the railway inoperable and affecting regional and statewide public transportation, freight service, the regional and state economy, and possible social consequences by loss of access to jobs in the region; and

Erosion of railway foundations.
Wildfire

A high-level assessment of exposure to wildfires was conducted, using fire hazard severity zones developed by CAL FIRE (2007) to evaluate the potential vulnerability of transportation infrastructure to seasonal wildfire risk. Fire severity zones consider a variety of factors influencing fire behavior, including fire history, natural vegetation, flame length, topography, blowing embers, and typical weather for the area.

Wildfire risk generally is highest along the north coast of Monterey County, between the Carmel Highlands and Santa Lucia range, and along the mountain crests west of the Salinas Valley (Figure 3-7). High and moderate wildfire risks exist, primarily along the southern inland areas of the RCIS area. Table 3-8 summarizes highways, main roads, and rail ways that traverse areas that are highly prone to wildfires.
FIGURE 3-7
Fire Hazard Severity Zones
Table 3-14. Summary of Wildfire Risks for Transportation Assets

<table>
<thead>
<tr>
<th>Monterey County Transportation Assets</th>
<th>Wildfire Hazard Severity Zones</th>
<th>Moderate</th>
<th>High</th>
<th>Very High</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Highways</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>State Route 68 (near Corral De Tierra)</td>
<td>1.9 miles</td>
<td>6.7 miles</td>
<td>8.3 miles</td>
<td></td>
</tr>
<tr>
<td>State Route 25 (near Lonoak)</td>
<td>9.8 miles</td>
<td>12.1 miles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>State Route 1 (Elkhorn Slough area)</td>
<td>34.4 miles</td>
<td>17.7 miles</td>
<td>65.8 miles</td>
<td></td>
</tr>
<tr>
<td>U.S. Highway 101 (Elkhorn Slough area)</td>
<td>55.5 miles</td>
<td>27.2 miles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>State Route 146 (near Harlem)</td>
<td>3.0 miles</td>
<td>6.7 miles</td>
<td>5.7 miles</td>
<td></td>
</tr>
<tr>
<td>State Route 198 (near Priest Valley)</td>
<td>22.4 miles</td>
<td>34.3 miles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>State Route 68: Planned future project (near Corral De Tierra)</td>
<td></td>
<td></td>
<td>2.2 miles</td>
<td></td>
</tr>
<tr>
<td>U.S. Highway 101: Planned future project (near Prunedale)</td>
<td></td>
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<td><strong>Main Roads</strong></td>
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<td>Holman Highway: Planned future project (near Carmel Woods)</td>
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<td><strong>Rail Lines</strong></td>
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<td>Amtrak-Coast Starlight (Elkhorn Slough area)</td>
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<td>Amtrak-Coast Starlight: Planned future project (Elkhorn Slough area)</td>
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</table>

Potential impacts on roadways (highways and major roads) include:

- Impassable roads because of wildfire and smoke;
- Increased emergency response times because of road closures;
- Limited access to neighborhoods or commercial areas during and after fires;
- Landslides that may follow fire events, damaging roadways;
- Extended travel time for passengers required to drive around areas affected by fires; and
- Large-scale effects on commercial shipping that are dependent on corridors.

Potential impacts for rail lines include:
- Delayed or canceled passenger or freight service during fires;
- Power switches, derails, and signals associated with railways may be damaged;
- Landslides that may follow fire events, damaging railways;
- Wooden ties along rail line may sustain damage, if in direct line of wildfire; and
- Direct wildfire impacts leaving railway inoperable, affecting regional and statewide public transportation, freight and passenger service, the regional and state economy, and possible social consequences from loss of access to jobs in the region.

