CENTRAL COAST



CALIFORNIA'S FIFTH
CLIMATE CHANGE
ASSESSMENT

Central Coast Regional Report

A Regional Report for California's Fifth Climate Change Assessment

Coordinating Agency

CA Governor's Office of
Land Use and
Climate Innovation

About California's Fifth Climate Change Assessment

California's Climate Change Assessments are the state's scientific foundation for understanding future climate-related vulnerability across California's regions and systems. Senate Bill 1320 (Stern, 2020) requires the State to report the impacts and risks of climate change across California at least every five years, beginning with California's Fifth Climate Change Assessment (Fifth Assessment). Building on decades of climate research and previous Assessments, the Fifth Assessment presents new findings about California's climate future, with a dedicated focus on Tribal partnerships, public engagement, and communities most vulnerable to climate impacts.

The Fifth Assessment's research and tools are designed to fill knowledge gaps about California's climate future, inspire strategic climate actions, and shape planning, investments, and policies at the state, regional, and local scales. Guided by research priorities identified by state, Tribal, and local leaders, community representatives, and subject matter experts, its findings are designed to help illuminate potential climate futures, the challenges they may present, and the opportunities to build resilience through adaptation pathways.

For the full suite of Fifth Assessment research products, please visit: www.ClimateAssessment.ca.gov.

Purpose of the Regional Reports

The Fifth Assessment Regional Reports bring together the latest climate science, community input, and adaptation opportunities to meet the needs of communities across nine California regions. These reports can inform regional and local vulnerability assessments, adaptation planning, and community resilience efforts. The Regional Reports include analyses of climate projections and impacts to natural systems, built systems, and social systems. They uplift case studies of adaptation solutions and highlight developments that have emerged since the Fourth Assessment was released in 2018. While climate impacts are felt across regional boundaries, the Regional Reports deepen our understanding of how climate change interacts with the unique communities, histories, waters, and landscapes across California.

Climate Modeling, Scenarios, & Time Periods

The Fifth Assessment Regional Reports consider the following climate models, greenhouse gas (GHG) emissions scenarios, and time periods:

- **CMIP6** (Coupled Model Intercomparison Project Phase 6) is the most recent version of a global collaboration that standardizes and combines the most advanced climate models to project how Earth's systems will react to our changing atmosphere. With CMIP6, we can see the most likely climate trends and the less likely, but still possible, extremes.
- **Greenhouse Gas Emissions Scenarios:** Current international climate models integrate two kinds of scenarios: Shared Socioeconomic Pathways (SSPs) and Representative Concentration Pathways (RCPs). The SSPs model how global society might evolve over the next century, including changes in population, policy, technology, and economic growth, while tracking the amount of heat trapped in the atmosphere. The RCPs correspond to GHG emissions and capture a quantifiable range of emissions and warming—how much do we expect the world will continue to emit, and the associated warming, throughout the century? Combined, these describe how global social conditions (e.g., population, technological, and economic growth) affect emission trajectories. This shift offers a more nuanced understanding of how our collective decisions today will shape the climate of tomorrow. The Fifth Assessment research primarily focuses on two RCP/SSP combinations:
  - **SSP 2–4.5** (i.e., utilizing the second SSP narrative and RCP 4.5) describes an intermediate scenario indicating improvements toward meeting mitigation commitments. This scenario shows carbon dioxide equivalent (CO_2e) emissions initially hover at current levels, then start to fall by mid-century.
  - **SSP 3–7.0** articulates a high emissions scenario and less optimistic pathway, assuming current emission levels continue throughout the year 2100. This scenario shows CO_2e emissions doubling by 2100.
  - The Fifth Assessment also references a more aggressive emissions scenario (**SSP5–8.5**), which describes a very high and unlikely emissions pathway that shows CO_2e emissions tripling by 2075. The Assessment includes this scenario as a reference tool for a worst-case emissions outcome for informational and planning purposes rather than a plausible climate change future.
- **Global Warming Levels** (GWLs) ask "What happens to California once the world reaches a certain level of warming?" The focus is on adapting to a change in the expected climate, such as a 2°C (3.6°F) increase. While these models identify a range of years when these thresholds might be reached, the emphasis is on the intensity of the impact rather than the calendar date. This is a different and complementary approach to the previously used *date-based approach*.
- **Downscaling with Localized Constructed Analogues (LOCA) and Weather Research and Forecasting (WRF):** To make global climate models (GCMs) useful for local planning, scientists use a technique called downscaling. While global models provide a *big picture* view of the planet, the Fifth Assessment uses the LOCA2 statistical and WRF dynamical downscaling techniques and a hybridized version of these techniques, LOCA2-Hybrid, to focus on California's particular climate future.
- **Time Periods:** The Fifth Assessment uses a 30-year timeframe for analyses, as shown in the table below, alongside historical projections to draw comparisons between current and future time periods.

Descriptive Term	Time Range
Historical	1981–2010
Mid-Century	2041–2070
Late-Century	2071–2100

CALIFORNIA'S FIFTH
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Map of California

Climate Change Assessment Regions

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Any references in this Assessment to the lingering and compounding effects of racism and discrimination are drawn from academic literature and are not factual findings of, or legal determinations by, the State of California or any agencies of the State, of prohibited discrimination in any particular instance. Similarly, any descriptions of potential future harms are not findings of or admissions by the State of California or any agencies of the State.

The research was reviewed by expert reviewers, Tribal Advisory Group members, and approved by an external editorial board to ensure scientific rigor as well as appropriate representation of the practitioners and partners to whom each report applies.

Use of Artificial Intelligence (AI):

AI tools were used in the preparation of this report; tools such as Google Gemini, Perplexity, and Claude were used for minor editing assistance, such as to improve brevity and sentence clarity, generate tables based on data, fact-check information in select instances, and for proofing citations and formatting the bibliography. Gemini Nano Banana and Adobe Firefly were used in figure upscaling and recoloring; prior to publication, the original graphs were overlaid onto the upscaled versions to ensure no data was changed. All AI information was carefully reviewed and edited as needed to assure accuracy. The author team takes full responsibility for the correctness of the report.

Executive Summary

The Central Coast region for this report includes Santa Barbara, San Luis Obispo, Monterey, San Benito, and Santa Cruz counties, and northwest Ventura County. The region's climate is shaped by its coastal, valley, and upland topography, and its proximity to the ocean. It is home to iconic beaches, coastal towns, and stunning natural landscapes, with land cover dominated by natural forests, scrublands, and grasslands. Small- to medium-sized cities are concentrated in the coastal areas and agricultural valleys. There are significant disparities between wealthier coastal tourism-based communities and more economically disadvantaged communities with limited resources to respond to climate hazards. Colonization violently disrupted Indigenous relationships to lands along the Central Coast, yet Chumash, Esselen, Amah Mutsun, Ohlone, Salinan, and other Indigenous Peoples continue to sustain and revitalize intergenerational ecological knowledge systems that guide stewardship, restoration, and care for their homelands and the living communities within them. Key economic drivers in the region include agriculture, tourism, food processing activities, fisheries, aerospace, and energy production.

Climate changes projected for the region include rising temperatures with increased variability of precipitation that manifests as more frequent extremes—intense winter storms alternating with severe droughts—that will increase the risks of flooding, wildfire, and water supply disruption. Already, average regionwide temperature has risen 1.5°F (0.83°C), with 9 of the 10 warmest years on record after 2014. This has coincided with severe droughts, storms, and wildfires. By late-century, temperatures are projected to rise an additional 6–10°F (3.33–5.56°C) with longer, more intense heat waves and inland areas regularly experiencing multi-day heat waves exceeding 100°F (37.8°C).

Sea level rise (SLR) is projected to increase. When combined with exposure to extreme storm surges along the coast there will be more coastal flooding, inundating some beaches, and eroding cliffs that will impact communities, infrastructure and iconic landscapes like Big Sur. SLR combined with increased groundwater withdrawals will also exacerbate already existing saltwater intrusion that can degrade water quality and reduce local water supplies. Rural communities and small well owners are less likely to have resources for strategies to address these impacts.

Water systems are already under stress in this groundwater-dependent region. Rising temperatures along with more extreme drought events will reduce surface water availability. This will lead to increased pumping, reduced groundwater storage, and the drying of wells. Under the 2014 Sustainable Groundwater Management Act (SGMA), many water agencies are addressing climate change impacts by enhancing groundwater storage, reducing demand, and increasing recycling and groundwater recharge.

Higher temperatures will increase agriculture demand for water, shift crop viability, increase pests and disease, and reduce soil carbon. Farmworkers are particularly vulnerable to drought and extreme heat. Improved wages, benefits, and health protections can increase the capacity of workers to address climate impacts. Agriculture's adaptation strategies include water-efficient farming, soil health practices, heat stress mitigation, and early warning systems. Agriculture also offers opportunities for greenhouse gas mitigation.

With warming temperatures and the later onset of precipitation, there is a high likelihood that the Central Coast will continue to have large, severe fires in the coming decades. However, there is uncertainty in spatial and temporal trends in fire risk due to the spatial complexity of these processes. Wildfires and post-fire flooding will degrade air and water quality and damage communities and ecosystems. Tools such as cultural burning by Tribes, home hardening, and community education are being used to improve wildfire resilience.

Terrestrial and coastal ecosystems that dominate the Central Coast landscape are increasingly stressed by heat, drought, loss of fog, and SLR, placing many endemic plant communities and endangered species at risk. The loss of spring-fed refugia due to groundwater overdraft will imperil the long-term viability of the region's streams, salmonids, and amphibians. Endemic vegetation is impacted by climate directly but also as mediated by changing fire cycles and invasive species. New restoration tools can help managers select plant species and ecotypes that will be adapted for future climates.

Marine ecosystems are also changing rapidly. SLR is putting recovery efforts for multiple endangered shorebirds at risk. Offshore, marine heat waves have caused kelp forest collapse, food web disruption, and fishery declines. Improved climate-informed fisheries management and diversified adaptation strategies have increased resilience for some fishing communities. Significant region-wide conservation efforts are underway, many of which are being led by, or being done in coordination with, Tribes in the region.

Communities, especially those with lower- and middle-income households, face rising health risks from heat, wildfire smoke, power shutoffs, and water insecurity, compounded by limited access to healthcare in rural areas. As public health impacts increase, the closure of rural hospitals will reduce access to care for more vulnerable populations. Economic losses from extreme events are rising, and lack of affordable insurance leaves many households financially exposed. Closing the insurance "protection gap" and investing in preparedness are critical.

Across the region, diverse communities, agencies, Tribes, and organizations are accelerating climate adaptation through community-led resilience and environmental justice initiatives. Current projects protect both people and ecosystems by enhancing wildfire preparedness and evacuation planning, creating local heat and drought action plans, and tracking poor air quality. Additionally, nature-based solutions like tidal wetland and dune restorations actively mitigate coastal flooding and safeguard vital transportation networks. Finally, expanding educational outreach equips frontline and vulnerable communities with the data needed to build lasting climate resilience.

Small agricultural towns remain particularly vulnerable, but local partnerships and advocacy—such as those emerging after Pajaro River flooding—demonstrate pathways for building more equitable and resilient responses to future climate impacts.