**Extreme Heat**

A review of previously completed and ongoing climate studies in the RCIS area was performed to understand the potential impacts that extreme heat poses on regional transportation infrastructure. Although all transportation assets are exposed to the same amount of incoming solar radiation, the dark surfaces of asphalt roadways and rail lines increase their exposure to extreme heat. Increasing temperatures can have considerable impacts on transportation infrastructure, particularly when temperatures exceed conditions for which the system has been designed. Transportation infrastructure traversing inland areas is particularly vulnerable to extreme heat, because inland areas have higher temperatures than coastal areas. Prolonged roadway exposure to extreme heat may include the following impacts:

- Early deformation or buckling of asphalt roadways, leading to safety issues, temporary road closures, or higher costs of infrastructure maintenance and repairs (Daniel et al. 2013);
- Increased emergency response times because of road closure during repairs;
- Increased travel time during road repairs; and
- An increase in the number of roadway accidents or, in an extreme scenario, hazardous waste spillage.

Potential impacts on rail lines include:

- Railway buckling or kinking because of metal expansion;
- Possible derailment from railway deformation;
- Increased maintenance, repair, and inspection costs; and
- Delayed passenger or freight service during heat speed restrictions, which may become more frequent and occur for longer durations.

---

1 Dark surfaces absorb more solar radiation, elevating local surface temperatures and increasing exposure to extreme heat.
4. DISCUSSION

4.1 Species, Natural Communities, and Other Conservation Elements

Stressors and Pressures

Habitat Loss

One of the primary causes of habitat loss and degradation in the RCIS area is the conversion of natural lands into urban and agricultural uses. Increasing human populations are putting increased demands on already limited supplies of land, water, and other natural resources (CDFW 2015). Focal species that already have a restricted range and/or are endemic to the RCIS area—monarch butterfly, Smith’s blue butterfly, Santa Cruz long-toed salamander, Hickman’s onion, Monterey gilia, Monterey spineflower, Pajaro manzanita, and Yadon’s rein orchid—increasingly will be negatively affected by habitat loss and degradation. These species also are associated with some of the most vulnerable natural communities to climate change. Beyond direct land conversion, increased human use of the landscape will bring additional stressors, such as invasive species, fire suppression, and insect control, further degrading natural community health (CDFW 2015).

Habitat Connectivity and Wildlife Corridors

The loss of habitat connectivity and increased habitat fragmentation will have a major impact on wildlife and natural communities in the RCIS area. Development of agricultural and urban areas, especially installation of new of linear features (e.g., roads and utility lines) can affect plant and wildlife dispersal and predator–prey relationships, leading to increased mortality and genetic isolation. Focal species such as mountain lion can be used as an indicator of healthy connectivity between different terrestrial habitat types, because of its occurrence in all the natural communities in the RCIS area and its large dispersal range.

Aquatic species are limited in their abilities to bypass connectivity barriers. Improving fish passage throughout riparian corridors can increase habitat connectivity for steelhead and other water-bound species. Furthermore, healthy connectivity between freshwater and saltwater habitats is important for the many aquatic and terrestrial species in the RCIS area that use both habitats.
In addition to providing habitat for aquatic species, riparian areas provide shade, water, and upland habitat for many terrestrial species. Riparian habitats disproportionately contribute to regional species richness (Krosby et al. 2018). These areas have the potential to act as dispersal corridors for both terrestrial and aquatic species because they often span multiple climatic gradients (Krosby et al. 2018). Riparian corridors in forested areas can reduce the effects of climate exposure by providing air and water temperature refugia (Klausmeyer et al. 2011). Conservation strategies focusing on maintaining connectivity between various riparian habitats in the RCIS area have the potential to create future climate refugia for vulnerable species and maintain current species richness.

**Non-Native Species**

Non-native species can have devastating impacts on species that already are experiencing negative pressures from other non-climate and climate stressors. Invasive plants can be found in a variety of natural communities, such as grasslands, riparian, oak woodlands, and coastal communities, and they tend to dominate in brackish aquatic habitats (CDFW 2015). By outcompeting and displacing native plant communities, these invasive species often provide inferior habitat for native wildlife (CDFW 2015). Invasive wildlife species occur in both terrestrial and aquatic natural communities and often have negative impacts on native species. For example, Monterey County is the epicenter of hybridization between California tiger salamander and the invasive barred tiger salamander.