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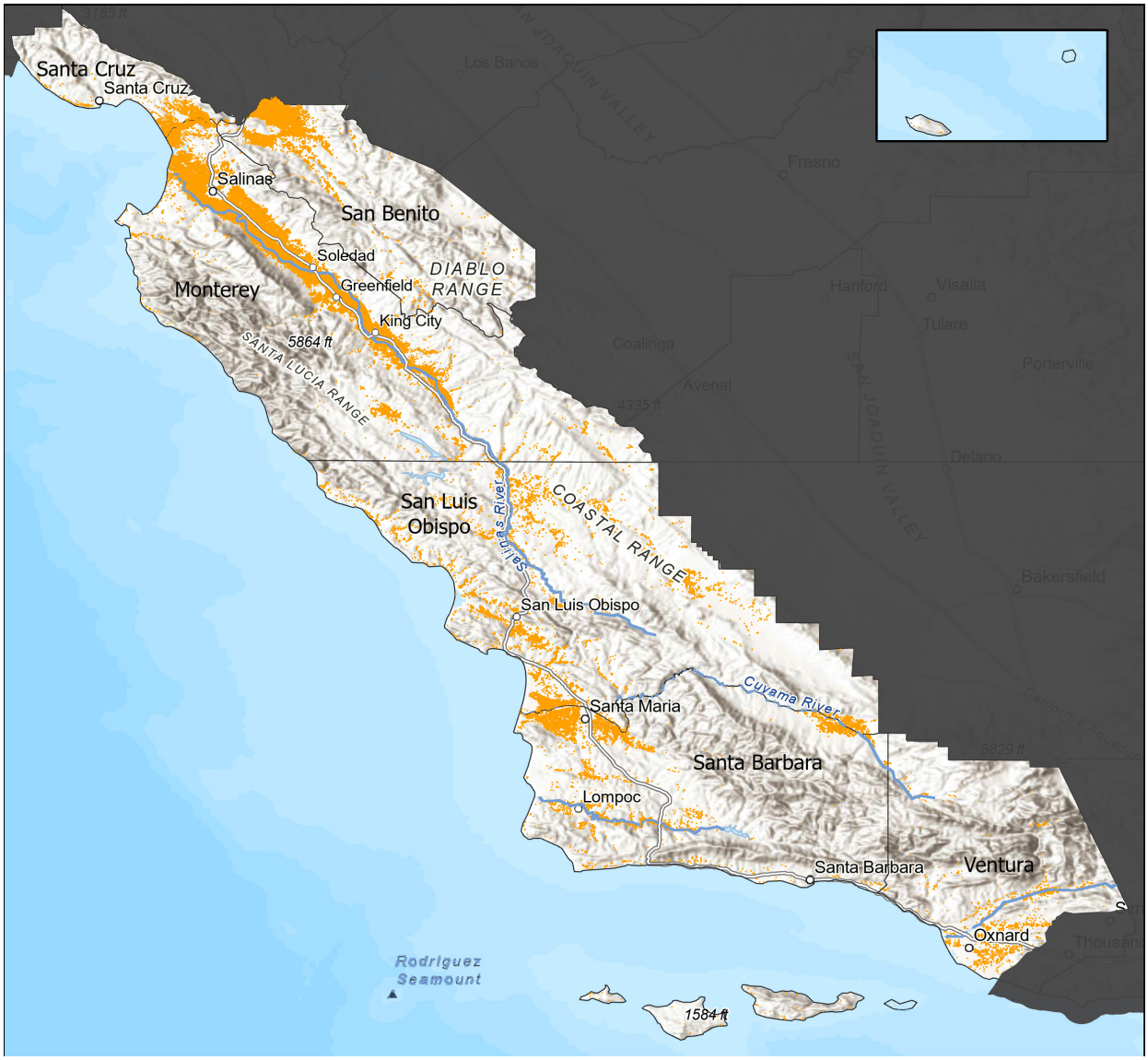
Chapter 1.

Introduction



1.1 The Central Coast

The Central Coast region for this report encompasses Santa Barbara, San Luis Obispo, Monterey, San Benito, and Santa Cruz counties, and northwest Ventura County. The report covers *climate science*—temperature and precipitation projections and impacts including extremes, fog, wind, fire, air quality, sea level rise, storms, and floods—and summarizes the climate impacts and adaptations for *natural and working lands and waters, the built environment*, and *communities* in the region. It incorporates insights from local community-organizations, Tribes, researchers, and state and



Map of the Central Coast Region

Figure 1: *Topographic map of the Central Coast region, showing major cities, rivers, and croplands (orange). Inset: southern two Channel Islands. Sources: ESRI, CropScape 2018.*

local agencies. The Central Coast region is dominated by undeveloped landscapes including hardwood forests, scrublands, and herbaceous grasslands (Tietie, 2019), and it is home to some of California's most iconic beaches, towns and stunning natural landscapes. The largest cities in the region are Oxnard (Ventura County) with a population of 202,063, and Salinas (Monterey County) with a population of 163,542 (USCB, 2022), however, there are over 2 million residents in small- to medium-sized cities as of the 2020 Census. Water supply security is the region's biggest concern (Andreozzi et al., 2023).

The mountains and coast shape the region's climate and communities. The western side of the Santa Lucia Mountain Range is wetter and cooler, whereas the valleys and inland mountain regions are drier. While agriculture is practiced in valleys and areas along the coast, the Salinas Valley is an agricultural hub. In 2020, the total agricultural production in the Salinas Valley was valued at more than $10 billion (CDFA, 2020). Water supplies come primarily from groundwater, and the Central Coast is the most groundwater dependent region in the state. Other economic drivers include tourism, fisheries, food processing, and power and oil production (Brady et al., 2023). The region is also home to several highly-rated educational institutions. There is significant economic inequality—high-income residents often work in aerospace and tech, and low-income residents are generally employed in agriculture, tourism, and retail (Brady et al., 2023).

1.2 History of Tribal Stewardship

Synthesis Authors: *Julisa Lopez and Adam French*

Settler colonialism can exacerbate the climate crisis through the state-sanctioned eradication and suppression of Indigenous Peoples and their intergenerational ecological knowledge and practices. California Indigenous Peoples were subjected to land dispossession across three colonization periods, the Spanish, Mexican and American. As Indigenous Peoples' relationships to their lands were disrupted, their ability to protect and steward their homelands was also undermined (Dartt-Newton & Erlandson, 2006; Laverty et al., 2003; Apodaca et al., 2024). Indigenous scholarship cites that the removal of Indigenous Peoples and their stewardship practices from their homelands through settler colonial practices as a major factor underlying elevated climate change and environmental disasters (Whyte, 2016; Howard Sandoval & Horton, 2023).

Despite state-sanctioned efforts to eradicate California Indigenous Peoples, these communities continue to protect and steward their homelands. Often, Tribal members do not currently reside in their ancestral territory due to land dispossession from colonization, as well as ongoing barriers related to a lack of federal recognition, land ownership, and real estate prices. One example is the Amah Mutsun Tribal Band whose ancestors survived the Missions of Santa Cruz and San Juan Bautista. The Amah Mutsun Land Trust was founded to restore the Tribe's access and stewardship of their homelands, and Tribal members now travel from the Central Valley into their homelands to practice stewardship and climate mitigation in the Central Coast and mitigate climate risks. The report features case-study examples of Indigenous communities and organizations like the Amah Mutsun Land Trust, who are restoring ancestral stewardship practices like cultural burning and other vegetation tending, which contribute to the climate resilient landscapes and ecosystems.

Chapter 2.

Climate Science: Historical & Projected Trends



Key Messages

Temperature:

- The region had 9 of its 10 warmest years on record after 2014, with 1.5°F (0.8°C) of warming occurring over the past decade. The mean annual temperature is projected to increase a further 6–10°F (3.3–5.6°C) by the end of the century, depending on the scenario.
- Warming will be relatively worse in the already hot summer and fall months, and rains will concentrate more in the early winter.
- Heat waves will grow significantly longer and more extreme; nearly all inland areas will experience multi-day heat waves of >100°F (37.8°C); some areas will exceed >110°F (43.3°C) by the end of the century.

Precipitation:

- Historic observations show increasing dry periods as compared to wet periods, and the
- frequency of dry periods co-occurring with hot periods has doubled in recent decades.
- Projections show an increased likelihood of severe drought in the future, particularly in the southern part of the region.
- Very dry years followed by very wet years are projected to become more frequent. Water management will need to shift towards co-management of drought and flood risks.
- Coastal fog provides critical moisture and nutrient inputs to ecosystems, but the future of fog under climate change remains highly uncertain.

Fire and Sediment Hazards:

- Several of the recent largest fires in California occurred in the Central Coast region.
- Fire severity, size, and area burned may increase, but uncertainty is significant due to wind, fog, topography, and other micro-climatic factors.
- Tools exist for managing wildfire, including Native American cultural burning, prescribed fires, home hardening, defensible space, and education.
- The region's steep watersheds are prone to post-fire debris flows triggered by high-intensity rainfall, which increasing fire severity and extreme precipitation may worsen.

Sea Level Rise (SLR) and Storms:

- SLR is increasing exposure to extreme storm surges along the coast, which are likely to affect over 20,000 people and over $6 million in property over the next 100 years. Storm surges in 2023–2024, combined with El Niño, caused coastal flooding that impacted 3,000 residents and destroyed iconic structures like the Santa Cruz Boardwalk.
- Cliffs and beaches hardened by seawall armoring are at high risk to rising seas.

Ocean Conditions:

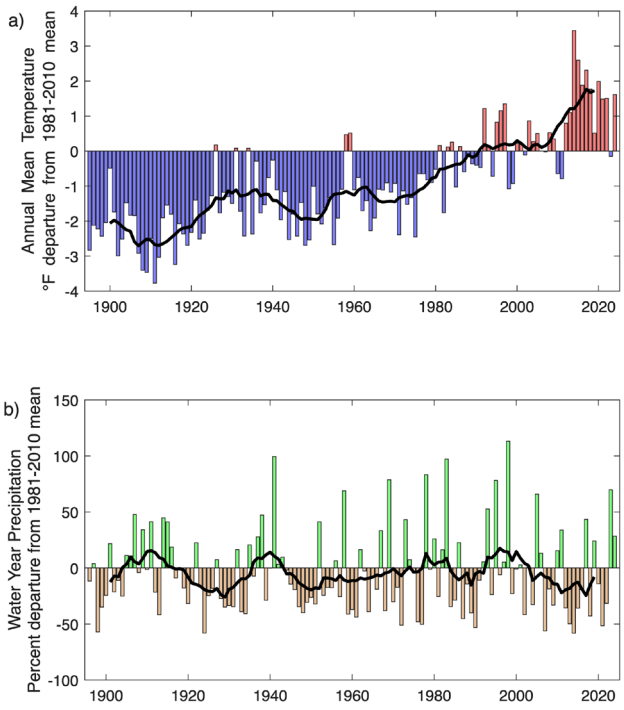
- Ocean changes are complex due to connections between winds, upwelling, and nutrients, but 2 of 3 models predict declining ocean productivity off the Central Coast.
- The largest ever recorded marine heat wave occurred in 2014–2016 and caused widespread kelp forest die-offs of kelp forests and range shifts of coastal biodiversity.

2.1. Historical and Projected Temperature and Precipitation

Synthesis Author: *Samantha Stevenson-Karl*

Contributing Authors: *Nathan Von Schmidt and Amy Parsons*

The Central Coast climate is seasonal; most precipitation is in the autumn and winter, with little in the summer. Seasonal temperature changes are more moderate, especially in coastal regions insulated by the ocean (Hale et al., 2024). Local climate is dependent on the topography (**Figure 1** and **Figure 4**): near-coastal areas are cooler than inland areas and are influenced by the marine layer (Iacobellis & Cayan, 2013; Potter, 2014; Clemesha et al., 2016) and the region's mountains, especially the Santa Cruz, Santa Lucia, and Transverse Ranges Mountains, that trap cooler air closer to the coast. Inland temperatures have larger warm and cold extremes (Peterson & Vose, 1997; Clemesha et al., 2018). There is strong year-to-year-variability with large influences from the El Niño/Southern Oscillation (ENSO): extremely wet winters are more common during the El Niño phase of ENSO (Dettinger et al., 2011; Jong et al., 2016). Very damaging compound wildfire and extreme rainfall events have occurred, such as the December 2017 Thomas Fire and subsequent January 2018 rain-driven Montecito debris flow (Oakley et al., 2018).



Observed Historical Trends in Temperature and Precipitation

Figure 2: *Regionwide mean (a) annual mean temperature (relative to the 1981–2010 mean, with negative departures in blue and positive in red), with the black line showing an 11-year running mean, and (b) precipitation (averaged over the October–September water year) shown as percent change relative to the 1981–2010 mean (negative departures are brown and positive are green).*

2.1.1 Historical Trends in Temperature and Precipitation

Temperature in the Central Coast region increased throughout the 20th and early 21st centuries, while precipitation showed no clear trend toward wetter or drier conditions (**Figure 2**).

Temperature increased by nearly 4°F (2.2°C) (black solid line; **Figure 2a**), with 9 of the 10 warmest years on record occurring after 2014. For precipitation there was major inter-annual variability, including many years of very wet (positive in **Figure 2b**) and dry (negative in **Figure 2b**) departures from the average. Consecutive dry years tended to be more frequent than periods of consecutive wet years, particularly when the largest precipitation accumulations are considered. Very wet and very dry years generally follow one another—such as when the record 2012–2016 drought was followed by an extremely wet 2016–2017 winter (Swain et al., 2018, 2025a, 2025b). Dry periods historically occurred during both cooler and warmer periods, but the frequency with which dry periods co-occurred with hot periods that increase water stress doubled in recent decades (**Figure 2a** vs **Figure 2b**), worsening drought impacts.

2.1.2 Projected Future Temperature and Precipitation

Box 1: *Climate Modeling and Future Scenarios*

Author: *John Abatzoglou*

Global climate models (GCMs) simulate the climate system's response to different factors and their interactions including: volcanic eruptions, El Niño, changes in greenhouse gas concentrations, and the physics, chemistry and biology of the atmosphere, land, and oceans. Scientific field and lab experiments cannot be performed with the Earth's atmosphere because of its immense scale, so simulation models are used as a "virtual lab." The Sixth Coupled Model Intercomparison Project (CMIP6) was a coordinated effort by over 49 modeling groups (and 100 models) to perform the same experiments. The benefit of using an ensemble of models is to capture commonalities and uncertainties in climate responses. Rather than projecting a single future scenario, ensembles provide a probabilistic view of the future.