**Recreation and Tourism**

As nature-based recreation and tourism has boomed in popularity, recognizing and addressing the negative impacts on species and natural communities is important. Hiking, walking, and mountain biking can lead to a reduction in vegetation cover, changes in species composition, and the introduction and spread of non-native species (Sumanapala and Wolf 2019). Long-term impacts, such as decline in plant growth, flowering, and seed production, also have been documented (Sumanapala and Wolf 2019). Increased encounters with wildlife from motorized and non-motorized recreational activities in both aquatic and terrestrial communities have been documented to have significant negative effects on all taxonomic groups (Larson et al. 2016).

**Climate Change Vulnerability**

The following focal and non-focal species ranked as Moderate and above in species-specific climate change vulnerability assessments and/or occupy natural communities that have a High Combined Vulnerability rank. These species are the most vulnerable to climate change in the RCIS area:

- **Amphibians and Reptiles:** California tiger salamander, Santa Cruz long-toed salamander, and Santa Lucia slender salamander
• **Mammals:** Southern sea otter and San Joaquin kit fox
• **Fish:** Steelhead and tidewater goby
• **Birds:** Western snowy plover, least Bell’s vireo, and tricolored blackbird
• **Invertebrates:** Vernal pool fairy shrimp and California brackish water snail
• **Plants:** Yadon’s rein orchid, Contra Costa goldfields, and eelgrass

The following focal species discussed below represent some of the most widespread and/or vulnerable habitats in the RCIS area: steelhead, Western snowy plover, and California red-legged frog. Conservation strategies focusing on these important indicator species have the potential to affect a large number of other focal and non-focal species that are vulnerable to the impacts of climate change.

**Steelhead**

Steelhead are an important indicator for the health of riparian and freshwater aquatic habitats because they are negatively affected by pressures such as urban wastewater, agriculture and forestry effluents, and dams and water management/use. Conservation strategies targeting steelhead population health, such as restoring flows and instream habitat conditions (NMFS 2013), can have large impacts on the health of riparian and freshwater aquatic systems. Restoration of riparian and steelhead habitats can provide substantial benefits for human communities, such as improving water quality and reducing flood damage (NMFS 2013).

Conservation strategies focusing on riparian communities are important because they are some of the most vulnerable habitats to climate change. Although representative plant species used in the climate change vulnerability assessment from riparian habitats are moderately sensitive (e.g., to temperature and fire), they have more developed life history traits to respond to climate stressors (Thorne et al. 2016). These communities have a Combined Vulnerability Ranking of Mid-High to climate change impacts. The projected effects of climate exposure and modelled spatial disruption are significant enough that it will be difficult for these communities to adapt to changing climate conditions.

**Western Snowy Plover**

Western snowy plover can be used as an indicator of coastline natural communities. This species has a Moderate ranking on the climate change priority list (Gardali et al. 2012) and a high dispersal ability (USFWS 2007). The high dispersal ability will allow this species to move to newly suitable coastline habitat in the RCIS area. Coastal natural communities in the RCIS area are some of the most at-risk to the effects of climate change and are projected to have some of the greatest losses in current spatial distribution. In addition, the representative plant species used in the climate change vulnerability assessments for these communities are not very adaptable (Thorne et al. 2016). When combined with
projected impacts of sea level rise and changes in temperature and precipitation, coastal natural communities are very vulnerable to climate change. Conservation strategies targeting non-climate stressors, such as recreation, land use changes, pollution, and invasive species, can help create new areas of suitable habitat that will help reduce the pressures of climate change on Western snowy plover.

**California Red-Legged Frog**

California red-legged frog habitats are projected to experience neutral impacts from climate change. The California Amphibian and Reptile climate change vulnerability assessment projects that 80 to 100 percent of its currently occupied area in California will remain, and the amount of suitable habitat is expected to increase/decrease no more than 20 percent (Wright et al. 2013). This species occupies a wide range of habitats, and successful conservation measures are in place throughout the RCIS area.

California red-legged frog can serve as a flagship species for other, more highly vulnerable amphibians in the RCIS area. California red-legged frog conservation strategies have the potential to positively affect other focal species, such as California tiger salamander, foothill yellow-legged frog, Santa Cruz long-toed salamander, steelhead, tidewater goby, and tricolored blackbird, as well as affect several non-focal species (USFWS 2002). California red-legged strategies can offer important protection for highly climate vulnerable California tiger salamander and Santa Cruz long-toed salamander.