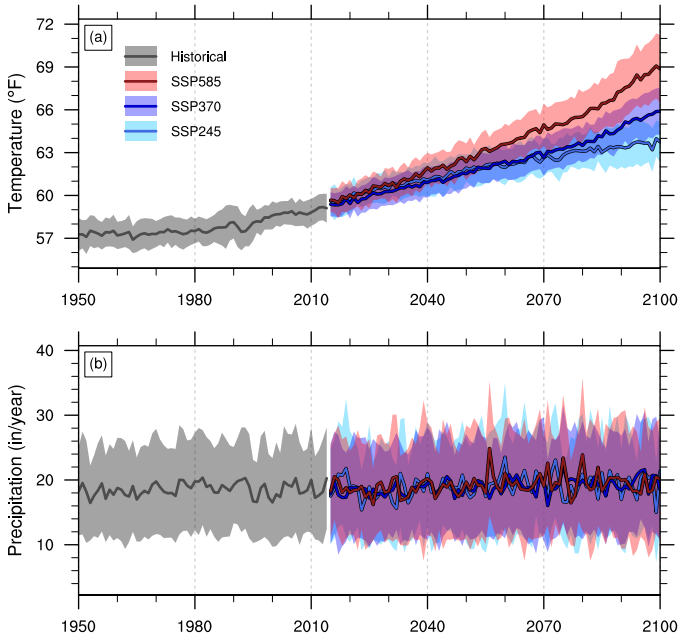
Shared Socioeconomic Pathways (SSPs) are scenarios built to explore how different future societal developments might influence greenhouse gas emissions and climate change (**Table 1**). Incorporating these socioeconomic narratives into climate models creates a wider range of potential climate futures to evaluate the effectiveness of various mitigation and adaptation strategies. The SSPs (1, 3, and 5, in this report) are paired with a *Representative Concentration Pathway* (RCP) based on that development trajectories' total radiative forcing value from 1750 to 2100 (4.5, 7.0, and 8.5 W/m2, respectively), resulting in 3 scenarios (**Table 1**). Each model-scenario combination is simulated multiple times (usually 3–10) creating different trajectories, or *ensemble members*, of weather and short-term climate variability with same long-term climate trends. Together, these capture a range of variable short-term weather patterns.

Table 1: *Primary climate change scenarios used by this report's global climate models*

Scenario	Emissions	Narrative description	Change in emissions from 2000 to 2100	Change in global temp.
SSP2-4.5	Intermediate	Improved meeting of mitigation commitments	Emissions decrease but do not reach zero	+4.5–5.4°F (+2.5–3.0°C)
SSP3-7.0	High	Business-as-usual, continuing current trends	Emissions double	+7.2°F (+4.0°C)
SSP5-8.5	Very High	Worst case—emissions accelerate	Emissions triple	+8.1–9.0°F (+4.5–5.0°C)

Projections for the Central Coast were computed using output from GCMs belonging to the latest model generation (Box 1). The high-emissions "business-as-usual" pathway SSP3–7.0 was the primary scenario for most analyses. Most measures report changes between the historical period (1981–2010) to the mid-century (2041–2070) or late-century period (2071–2100). The 30-year windows ("*climate normals*") average over three decades to statistically assess longer-term changes like ENSO change over time. Measures are computed for multiple ensemble members for each model and SSP combination, increasing statistical accuracy (see **Appendix A2.1** for additional tables). **Figure 3** shows modeled mean temperature and precipitation for the historical period (1850–2014) and projected futures (2015–2100) under various SSP scenarios for the Central Coast region.

The observed historical (**Figure 2**) and model-simulated (**Figure 3**) data show a similar magnitude of historical increase in temperature—roughly 1.5°F (0.8°C) from 1950 to 2015—indicating models reasonably represented the region's historical climate. Over the near term (2020–2040), the temperature projections show continuing warming across SSPs, particularly for the high-emissions scenario (SSP5–8.5). Divergence among scenarios becomes larger in the mid-to-late 21st century, with end of century temperatures being 5–6°F (2.8–3.3°C) warmer in the highest- compared to the lowest-emissions projections. Trends in mean precipitation are minimal in all three future scenarios considered, but precipitation patterns are projected to be more variable within and between years (see *Section 2.2.1 Extreme Precipitation and Temperature*).

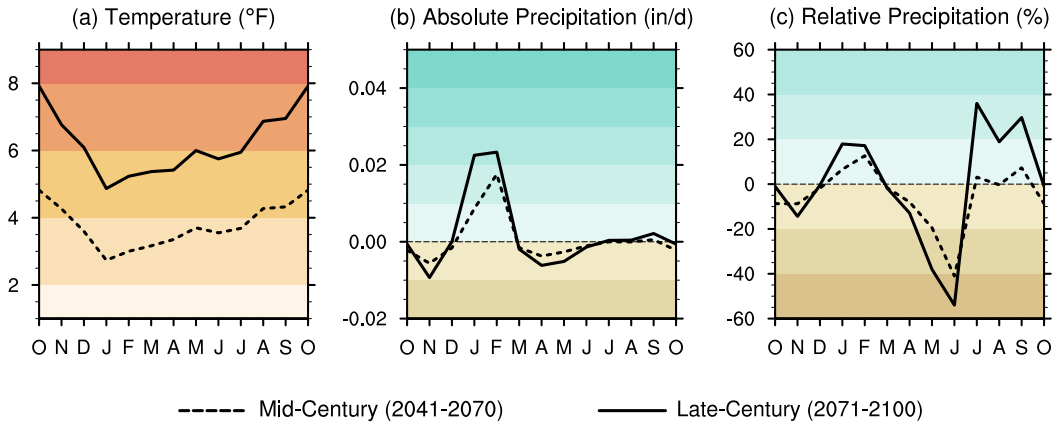


Modeled Historical and Projected Mean Temperature and Precipitation

Figure 3: *Projected (a) temperature and (b) precipitation trends for the Central Coast. Historical (1950–2015) simulations shown in gray, with the ensemble mean plotted as the solid gray line. Future SSP projections are shown in colors: SSP5–8.5 (red), SSP3–7.0 (dark blue), and SSP2–4.5 (light blue), with corresponding ensemble means plotted as solid lines.*

Projections also indicate seasonal variation in temperature and precipitation changes. Greater temperature increases occur in the summer and fall months when the weather is already hotter, worsening exposure to extreme heat, while precipitation concentrates in a shorter and more intense early rainy season from January–February (**Figure 4**).

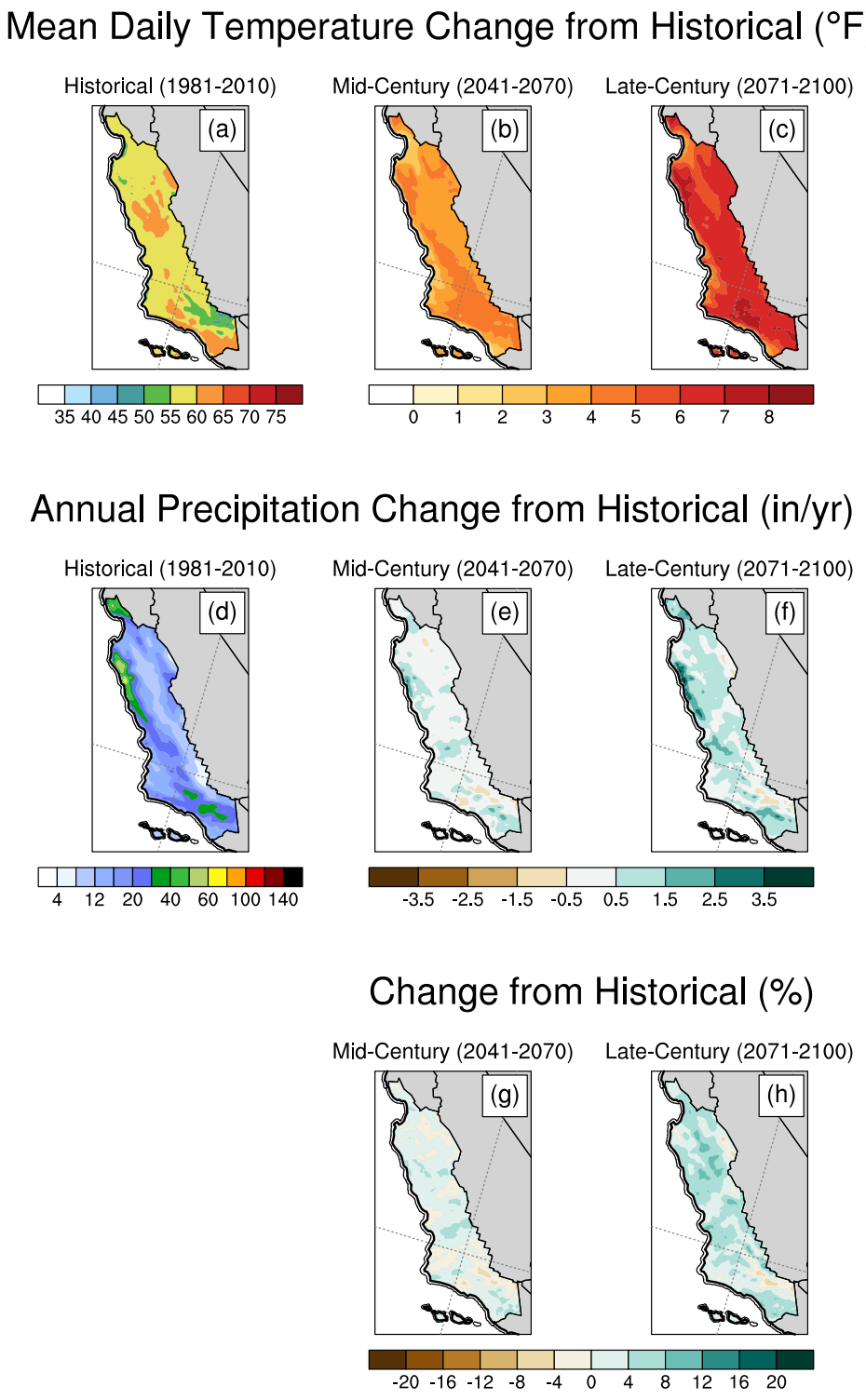
These are region-wide averages. However, the Central Coast's varied topography and distance from the coast significantly influences projected changes in temperature and precipitation as illustrated by the map in **Figure 5**. Temperature increases by mid-century are largest inland (**Figure 5b**). Coastal mountains and higher-elevation inland areas warm more (~3–4°F [1.7–2.2°C] by mid-century) than the coastal plains (~2°F [1.1°C]; **Appendix Table A2.2**), and by late-century, warming in these areas reaches ~7–8°F (3.9–4.4°C; **Figure 5c**).



Seasonal Changes in Temperature and Precipitation

Figure 4: *Seasonal changes in temperature and precipitation (monthly mean change, SSP3–7.0 future minus historical) for (a) absolute temperature, (b) absolute precipitation, and (c) percentage change in precipitation relative to that month's historical average. X-axis is the calendar month, showing the first letter of each month's name.*

Precipitation (future average annual) shows no trend region-wide (**Figure 3**), but some areas have weaker trends (**Figure 5**). The largest precipitation increases are in the coastal mountains that historically received the most precipitation (**Figure 5d**), especially during late-century when they received more than 3 in/yr (76 mm/yr) of additional precipitation on average (**Figure 5e, f**). These increases may be related to an increase in the magnitude of extreme precipitation associated with atmospheric rivers (Gershunov et al., 2019; Huang et al., 2020). As a relative percent change, most areas see small (<4%) changes in mean precipitation by mid-century. By late-century however, much of the Salinas Valley becomes 8–12% wetter, while the mountains remain <8% wetter (**Figure 5g, h**). Eastern inland mountains are the only areas projected to dry, but average spatial changes are small (<4 in/yr) relative to year-to-year variability (~20 in/yr).



Projected Change in Average Temperature and Precipitation

Figure 5: *Spatial patterns of projected future temperature and precipitation change over the Central Coast. Top row: historical mean temperature (a) and changes between the mid-century and late-century versus historical (b, c). Middle row: the same but for precipitation (d,e,f). Bottom row: percentage changes in precipitation between mid-century/late-century and the historical period (g,h).*

2.2 Key Climate Impacts and Events

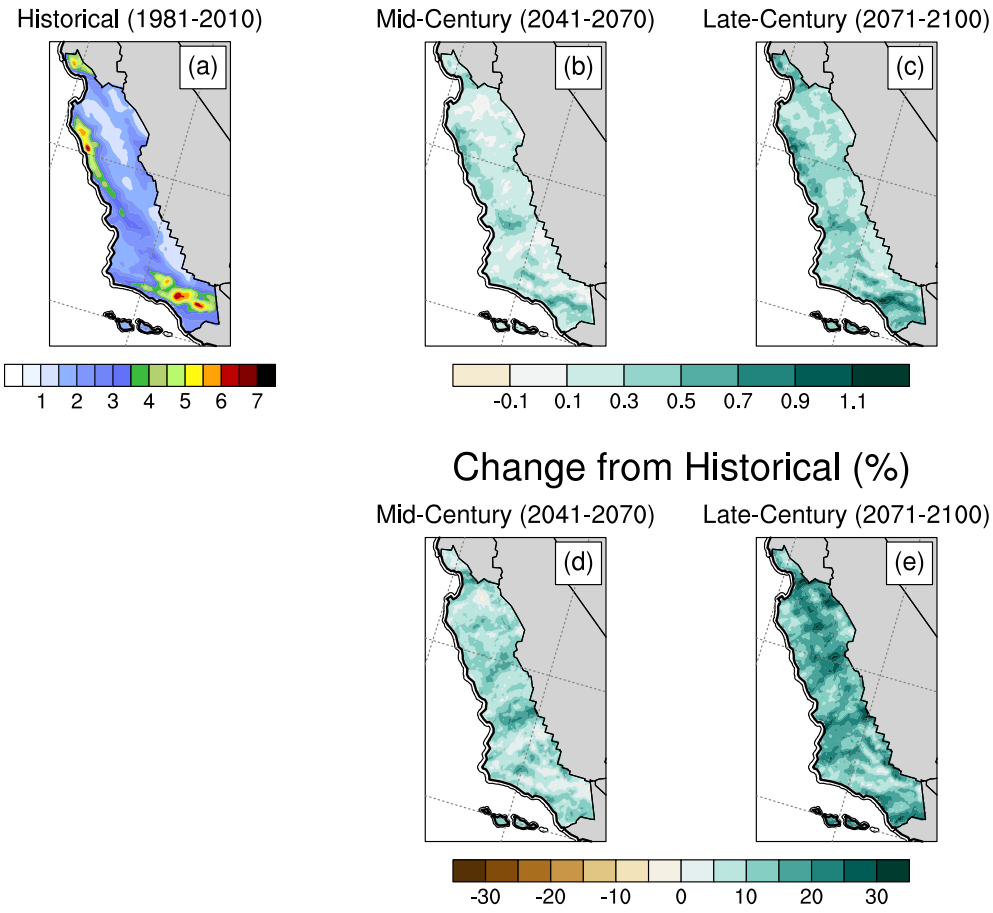
2.2.1 Extreme Precipitation and Temperature

Synthesis Author: *Samantha Stevenson-Karl*

Contributing Authors: *Nathan Von Schmidt, Amy Parsons, Julie Kalanski, and Ruth Langridge*

EXTREME PRECIPITATION

Projected changes in the wettest day of the year (**Figure 6**) show the highest-precipitation day will become up to 30% wetter by the late-century period (**Figure 6e**) for the Central Coast region. Areas such as Salinas Valley and Gilroy-Hollister Valley (**Figure 6d, e**) have large relative increases in extreme precipitation. Absolute increases in extreme precipitation are generally highest in mountainous regions (**Figure 6b, c**) that already receive the most rainfall (**Figure 6a**).



Projected Changes in the Wettest Day of the Year (in/day)

Figure 6: *Map of absolute (top) and percent (bottom) change in the rainiest day of the year (in/day) from the historical period (1981–2010) to the mid- and late-century periods (SSP3–7.0 scenario).*

Atmospheric Rivers

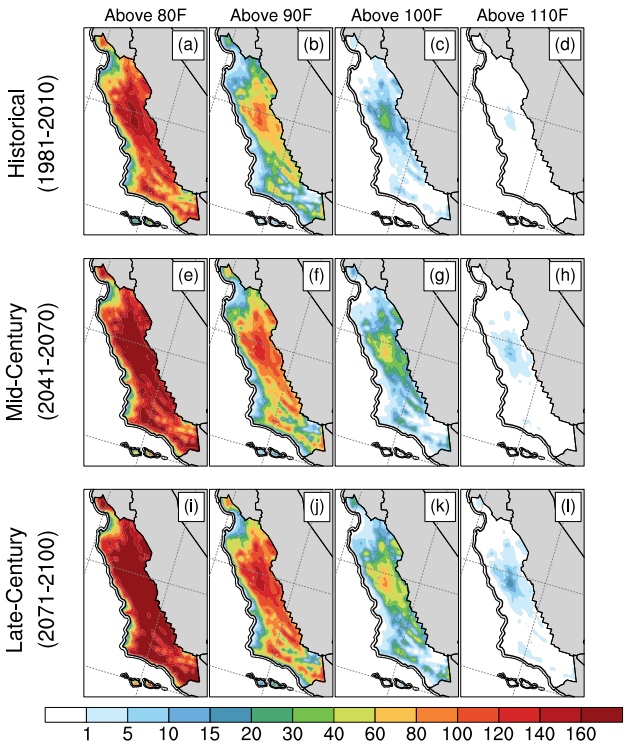
Precipitation extremes are historically associated with Atmospheric Rivers (ARs), long, narrow regions of intense atmospheric moisture that can penetrate far inland along preferred topographic corridors (Rutz et al., 2015; Konrad & Dettinger, 2017). Statewide, ARs are responsible for much of midlatitude extreme precipitation and produce more than 50% of California's total annual precipitation (Gershunov et al., 2017). Warming is expected to increase atmospheric moisture and lead to ARs of unprecedented strength (Henny & Kim, 2025; Swain, 2025). While there is uncertainty whether there will be more ARs overall, Gershunov et al. (2019) showed a clear upward trend in ARs during 2000–2050 that continues in projections to 2100.

Within the Central Coast, during the 2022–23 water year, a series of significant ARs left 49 inches (125 cm) of rainfall in San Luis Obispo (ITRC, 2023), the second largest ever recorded since 1870, breaking precipitation records at 50 stations (NOAA, 2024a) and causing major flooding. A growing share of the region's precipitation is projected to come from ARs by mid- and late-century as AR precipitation increases, while non-AR precipitation is reduced (**Figure A2.1**).

EXTREME HEAT

California's coastal regions are at elevated risk for heat waves (Guirguis et al., 2024). **Figure 7** maps the number of days per year on average that temperatures will exceed different threshold values (80, 90, 100, and 110°F [26.7, 32.2, 37.8, and 43.3°C]) in historical and future periods.

The temperature threshold considered a heat wave varies based on location. For inland communities, "normal" daily maximum temperatures exceed 90°F (32.2°C) throughout the summer, but coastal communities experience temperatures above 90°F only a few times a year, often lack air conditioning, and are at risk for health impacts in a 90°F heat wave (Guirguis et al., 2014). Inland valleys, especially the upper Salinas Valley, currently experience the greatest extreme heat (**Figure 7 a-d**), exceeding 100°F (37.8°C) for 5–30 days on most years. By mid-century, the Santa Ynez Mountains will experience extremely hot days much more frequently (**Figure 7 e-h**) with daily highs above 80°F (26.7°C) occurring for roughly half the year. By late-century, temperatures >110°F (43.3°C) are projected to occur regularly in the upper Salinas Valley (1–20 days/year; **Figure 7 i-l**). Above this heat threshold (assuming 50% humidity) even young, healthy



Average Number of Extreme Heat Days

Figure 7: *Current and projected future heat wave days, defined as the mean number of hot days per year where the temperature exceeds a given value. Top row: (a–d) historical average number of days per year exceeding thresholds of 80°F, 90°F, 100°F, and 110°F. Middle row: (e–h) Same for the mid-century period. Bottom row: (i–l) Same for the late-century period.*

adults cannot thermoregulate for long periods (Vecellio et al., 2022; Matthews et al., 2025). This may also affect agriculture as photosynthesis is impaired above 104°F (40.0°C) (Venios et al., 2020).

Minimum nighttime temperatures are rising faster than maximum daytime temperatures in many areas (**Figure A2.2**; Kalkstein & Davis, 1989; Dousset et al., 2011). Humans need cooler nights to recover from daytime heat, especially during extreme heat in urban heat islands and humid coastal areas (Kim et al., 2023; Brown, 2025). Warm nights at the 60°F (15.6°C) threshold nearly double in many areas by mid-century (**Figure A2.2d**), with larger increases by late-century (**Figure A2.2g**). Proportional increases are even larger for higher temperature thresholds. For example, the Monterey area has minimum temperatures above 70°F (21.1°C) for 5–10 days/year in the historical period, increasing to ~40 days/year by the end-century. Historically, no part of the region exceeded minimum temperatures of 80°F (26.7°C) (**Figure A2.2c**), but mountainous areas will in the future (**Figure A2.2f,i**).

Peak heat on a single day is the greatest risk, but heat waves that last 4+ days have higher mortality risk (Gasparrini & Armstrong, 2011). Longer heat waves with warmer nights can cause transformers to fail. The average heat wave duration is currently around 3 days for the Central Coast region but is projected to increase by 6–10 days in inland areas by the late-century period (**Figure A2.3**).

DROUGHT

Synthesis Author: *Ruth Langridge*

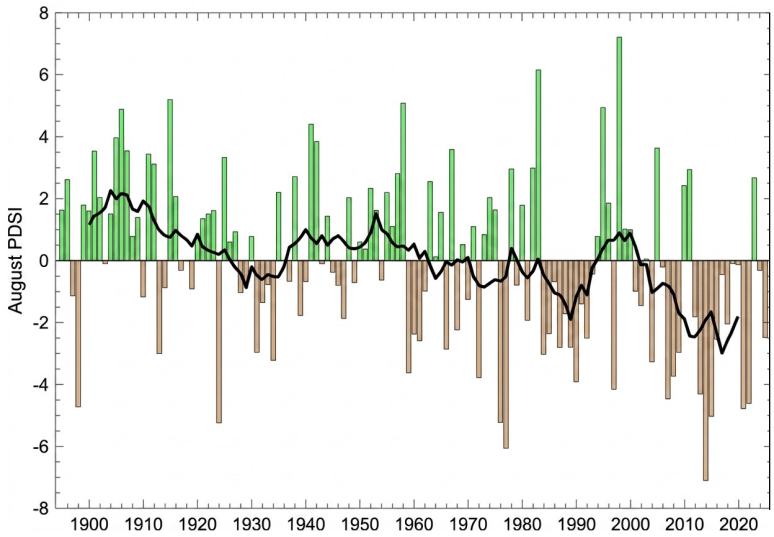
Contributing Authors: *JohnAbatzoglou and Samantha Stevenson-Karl*

Box 2: *Definition and Characterization of Drought*

Drought is a complex phenomenon contextually defined by different communities (Harpold et al., 2017) with effects and impacts accumulating over time (Wilhite & Buchanan-Smith, 2005; Cook et al., 2018). Drought is classified as meteorological, agricultural, hydrological, socioeconomic and ecological. Drought severity defines the intensity of drought conditions, usually measured by comparing a region's current moisture levels to normal levels. Extreme droughts can include prolonged periods of abnormal low precipitation and can be magnified by warm temperatures and increased evaporative demand (Eto), often described as soil moisture deficit. Drought can occur on a range of timescales (Pendergrass et al., 2020; Garreaud et al., 2020; Williams et al., 2022). Droughts will become increasingly extreme in the late 21st century (He et al., 2018), with climate change magnifying drought intensity and duration (Williams et al., 2020, 2024). Common drought measurement indicators include the Palmer Drought Severity Index (PDSI), Standardized Precipitation Index (SPI), and Standardized Precipitation Evapotranspiration Index (SPEI). These account for precipitation and evaporative demand, which increases with temperature. PDSI has been used in conjunction with other inputs to construct US Drought Monitor (USDM) data that defines drought intensity and severity and has become the de facto standard for US drought monitoring.

Historical Droughts

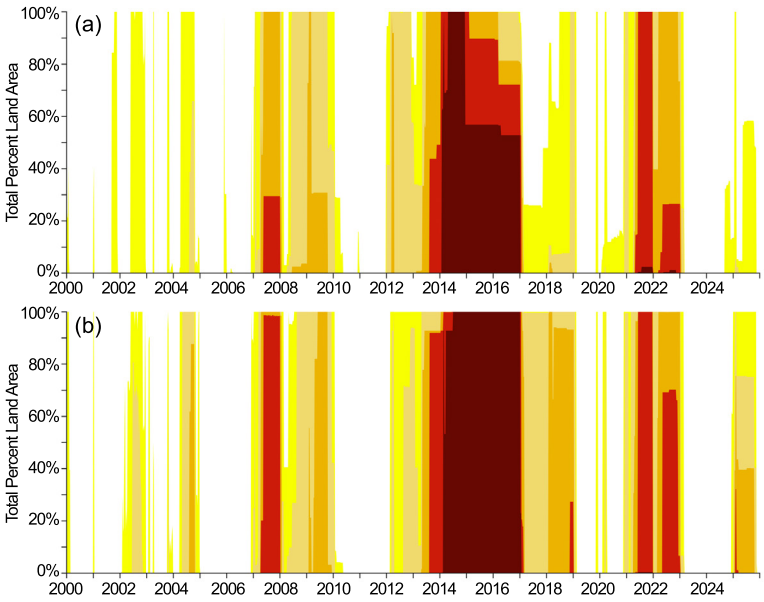
California has historically been subject to alternating periods of high and low precipitation and, in the past few decades, increasing temperatures (see *Section 2.1 Historical and Projected Temperature and Precipitation*). For the Central Coast, water year precipitation changed little over the last 130 years, but significant warming and increased Eto have resulted in increased aridity and a trend toward more drought conditions, with the likelihood of dry periods increasing (**Figure 10**).