The California amphibian and reptile climate change vulnerability assessment projects future California tiger salamander range decreases of 50 to 99 percent across California by 2050, under high emission scenarios (Wright et al. 2013). Santa Cruz long-toed salamander, which was not included in the climate change vulnerability assessment by Wright et al. (2013), is likely to have similar reductions in range because of its highly restrictive current range. The USFWS Recovery Plan (USFWS 2017) for California tiger salamander identifies climate stressors, such as increased periods of drought and higher temperatures, that can reduce the availability of breeding ponds and favor the life history of non-native species. Santa Cruz long-toed salamander and other salamanders in the RCIS area are likely to be affected by similar climate stressors.

These species also are susceptible to most of the non-climate stressors that have been identified in the RCIS area, such as linear features, non-native species, and disease. The California red-legged frog Recovery Strategy already addresses many of these non-climate stressors (USFWS 2002). Increased implementation of these strategies across the RCIS area, focusing on habitats with vulnerable salamanders, can have an increasingly positive impact as range contractions for these species occur.
4.2 Ecological Resilience

Areas identified as having high ecological climate resilience, among other ecological factors, include the Fort Ord National Monument, Fort Hunter Liggett, Northern Camp Roberts, Santa Lucia Range, Los Padres National Forest, and Cholame Valley. According to the ACE dataset (CDFW 2018b), these locations are projected to remain as suitable habitat for native species, and to continue to support high biodiversity, significant habitats, and habitat connectivity.

4.3 Transportation Infrastructure Vulnerability

In the RCIS area, climate change is projected to pose an increasing risk for transportation infrastructure, primarily through more severe, frequent flooding, an increase in the intensity and extent of areas prone to wildfires, and infrastructure damage because of extreme heat days. Although the transportation infrastructure in the RCIS area has been designed to accommodate a large range of climatic conditions, it often is disrupted by natural disasters that will be exacerbated by climate change. Projected exposure to climate hazards will affect the reliability and capacity of transportation networks, while also increasing the cost of the transportation system through more frequent maintenance and replacement of physical assets.

Transportation infrastructure in Elkhorn Slough and the along the oceanfront areas of the city of Monterey was identified as highly vulnerable to rising sea levels because of coastal flood exposure. Sections of roadways and rail lines running through Elkhorn Slough already are flooded routinely during spring tide conditions, causing traffic and operational disruptions. Sea level rise also will influence coastal erosion, which was not evaluated in this assessment, but will have large implications for the transportation assets in the RCIS area. Much of the coastline is characterized by a series of eroding coastal cliffs and generally is undeveloped, except the scenic and popular State Route 1, which traces much of the cliff’s edge. Although considerable uncertainty exists in historic cliff erosion rates and their shoreline variability because of limited data availability, many studies agree that sea levels will exacerbate future erosion rates (City of Monterey 2016; USGS 2007). Landslides commonly affect State Route 1 access and recently have triggered landward relocation of a section of the roadway in neighboring San Luis Obispo County.

Fluctuations in the hydrological cycle resulting from increases in temperatures, changes in precipitation patterns, and increased durations and frequency of drought conditions also are projected to affect the potential for wildfires across the RCIS area. Monterey County is connected by a series of major highways, main roads serving as arterials to cities and towns, and a rail network that provides access to the region. All of these transportation assets pass through or are in close proximity to forested areas that are prone to strong wildfires, particularly highways traversing remote mountain areas. Even if the
physical infrastructure would not be directly affected by fire damage, secondary effects, such as severe flooding, debris flows, landslides, and downed trees also may disrupt use of roadways and rail throughout the RCIS area.