Historical Wet and Dry Periods for the Central Coast (1985–2005)

Figure 8: *Time series of the Palmer Drought Severity Index (PDSI) for August over the Central Coast Drainage climate division from 1895–2025. Negative values (brown) denote relatively dry periods, and positive values (green) relatively wet periods. An 11-year moving average is shown by the black line. Data from NOAA NCEI (2025). Data excludes Ventura County.*

Notably, drought duration and intensity show significant spatial differences as you go from north (Monterey County) to south (Santa Barbara County) (**Figure 9**), and they increase over the 2001–2025 time period for every Central Coast County (US Drought Monitor, 2026).



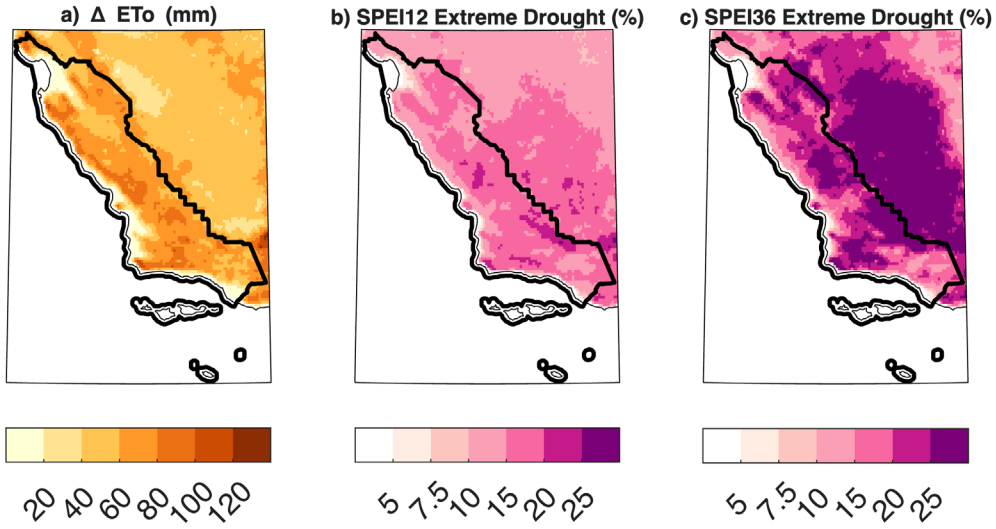
Comparison of Drought Duration and Intensity 2001–2025

Figure 9: *USDM drought severity and intensity in (a) Monterey and (b) Santa Barbara counties from 2001–2025 (USDM, 2025). Darker red hues indicate drier conditions, estimated as observed precipitation deviations from the climatological average over the 9 months leading up to the dates from 2001–present time period.*

Drought Projections

The frequency with which hot conditions co-occur with dry conditions in the Western US has increased, raising drought risk even with limited evidence of a trend in precipitation (Mann & Gleick, 2015). Temperature changes and increased atmospheric Eto in the hot, dry seasons are projected to increase the frequency and duration of droughts. Drought severity is also generally predicted to intensify due to greater inter-annual precipitation variability and projected warming (Yuan et al., 2023).

The likelihood of severe drought in the Central Coast region shows an increase in downscaled climate projections viewed through both the 12- and 36-month SPEI (**Figure 10**).



Change in Annual Evaporative Demand and the Likelihood of Extreme Drought

Figure 10: *Multi-model mean (a) change in annual evaporative demand (Eto; calculated using the Penman-Monteith approach; Yang et al., 2019), and the likelihood of extreme drought realized through (b) 12-month SPEI, and (c) 36-month SPEI for mid-century (2041–2070) under the SSP2–4.5 scenario. Extreme drought was defined as the 5th percentile for historical conditions based on the period 1951–2000. For this figure a subset of 7 models was chosen based on whether the data to compute Eto was available.*

Such changes in the likelihood of severe droughts are magnified by the increased Eto, affecting surface water (**Figure 10a**). Single year extreme droughts (12-month SPEI) are projected to more than double across the region by mid-century, and the likelihood of multi-year droughts (36-month SPEI) are more acute (**Figure 10 b,c**).

Impacts on Water Supply for Social and Ecological Communities

See also *Section 3.2 Water.*

The Central Coast region is primarily reliant on groundwater for agricultural irrigation and drinking water. During drought, withdrawals increase significantly to accommodate water shortages, while high temperatures increase Eto and reduce soil moisture, affecting groundwater recharge and

storage in local reservoirs. Higher temperatures and less water availability for agriculture will increase crop water demand (Williams & Abatzoglou, 2025), and one year of extreme drought can decrease vegetation productivity for grasslands and shrublands almost 40% (Smith et al., 2024). Rural, low-income, and minority communities are particularly vulnerable to drought, especially if reliant on shallow groundwater wells (Mount et al., 2021). Agricultural workers may face job losses and water access issues. Examples of drought impacts in the region include:

Santa Barbara County: Lake Cachuma reservoir provides 85% of the Goleta District's water supply. It plummeted during the 2012–2016 drought and was at 7.3% of capacity in October 2016 (USBR, 2016). Reservoir levels recovered slowly following wet years in 2018 and the winter of 2022–2023 (Bolton, 2025), but the region's surface water supplies remain vulnerable to long-term droughts (Santa Barbara County, 2021).

San Luis Obispo County: Agricultural irrigation relies primarily on groundwater. Large volume basins can supply water through multiple drought years, but small volume basins and other limited groundwater sources are more vulnerable to drought. Recharge relies on spatially variable rainfall. The Santa Lucia Mountain Range can receive over 40 inches of rain per year, while the County's eastern portion typically receives less than 10 inches per year on average.

Adaptations to Drought

See also *Section 3.2 Water*.

Central Coast counties, nonprofits, and communities are collaborating through local, statewide, and regional initiatives to proactively address future droughts and reduce the risks of water shortages. Examples include:

San Benito County: The Accelerated Drought Response Project will improve drought resilience by storing excess wet-year water in the local groundwater basin and recovering it in future droughts.

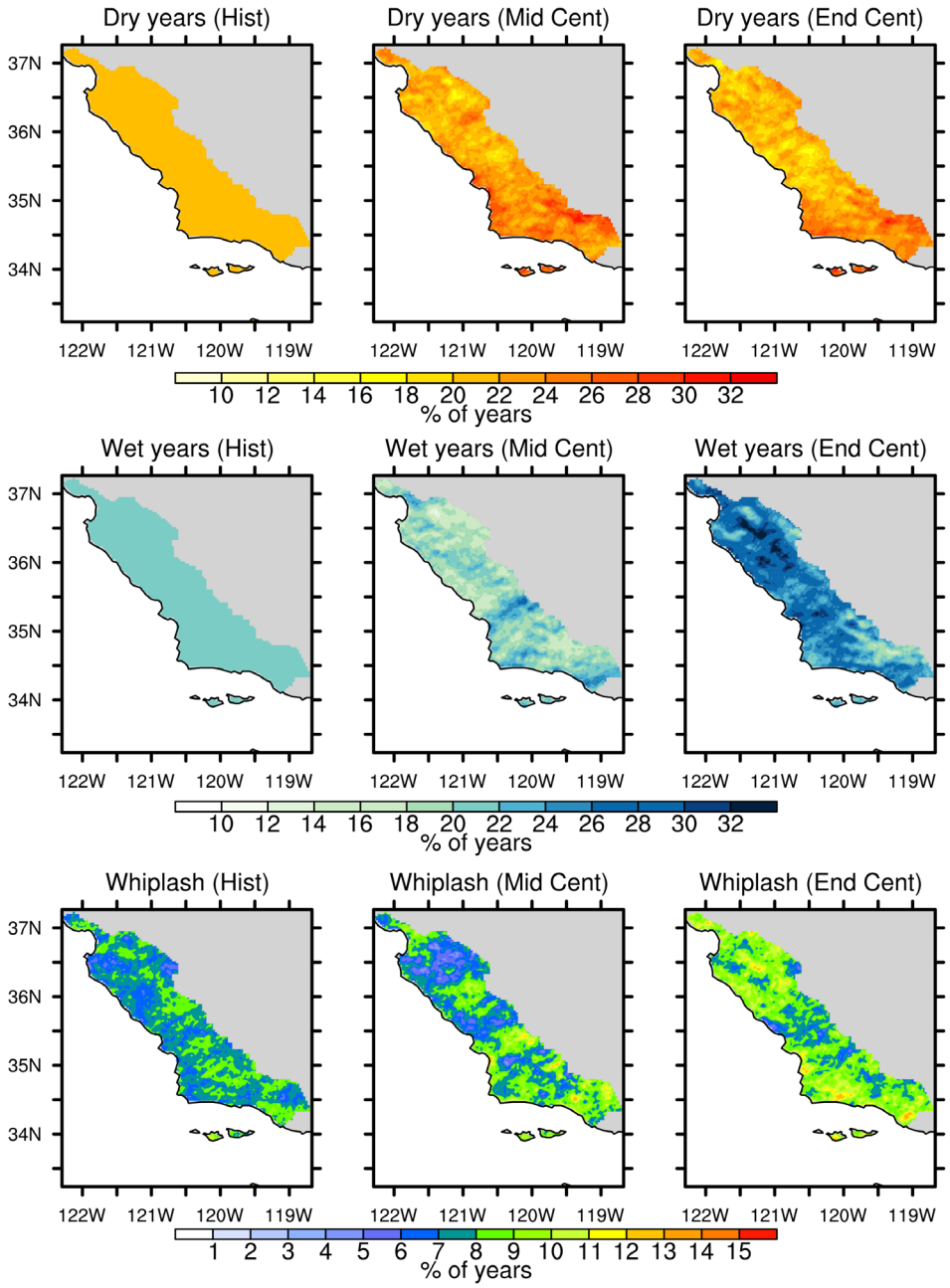
Santa Barbara County: The Drought Resilient Interscale Portfolio Planning model integrates climate and hydrological variability with high-fidelity representations of urban water distribution, available technology options, and demand reduction measures to assess how least cost water supply portfolios vary under different drought scenarios (Zaniolo et al., 2023).

Santa Cruz County: A Climate Action Adaptation Plan incorporates strategies for both mitigating and adapting to climate change impacts, including drought.

The Central Coast Climate Collaborative (4C) includes local governments, nonprofits, businesses, and Tribes to address climate change issues and drought resilience.

HYDROCLIMATIC WHIPLASH

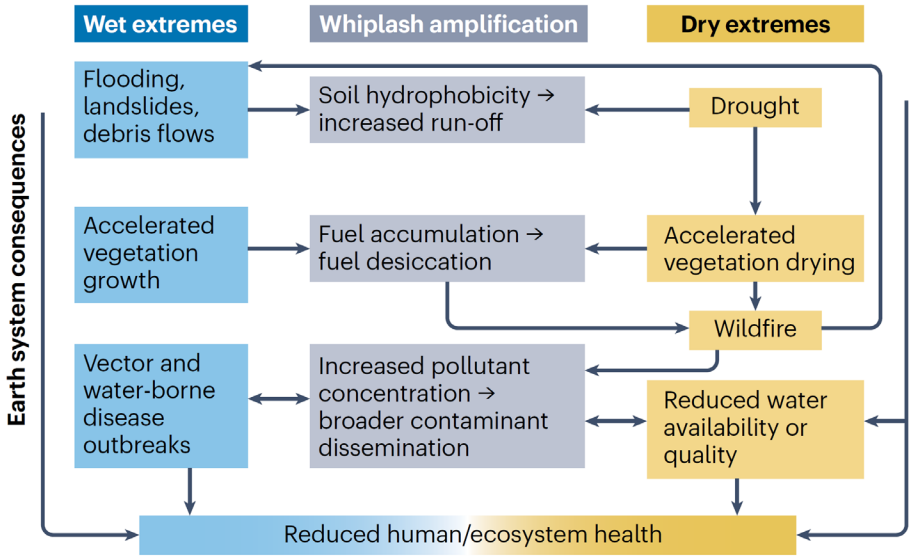
Hydroclimate whiplash refers to sudden shifts between very dry and very wet annual average conditions (Swain et al., 2025). It can be defined as a year with precipitation totals under the 20th percentile followed by a year exceeding the 80th percentile, or vice versa (Swain et al., 2018; Persad et al., 2020; Chen et al., 2022). In the Central Coast, whiplash manifests with wet and dry periods becoming more extreme (**Figure 11**).



Increasing Interannual Variability of Precipitation and Whiplash

Figure 11: *Projected change in precipitation variability under the SSP3–7.0 scenario, based on the frequency of (a) dry years (below the 20th percentile of historical 1981–2010 precipitation), (b) wet years (above the 80th percentile), and (c) whiplash years (consecutive occurrence of wet and dry years). Historical occurrence of wet and dry years is defined as 20% everywhere.*

Increases in hydroclimate volatility amplify hazards such as flash floods, wildfires, landslides and disease outbreaks (Swain et al., 2025), and may negatively affect water quality and groundwater recharge (**Figure 12**). There will be a need for increased flood control (AghaKouchak et al., 2014; Casson et al., 2019; Persad et al., 2020; Facincani Dourado et al., 2024) and for water management to shift toward co-management of drought and flood risks (Swain et al., 2025).



Cascading Impacts of Hydroclimate Whiplash

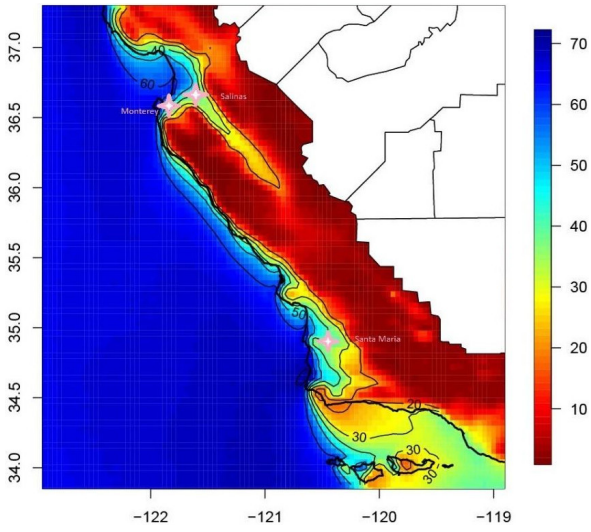
Figure 12: *Cascading impacts of hydroclimatic "whiplash" between very wet and very dry years, or vice versa. Black arrows represent cascading relationships. From Swain et al., (2025b).*

2.2.2 Coastal Low Clouds and Fog

Synthesis Author: *Peter Weiss-Penzias*

Contributing Authors: *Rachel Clemesha, Sara Baguskas, and Patrick Chuang*

Marine layer clouds, including coastal low clouds and fog, are common during the summer along the Central Coast. We use "coastal low clouds", "low clouds", and "fog" synonymously. Fog water inputs are only 2.5% of annual precipitation on average in Santa Cruz (Weiss-Penzias et al., 2016), but fog relieves canopy water stress, adds nitrogen to the soil (Ewing et al., 2009), supports coastal forests and chaparral communities, influences species composition (Dye et al., 2024), and transfers compounds (**Appendix A2.2.2.1**). Local topography and orientation of the coastline impact how far inland low clouds penetrate (**Figure 13; Appendix A2.2.2**). The low-lying coastal plains in Santa Barbara County and Monterey Bay are consistently overcast, where beaches experience cloudy conditions approximately 60% of the time during July and August. Along the Big Sur coast, the Santa Lucia Mountains prevent fog from moving inland.



July and August Coastal Low Cloud and Fog Cover (%)

Figure 13: *Long term (mean 1996–2024) frequency of day and night July and August low cloud cover (colors and thin black contours show %). From the GOES-WEST satellite derived record described by Clemesha et al., 2016, updated to cover years 1996–2024.*

HISTORICAL CHANGES IN FOG

Cloud records at Monterey, Salinas, and Santa Maria airports (the longest-term monitoring sites) do not show any long-term trend in fog over the past ~70 years. However, Johnstone & Dawson (2010) found evidence of a 33% reduction in fog frequency since the early 1900s.

THE FUTURE OF LOW COASTAL CLOUDS AND FOG

Fog in coastal California depends on 1) cold sea surface temperatures (SSTs) near the coast due to ocean upwelling driven by the strong, consistent winds of the Pacific High and 2) Hadley Circulation—warm, dry air from the tropics that sinks downward from altitudes of more than 0.6 miles (1 km). Changes in both the Pacific High and the Hadley Circulation are expected under climate change, though with low confidence. Weakening coastal winds will bring less cold water to the surface, increasing SSTs and inhibiting the formation of fog (Rykaczewski et al., 2015; Pozo Buil et al., 2021). The Hadley Circulation will transport air that is predicted to be drier (Lau & Kim, 2015) and warmer (Lee et al., 2021) to the Central Coast, albeit at a slower speed (Wu et al., 2024). Drier air also promotes cloud formation by increasing cloud top cooling that can then absorb more water from the ocean. A warmer Hadley Circulation can conversely promote cloud formation by inhibiting the mixing of warm, dry air with the wet, cold air from the ocean surface. Smaller-scale atmospheric features can also impact coastal clouds (such as the land-sea breeze circulation, vertical wind shear, coastal jets, and coastal surges) but are less predictable than the large-scale Pacific High and Hadley Circulation demonstrating the need for more research in this area.

2.2.3 Wind

Synthesis Authors: *Charles Jones and Callum F. Thompson*

The complex topography of the Central Coast region, ranging from coastal areas to mountain ranges and deserts, plays a major role in generating downslope and surface wind patterns at local and regional scales. Downslope windstorms are mesoscale (intermediate size) phenomena with 10–100 km horizontal scales that can lead to hazardous fire weather conditions. They are typically coupled with elevated temperatures, low humidity, and the ability to quickly dry vegetation. An ignition during a downslope windstorm can cause fires to spread rapidly and pose significant threats to populations in the wildland-urban interface (Fovell et al., 2018; Larsen et al., 2011; Seto et al., 2022).

Sundowner winds in Santa Barbara County are a type of downslope windstorm whose onset typically occurs in the early evening on the south facing sides of the Santa Ynez Mountains. These winds reach their highest frequency in the spring, but they have been associated year-round with all major south coast wildfires (Blier, 1998; Carvalho et al., 2024; Duine et al., 2022; Jones et al., 2021; Zigner et al., 2020, 2021). Santa Lucia downslope winds occur in San Luis Obispo County when high-pressure systems situated to the north or northeast cause the winds to blow and descend through the mountain passes and canyons. Santa Ana downslope winds affect the southernmost area of the region (the Channel Islands and Western Ventura), as well as Los Angeles and San Diego. They are most prominent during the fall and winter and originate from high-pressure systems over the Great Basin and flow southwestward, descending through mountain passes and canyons (Abatzoglou et al., 2013; Fovell & Cao, 2017; Gershunov et al., 2021; Guzman-Morales & Gershunov, 2019; Hughes et al., 2011; Jones et al., 2010). In January of

2025, Santa Ana winds reached 100 miles per hour (160 km/h) and contributed to the incredibly destructive Eaton Fire in Altadena and the Palisades Fire in Pacific Palisades.

Studies of surface wind trends over the Central Coast are limited and mostly rely on climate model and reanalysis data. Although the intensity of extreme Santa Ana winds shows a modest increase over recent decades (Guzman-Morales et al., 2016), trends in Sundowners or Santa Lucia winds are still unknown. In addition, offshore surface winds in the California coastal jet show robust increases during fall (Thompson et al., 2023), and also during spring and summer (García-Reyes & Largier, 2010). Surface wind speeds have decreased from the Channel Islands south to Baja (Thompson et al., 2023), though over land, wind speeds may have increased or not changed, with a lack of consensus (Pryor et al., 2018; Holt et al., 2012; Thompson et al., 2023).

Climate change may decrease Santa Ana wind conditions in late fall, and less so in the peak winter season (Guzman-Morales & Gershunov, 2019; Hughes et al., 2011; Miller & Schlegel, 2006). Climate change impacts on Sundowner and Santa Lucia winds remain unexplored. Projections of future surface wind speeds for the region are varied (Rasmussen et al., 2011); mid-century projections indicate increasing wind speeds in summer and slower wind speeds in autumn and winter, but improvements are needed (**Appendix A2.2.3**; Wang et al., 2018).

2.2.4 Wildfire

Synthesis Author: *Naomi Tague*

Contributing Authors: *Sloane Stephenson, Max Moritz, Nadia Hamey, Patrick Brown, Christina Richardson, Kate Wilkin, Amanda Stasciewicz, Samantha Kramer, Sarah Anderson, Frank Davis, and Shane Dewees*

OVERVIEW

When European colonists arrived in the Central Coast, they found landscapes extensively burned by the Ohlone, Salinan, and Chumash Peoples (Anderson, 2007; Timbrook et al., 1982). By burning habitats at specific seasons and frequencies, Tribes increased productivity of useful plants and game, facilitated hunting and movement, and improved fire defense (Anderson & Keeley, 2018; Anderson, 2007). In coastal areas, salt marsh coyote brush (*Baccharis* spp.) was burned to promote valuable species like willow and sedge. Burning was also a hunting tool (e.g., Chumash rabbit drives; Timbrook et al., 1982). These practices created a heterogeneous mosaic of grasslands, shrublands, and woodlands with less chaparral, greater floristic diversity, and higher wildlife diversity (Timbrook et al., 1982; Anderson & Keeley, 2018; Keeley, 2002; Diekmann et al., 2007). In 1793, Spain criminalized cultural burning under the mission system, violently enforcing the ban (Timbrook et al., 1982). This greatly reduced traditional burning on the Central Coast as early as the year 1800. Over the next two centuries, continued bans under American governance created denser and more homogeneous vegetation, which led to more severe, frequent, and larger wildfires (Martinez et al., 2023).

Sizable wildfires are now a frequent occurrence in the Central Coast region, often with dramatic impacts on human health, infrastructure, and terrestrial and aquatic ecosystems. Several of the largest California fires on record have occurred in the region, including the Thomas (281,000 acres [1,137 km2] in 2017), Zaca (240,000 acres [971 km2] in 2007), and Matilija (220,000 acres [890 km2] in 1932) fires. The 2020 CZU Lightning Complex Fires (**Figure A2.4**), while smaller in

area (87,000 acres [352 km2]), was one of the most destructive wildfires in terms of structures lost. Many Central Coast communities are in the wildland–urban interface (WUI) where they are at greater risk of fire impacts (Moritz, 2014). Loss of lives, homes, and infrastructure regularly occur, both directly during the fires and from post-fire flooding events. See **Appendix 2.2.4** for examples of impacts from the 2017 Thomas Fire and 2025 Madre Fire.

CLIMATE-FIRE RELATIONSHIP, CLIMATE CHANGE, AND FUTURE FIRE REGIMES

Fire regimes in the region are complex due to topographic, climatic, and vegetation heterogeneity (Parisien & Moritz, 2009; Borchert & Davis, 2018; Abatzoglou et al., 2009; Jones et al., 2021). Fires tend to occur during the dry summer and fall but can also occur in winter in years with low precipitation. Fuel moisture is a strong predictor of fire size and frequency (Park et al., 2022). Fuel accumulation contributes to fire, as years following wet conditions where biomass accumulates can experience increased fire activity (Park et al., 2021). Persistent drought may decrease fuel by reducing growth or converting chaparral to grass (Storey et al., 2021; Dewees et al., 2022). Housing expansion and fuel accumulation from fire suppression policies can increase wildfire risk (Murray et al., 2023). Fire probabilities increase with initial increases in housing density and can decline in dense urban developments (Park et al., 2021). Wind also plays a critical role in many Central Coast fires (see *Section 2.2.3 Wind*).

The Central Coast region will likely continue to have large, severe fires in the coming decades with warming temperatures and later onset of precipitation (Luković et al., 2021), with significant uncertainty in spatial and temporal trends. Since 1960, fire size in the region has increased, although trends are weakly significant (Keeley & Syphard, 2021). There is no significant trend in fire frequency, with some projections showing increases and others decreases (Dye et al., 2023). Understanding how the region's fire regimes will evolve will improve with more information on how larger scale synoptic (broad area) climate patterns influence downslope winds (Carvalho et al., 2020) and fog (Williams et al., 2018; Emery et al., 2018). Wildfires can have long-lasting effects on water quality (Smith et al., 2011; Paul et al., 2022; Raoelison et al., 2023) (*See Water Quality in Section 3.2.2 Climate Impacts to Water Security and Sustainability* and *Section 2.2.6 Air Quality*).

FUEL TREATMENTS AND MANAGEMENT

Tribal Cultural Burning

Cultural burning is long practiced by California Native American Tribes, predominantly in summer post-harvest of native grass seeds (e.g., by the Chumash; Timbrook et al., 1982). While modern techniques target sites to reduce wildfire risk, cultural burns steward the entire landscape to maintain a desirable mix of plants, animals, and habitats (Diekmann et al., 2007; Martinez et al., 2023). In 2021, California law (SB 332) codified cultural burning to help return land management sovereignty to California Native American Tribes (Martinez et al., 2023).