As temperatures continue to increase through this century, highway and rail infrastructure may be affected by extreme heat days during the summer. For highways, the primary impact of extreme heat exposure may be an accelerated degradation of asphalt roadway materials. For rail, extreme heat may cause kinking or buckling of the rail line, which will affect the safety of rail operations. The potential for extreme heat impacts is highest for highways and rail lines traversing the inland RCIS area, which has higher temperatures than the coastal region.
DRAFT Focal Species Stressors and Pressures

5. REFERENCES


Appendix A. Non-Focal Species and Other Conservation Elements Stressors and Pressures
<table>
<thead>
<tr>
<th>Species</th>
<th>Airborne Pollutants</th>
<th>Dams and Water Management /Use</th>
<th>Housing and Urban Areas</th>
<th>Livestock, Farming, and Ranching</th>
<th>Recreation and Tourism</th>
<th>Renewable Energy</th>
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**Focal Other Conservation Elements**

**Non-Focal Other Conservation Elements**

**Notes on additional stressors and pressures on non-focal species not identified in the State Wildlife Action Plan:**

1. The Draft Recovery Plan for the Least Bell’s Vireo (1998) describes recreational developments as being a major contributor to habitat loss.
Appendix B. Vegetation Community Climate Change Vulnerability Results
### Summary of Focal and Non-Focal Species and Other Conservation Elements

**Natural Communities Climate Change Vulnerability**

<table>
<thead>
<tr>
<th>Species</th>
<th>Natural Communities</th>
<th>Mean Combined Vulnerability Rank</th>
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<td></td>
<td>Low Emissions (RCP4.5)</td>
<td>High Emissions (RCP8.5)</td>
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<td>Focal Wildlife Species</td>
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<td>Annual Grassland</td>
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<td>Mid-High</td>
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<tr>
<td></td>
<td>Coastal Scrub</td>
<td>Low (Warm and Wet)</td>
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<tr>
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<td>Moderate</td>
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(All values represent combined vulnerability rankings, with categories ranging from Low to High, and subcategories for conditions such as 'Hot and Dry'.)
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Non-Focal Plant Species

Non-Focal Other Conservation Elements

Coastal Oak Woodland | Coastal Oak Woodland | Moderate | Moderate |
### Species Stressors and Pressures

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### Natural Communities Climate Change Vulnerability Assessments Under a Low Emission (RCP4.5) Scenario

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<th>Climate Exposure and Spatial Disruption Rank</th>
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**Note:** The table shows the mean combined vulnerability ranks for different natural communities under low and high emission scenarios. The sensitivity and adaptability ranks are categorized as Moderate, Mid-High, and Low, with corresponding climate exposure and spatial disruption ranks.
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<td>Saline Emergent Wetland Wet Meadow</td>
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<td>Wet Mountain Meadow</td>
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<td>Mid-High</td>
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</table>

**Tree – Evergreen**

| Coastal Oak Woodland                   | California Foothill and Valley Forests and Woodlands       | Moderate                         | Moderate                                     | Moderate                     |
|                                        | California Foothill and Valley Forests and Woodlands       | Moderate                         | Moderate                                     | Moderate                     |

**Wetland**

| Riparian                               | American Southwest Riparian Forest and Woodland¹²          | Moderate                         | Moderate                                     | Moderate                     |
| Salt Marsh Meadows                     | Moderate                                                       | High                             | High                                        | High                         |
| Wet Mountain Meadow                    | High                                                           | Mid-High                         | Mid-High                                     |                             |
### Monterey County RCIS Natural Community

<table>
<thead>
<tr>
<th>Monterey County RCIS Natural Community</th>
<th>United States National Vegetation Classification (common name)</th>
<th>Sensitivity and Adaptability Rank</th>
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<tr>
<td>Rocky Outcroppings</td>
<td>California Foothill and Coastal Rock Outcrop Vegetation</td>
<td>Mid-High</td>
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<td>Moderate (Hot and Dry)</td>
<td>Mid-High (Hot and Dry)</td>
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**Notes:**

1. Analysis conducted by Hutto et al. (2015) addressed sensitivity, exposure, and adaptive capacity for “Beaches and Dune” habitats, resulting in a final ranked vulnerability (weighted score) of Moderate-High.
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Natural Communities Climate Change Vulnerability Assessments Under a High Emission (RCP8.5) Scenario

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<td>Moderate (Warm and Wet)</td>
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