Fuel Treatments for Wildfire Reduction

State-wide analyses also suggest that fuel treatments such as reintroducing low-intensity fire and thinning dense forests can restore historical fire regimes and improve ecosystem resilience (Graham et al., 2004). These large-scale analyses show benefits for the Central Coast when

aggregated (e.g., Brown et al., 2025) but often rely on models and tools that have not been well-tested in the understudied Central Coast region. Most prescribed burning in the region is conducted in grassland, oak woodland, coastal sage scrub, or chaparral foothills below 4,000 ft (1,220 m) (Borchert & Davis, 2016). There is relatively little science-based research on the effectiveness and impacts of prescribed fire in these ecosystems compared to other forests, and key questions remain. Long-term research and meaningful collaboration with Tribes is needed to inform when, how, and how frequently to intentionally burn in different settings to meet management objectives and Tribal cultural goals (Andreozzi et al., 2023).

Box 3: *Restoring Cultural Fire to the Central Coast*

The Amah Mutsun Land Trust is actively working to restore cultural burning to the Quiroste Valley Cultural Preserve (QVCP), a 225-acre portion of Año Nuevo State Park that is a historic site for the Quiroste Tribe (of which there are no known living descendants) and is a sacred place for the Amah Mutsun Tribal Band. The project is centered around enhancing native plant health and diversity and reducing fuel loads in coastal grasslands that have experienced significant encroachment from both native woody species and non-native invasive species in the absence of Indigenous stewardship. With support from state and local partners, the Amah Mutsun plan to return cultural burning to QVCP by 2027. It is one of several locations within Mutsun and adjacent Tribal territories where the Amah Mutsun plan to restore Indigenous-led "good fire" (Clark et al., 2024). This work is grounded in long-standing ecological and archaeological research involving the Tribal Band, academics, and agencies (e.g., Lightfoot et al., 2025). This research provides strong evidence that Native Peoples use the regular application of low-intensity fire at QVCP and in other Central Coast areas as a tool to reduce fuel loads while tending plant species that are important for food and other uses (Cuthrell, 2013; Lightfoot et al., 2013).

In one of many other examples, members of the yak titᵛu titᵛu yak tiłhini (ytt) Northern Chumash Tribe are conducting cultural burns on Carrizo Plain National Monument grasslands to foster native grassland species in a constantly evolving environment managed by people. While ytt Tribal members interviewed for this report accept that some climate change impacts may not be avoided, they continue to let their cyclical view of time guide their adaptation efforts. Providing opportunities for ongoing cultural stewardship and educating about the benefits of cultural burning is integral to their approach.

Studies being conducted in the Central Coast region highlight partnerships between research and practice (see **Box 3**). In 2023, UC Santa Barbara began a 10-year Vegetation Management Program with the California Department of Forestry and Fire Protection (CAL FIRE) and the Santa Barbara County Fire Department (SBCFD) to conduct prescribed burns (e.g., **Figure 14**) at the UC Sedgwick Reserve for fuel management and scientific research in the reserve's foothill ecosystems.

Since 2022, there have been detailed studies of four burns in oak woodland and sage scrub ecosystems. Sedgwick Reserve is also collaborating with The Nature Conservancy, SBCFD, and many other local partners to conduct annual Prescribed Fire Training Exchanges (TREX) that combine firefighter training, fuel management, and prescribed fire research. Early research has shown that despite similar site and weather conditions, there is wide variation in fire behavior and severity, both within and between burns, leading to large variations in post-burn outcomes in terms of overstory oak mortality, shrub recovery, and herb diversity.



Prescribed Burn on Spaulding Mountain

Figure 14: *A prescribed burn in Santa Barbara County in 2021. (Photo: Ethan Turpin)*

URBAN FIRE MITIGATION

Mitigating wildfire hazards on structures ahead of a wildfire has been shown to increase structure survival in the region. Syphard and Keeley (2019) investigated the role of building structural characteristics, defensible space distance, and defensive actions, and found that structural characteristics explained more difference between survived and destroyed structures than defensible space distance. Their study, based on more than 40,000 records of structures exposed to wildfires from 2013–2018, pointed to enclosed eaves, vent screens, and multi-pane windows as the most significant factors in preventing wind-born ember penetration into structures. Similarly, in a study of the Woolsey Fire, Mockrin et al. (2023) found that building materials along with environmental context were the most important mitigation factors related to survivorship. California codes have required upgraded materials in codes, resulting in higher rates of building survival in wildfire (Knapp et al., 2021; Baylis & Boomhower, 2022). However, retrofitting these materials may be costly, and post-fire assessments have yielded inconsistent conclusions about critical locations or scales at which to implement less costly defensible space mitigations (Knapp et al., 2021).

Mitigation implementation can be challenging, and residents are often inconsistent in completing recommendations to specified standards (Wilkin et al., 2025; McCaffrey et al., 2015; Paveglio et al., 2018). Barriers to residents fully mitigating property-level risk include lack of individual capacity (e.g., physical ability, time, money), trade-offs with other values (e.g., erosion control, shade/energy use, or aesthetics), perceived efficacy of the mitigations (including concerns about spillover effects from adjacent properties), and social and cultural norms (McCaffrey et al., 2011, 2015; Toman et al., 2013). For example, many homeowners in the Santa Cruz Mountains felt tree removal and spacing requirements were incompatible with slope stabilization concerns, the need for riparian corridors, and perceptions of the protected status of species (e.g., redwoods). Residents need guidance on prioritizing mitigations and the tradeoffs between different options (Wilkin et al., 2026).

COMMUNITY ADAPTATIONS

Wildfire experiences on the Central Coast often lead to immediate community focus on mitigation and preparedness (Hui et al., 2022; Wibbenmeyer et al., 2019). Sustaining these activities is challenging and requires continued organization and outreach to multiple organizations that address fire risk (Kelly et al., 2019). Counties, cities, and local groups are adopting wildfire planning frameworks to reduce wildfire ignition, increase community preparedness, and bolster wildfire resiliency. Five Central Coast counties have a county "Fire Safe Council" to coordinate fire resilience activities. For example, Santa Barbara County—with seven fire departments, nine Community Wildfire Protection Plans (Palsa et al., 2022), and over 20 Firewise USA® communities (Kampfschulte & Miller, 2023)—formed the Santa Barbara County Fire Safe Council (SBCFS), which adopted a model Regional Wildfire Mitigation Program to coordinate their activities (Moritz et al., 2022). Creating community-level resilience also involves efforts to educate the public about wildfire, engage homeowners, build relationships among local agencies and non-governmental organizations, and coordinate to secure local funding for programs such as free wood chipping (Moritz et al., 2022). Providing information on available programs is key: for example, the City of Buellton and the SBCFS sponsored the Burn Cycle Project to bring a pop-up multimedia immersive video experience to the city (**Figure A2.5**) with accompanying videos for children and other informational materials.

Despite these successes, many challenges still exist, particularly for vulnerable communities (Anderson et al., 2023; Baker et al., 2024; Davies et al., 2018; Lambrou et al., 2023; Ojerio et al., 2011; Schinko et al., 2023). Low levels of legislative and public support for preparedness (Anderson et al., 2023; Healy & Malhotra, 2009) and wildfire mitigation (Paveglio, 2021; Yung et al., 2022) combine with the unique challenges of vulnerable communities. Non-English-speaking communities have reported difficulties accessing information about preparedness, evacuation, and recovery (Baker et al., 2024). Further, multiple concurrent fires limit available resources, hinder wildfire suppression, and can make it impossible to save individual homes, such as in 2020 when there were nearly 400 concurrent wildfires during the CZU, LNU, and SCU Lightning Complex Fires. In that case, in the Santa Cruz Mountains, agencies prioritized saving lives over structures while neighbors and social groups formed "renegade brigades" who stayed and defended their homes or neighborhoods (Hagemann, 2024). Efforts to increase community adaptation and resilience would benefit from addressing this tension between community interests and needs (e.g., stay and defend, areas of last resort) and agency priorities and resource limitations.

2.2.5 Sediment Hazards and Resources

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The Central Coast region's many small, steep watersheds produce large amounts of sediment. Steep hillslopes are prone to landslides and debris flows during intense rainstorms, or during and after unusually wet winter seasons. The region has also been prone to wildfires, and much of the sediment production occurs in response to intense rain falling on burned landscapes that typically produce more sediment than unburned terrain. Projections show increasing intense rain and the high likelihood of large, severe fires in the coming decades (*Section 2.2.2 Coastal Low Clouds and Fog* and *Section 2.2.4 Wildfire*), with the region's watersheds likely seeing increasing sediment output (Sankey et al., 2017).

Wildfire often increases soil and sediment erosion rates 5- to 10-fold (McGuire et al., 2024) as burned soils can repel water and there is less vegetation to intercept the rain. When intense rain occurs after a fire, it can run off burned slopes and quickly form dangerous sediment-laden floods or post-fire debris flows (PFDFs). PFDFs are typically initiated by short-duration (<1 hour), high-intensity rainfall within the first few years after a wildfire. Atmospheric rivers (ARs) are associated with more than half of PFDF events, with most PFDFs occurring during weak- and moderate-strength ARs (Ralph et al., 2019). PFDF frequency is highest following years with significantly above-average area burned, while wetter-than-average water years do not necessarily correspond to more PFDFs (Oakley et al., 2025). Of the large Central Coast fires that occurred from 1984–2022, six had documented PFDFs, causing an estimated 3.1 megatons of sediment to flow from hillslopes and small streams (Dow, Kostelnik, et al., 2024; **Appendix 2.2.5**).

Transitions from anomalously wet to anomalously dry conditions amplify fire risk and subsequent PFDFs by exacerbating fuel accumulation and drying cycles (Swain et al., 2025). With recent lengthening of the dry season (Luković et al., 2021) fires can occur closer to winter rains, exposing burned areas to intense rain before vegetation begins to recover, as occurred in the January 2018 Montecito mudslide disaster. Drought years are also projected to increase (*Section 2.2 Key Climate Impacts and Events*), stressing vegetation and increasing its flammability (Asner et al., 2016). The

cascading hazard of drought, fire, and intense rain is likely to increase, worsening fire and post-fire hazards (**Appendix A2.2.5**) and increasing sediment output (East & Sankey, 2020; Sankey et al., 2017).

Sediment mobilized by intense rain and post-fire erosion causes costly, long-term infrastructure problems even after storm damage is repaired. PFDFs, and even minor "nuisance" sediment movement, can cause recurring road damage with new rain events (**Figure 15**). This resulted in damage to properties in the region after the 2020 CZU Lightning Complex, Carmel, River, and Dolan Fires (Safford et al., 2022; Thomas et al., 2023) (**Figure 15**). Most regional post-fire erosion occurs upstream from reservoirs (Dow et al., 2024), causing sedimentation and diminishing water-storage capacity. Notably, Los Padres reservoir on the Carmel River has lost approximately a third of its storage capacity since its construction in 1949, primarily due to post-fire sediment delivery (East et al., 2024). Sediment- and dam-management options are being considered for the reservoir (AECOM, 2023), but water supplies from other local reservoirs are also likely to be impacted by post-fire erosion (Hallema et al., 2018).

Landslides and PFDFs during winter storms can be extremely hazardous even in terrain that has not burned recently. Several deep-seated landslides caused major damage in the region: the 1982 Love Creek landslide in Ben Lomond (Santa Cruz County) occurred during extreme rain (Ellen & Wieczorek, 1988) and the May 2017 Mud Creek landslide along the Big Sur coast (Handwerger et al., 2019) followed one of the wettest winters on record. In 2017 and 2023, flooding and landslides (some of which damaged properties and closed major roads) were triggered by "families" of AR storms that arrived in close succession (Fish et al., 2019; Gershunov et al., 2017). Soils did not have time to dry out between storms and were more prone to landsliding—there were several hundred damaging landslides in Santa Cruz County in 2017 (East et al., 2018).



Damage to Nacimiento-Fergusson Road in Monterey County

Figure 15: *A road damaged by debris flows and flooding after the 2020 Dolan Fire. Large masses of sediment in a creek bed are perched above the road because of 2021 debris flows, creating a persistent source of sediment deposited episodically onto the road. (Photo: Amy East, USGS)*

An increase in sediment supply from the landscape can sometimes provide beneficial resources. An unusually wet winter season greatly increases the amount of river sediment transported to the coast, bringing new sand to beaches near the river mouths. Conversely, burial by sediment may affect riverine or coastal ecosystems detrimentally if sediment-related disturbances exceed the adaptive capability of affected organisms, which may have implications for Central Coast communities and economies (fisheries, shellfish harvesting). For watersheds where dams and reservoirs trap sediment, sediment discharge to coastal systems is limited or eliminated.

Recent major fires and storms provided data to better understand public risk from intense rain, landslides, and PFDFs (Staley et al., 2016, 2017; Thomas et al., 2023). Public communication about the likelihood of these hazards has been part of the region's disaster risk reduction after recent fire seasons, including public meetings, social media posts, and updates to County and

State websites (e.g., Santa Cruz County, 2020; Monterey County, 2021, 2025). Planning ahead for potential PFDF situations (Oakley, 2021) will be increasingly important and require a more complete understanding of factors leading to the greatest risk to life, property, and ecosystems.

2.2.6 Air Quality

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Contributing Author: *Samantha Kramer*

Rising temperatures, altered precipitation patterns, intensified wildfires, and prolonged droughts can deteriorate air quality. Monterey, San Benito, and Santa Cruz counties make up the North Central Coast Air Basin (NCCAB), where three pollutants pose significant health risks: PM2.5 (wildfire, vehicles, industry), PM10 (dust, construction), and ozone (**Appendix 2.2.6**). The NCCAB has experienced air quality notably worse than state and federal standards for all three pollutants based on annual average concentrations (**Appendix Figures A2.6–A2.9**).

WILDFIRES

Wildfires release organic particulate matter and emit substantial amounts of volatile and semi-volatile organic materials and nitrogen oxides (NOx), which form ozone. Higher temperatures accelerate the photochemical reactions that produce ground-level ozone. The pollutants can affect first responders, local residents, and regions far from wildfires (NOAA, 2025). Over 2008–2017, the region experienced some contribution from wildfire smoke on ~50–70% of all days, with significant impacts to air quality under extreme conditions (Kramer et al., 2023). Prescribed burns can also produce pollution from smoke, but these impacts are much less when compared to wildfires (Maji et al., 2024; see *Section 2.2.6 Air Quality* and *Section 5.1 Public Health*).

Wildfires in the Central Coast increased concentrations of PM2.5 and PM10, including the 2016 Soberanes Fire, the 2020 CZU Lightning Complex and Dolan Fires, and the 2021 Alisal Fire. Most particles are PM2.5, but some are PM10 (**Figure A2.6**). For the NCCAB, wildfire years resulted in peak 24-hour mean PM2.5 concentrations exceeding the federal standard. Peak PM10 levels are generally above the California state standard but show sharp increases during wildfire events. Prescribed fires also reduce air quality (**Appendix A2.2.6**). Despite large fires, ozone levels remain mostly under the state and federal standards in the region (**Figures A2.8** and **A2.9**).

RISING TEMPERATURES, DROUGHTS, AND AIR POLLUTION

Higher temperatures accelerate ground-level ozone production and measurably increase ozone levels (OEHHA, 2022). Drought can also contribute to ozone formation, as reduced water can lead to crop failure and increased burning of dead and dying crops. The release of fine particulate matter, volatile organic compounds (VOCs), and NOx is exacerbated when drought coincides with low relative humidity and high temperatures, further contributing to ozone formation (Lee et al., 2023) and increased dust and pollen emissions (Adebiyi et al., 2025) (see *Section 3.3 Agriculture* and *Section 5.1 Public Health*).

PRESCRIBED BURNS

Prescribed fires mitigate wildfire risk and reduce hazardous fuel buildup but also create smoke and can increase levels of PM2.5, PM10, and ozone. While increases are significantly less than those of wildfires (Maji et al., 2024), short-term increases were measured on the Central Coast (**Appendix 2.2.6.1**). Between 2008–2017, the region experienced a contribution from wildfire smoke on ~50-70% of all days, with significant impacts to air quality (Kramer et al., 2023). Only ~20% of all days had contributions from prescribed fire smoke, with negligible air quality impacts (<1 microgram per cubic meter [µg/m3]). If the state's prescribed priority fuel reduction targets (Kramer et al., 2023; Rosenberg et al., 2024) are met, the region may see a threefold increase in the percentage of days with impact from prescribed fire smoke, but in negligible concentrations (1–5 µg/m3), except Santa Cruz, where future concentrations reach 1–13 µg/m3 in extreme scenarios.

FUTURE DIRECTIONS AND ADAPTATION

Cooling and breathing centers were established in Santa Cruz and Monterey counties to support vulnerable populations, and for use during extreme smoke and heat events in San Luis Obispo County (see *Section 5.1 Public Health* and *Section 4.4 Emergency Preparedness*). Air quality monitoring stations and field air quality sensor data will be used to inform the public about breathing centers throughout California. The California Air Resources Board maintains a map, accessible online, of permanent and temporary Clean Air Centers.

2.2.7 Sea Level Rise

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Contributing Authors: *Ryan Anderson, Jenny Dugan, Charles Lester, Crissy Pickett, Borja Reguero, Stefan Talke, Ian Walker, and Tiffany Wise-West*

OVERVIEW

Sea level rise (SLR), colliding with extreme storms, is increasingly drowning beaches, eroding bluffs, flooding homes and businesses, and damaging roads and other essential public infrastructure (COPC, 2024). Along the Central Coast, the rate of SLR has increased by 24% in the last decade in Monterey to 0.08 in/yr (2.1 mm/yr)—with 4 in (10 cm) of SLR occurring over the last 50 years. Similarly, the SLR rate at Port San Luis increased from 0.04 in/yr (1 mm/yr, 1945–2019) to 0.07 in/yr (1.8 mm/yr, 1990–2019) (Talke, 2025). Thus, the Central Coast lags behind the global average of 0.18 in/yr (4.5 mm/yr) of SLR (Hamlington et al., 2024). It is also below the Central Coast's historical seasonal sea level variability in a typical year (~8 in [20 cm]) or due to an El Niño Southern Oscillation (ENSO) warm phase event (4–6 in [10–15 cm]).

An example of SLR contributing to recent coastal flooding and erosion events occurred in January and December 2023, when large waves and wave runup coincided with high tides (e.g., Emerson, 2024). At Port San Luis, recent relative SLR resulted in mean water levels approximately 2.8 in (0.07 m) higher than in 1983, another year where there was notable wave damage. These long-term sea level increases, combined with the elevated water levels during the El Niño event in the winter of 2023–2024, contributed to large wave runups (see Appendix). Thus, long-term SLR and seasonal

sea level increases are a flood risk factor, and the coastal erosion caused during big El Niño years (1982–83, 1997–98, 2015–16, 2023–24) is a harbinger of what will happen more often as sea level continues to rise.

For SLR projections, guidance has been updated since 2018 at the federal (Sweet et al., 2022) and state levels (CA Ocean Protection Council, 2024) with similar methodologies. Projections across the Central Coast region show an increase in monthly mean water levels over historical (1970–2000) values, particularly during winter El Niño events. At the Santa Barbara, Port San Luis, and Monterey stations, the intermediate projection of SLR is ~ 7 inches (19 cm) by 2050 (likely range 4–13 inches, 10–34 cm) and ~34 inches (86 cm) by 2100 (likely range 8–76 inches, or 20–192 cm), referencing a 2000 baseline.

FLOODING

Communities in the Central Coast region are subject to long-term SLR and short-term extreme events that can lead to increased rates of cliff and bluff erosion and flooding of low-lying shoreline areas. Even small SLR will exponentially increase the frequency and magnitude of coastal flooding (Vitousek et al., 2017a; Taherkhani et al., 2020). Only ~ 7 inches (19 cm) of SLR (expected by 2050 under the intermediate SLR scenario) could increase flood frequency by a factor of 5, and with ~12 inches (30 cm), flood frequency could increase by a factor of 100 (Kalansky et al., 2026). Today's Central Coast 100-year coastal flooding event is predicted to occur ~50–100 times per year or more by end-century with the intermediate SLR scenario (3.3 feet [1 m]) (NASA Flooding Analysis Tool).

Socioeconomic exposure (e.g., population and property values) to flooding also increases substantially with SLR (**Figure 16**) (Barnard et al., 2019).

Storms are the dominant driver of risk to people and property with 0–20 inches (0–50 cm) of SLR, when ~3,000 residents and $1 billion of property are exposed on the Central Coast. With 20–40 inches (50–100 cm) of SLR, exposure to everyday flooding (i.e., no storm scenario) doubles. Exposure steadily increases with 59–79 inches (150–200 cm), except for the 100-year storm event where exposure nearly doubles to 21,000 residents and $6.5 billion in property. Santa Barbara County accounts for > 50% of the region's exposure risk for all scenarios, with the cities of Carpinteria and Santa Barbara at highest risk. Notable flooding exposures in other counties include Pismo Beach, Los Osos, Morro Bay, Monterey, Rio Del Mar, Capitola, and Santa Cruz.

Tsunami impacts will also be exacerbated by SLR (see the Fifth Assessment report "Influence of Future Sea Level Rise on Tsunami Hazards in California", prepared by the Department of Conservation [Patton et al., 2026]). Santa Cruz and Ventura also have disproportionate tsunami risk, both historically and amplified with future SLR.



Exposure to Flooding Under SLR Scenarios

Figure 16: *Exposure of (a) population and (b) property values for the region to SLR and storm-driven flooding using the Coastal Storm Modeling System (CoSMoS: Barnard et al., 2019) and the Hazard Exposure Reporting and Analytics web tool (HERA: Wood et al., 2023).*

GROUNDWATER

SLR will cause the water table in unconfined aquifers along the coast to rise closer to the surface. As groundwater becomes shallower and emerges at the surface in some locations, subsurface infrastructure such as building and road foundations, septic and stormwater systems, and public utilities could be compromised and subsurface pollutants could be mobilized and released (Hill et al., 2023; Habel et al., 2024).

The exposure of residents and property values to shallow (water table <2 m from surface) and emerging groundwater increases by 8% (residents) and 20% (property), respectively, with 0–6.6 feet (0–2 m) of SLR (**Figure 17**), although the increase in exposure is not as rapid as from overland flooding (5-fold increase in daily flooding).

The intermediate SLR scenario (3.3 feet [1 m]) (OPC, 2024) would expose ~50,000 residents and $9 billion in property to groundwater hazards along the Central Coast, ~7 times the exposure of daily tidal flooding alone. Further, as SLR continues, groundwater hazards are translated inland, significantly increasing the exposure of residents and property to emergent and extremely shallow groundwater (water table < 3.3 feet (1 m) from the surface). Property value exposure to emerging groundwater increases by 80% with 6.6 feet (2 m) of SLR. Both groundwater and flooding hazards should be included in coastal adaptation plans to reduce the impacts of SLR.

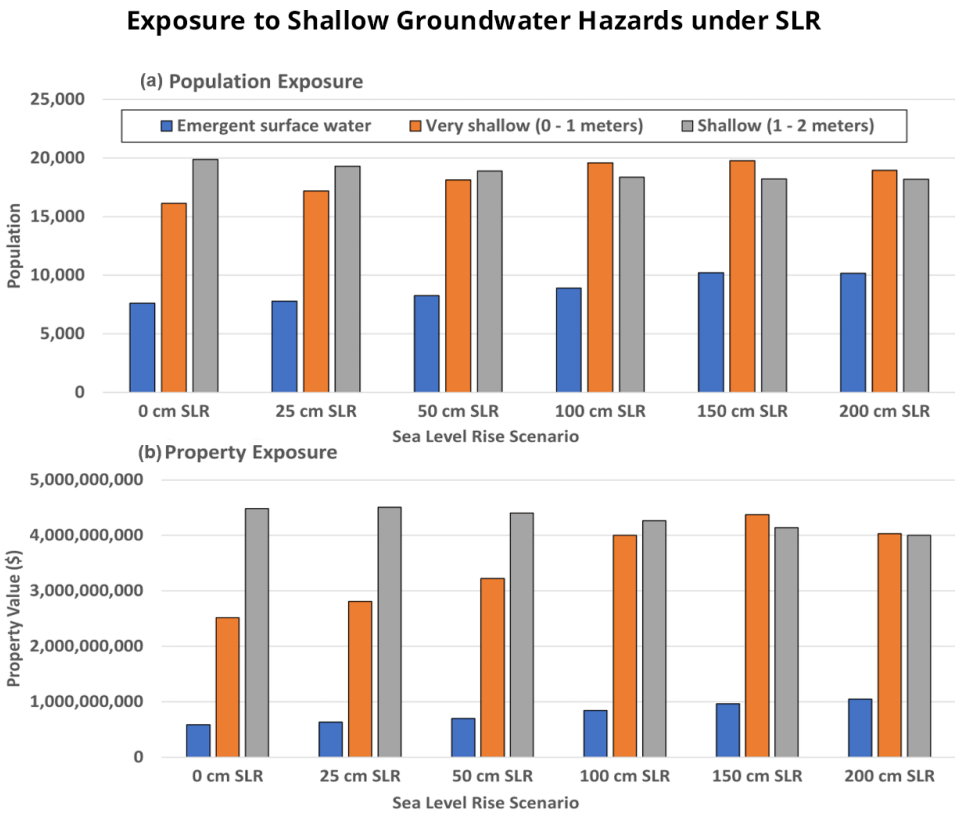


Figure 17: *Exposure of (a) population and (b) property values for the Central Coast region to shallow groundwater hazards based on CoSMoS-GW (Befus et al., 2020) and the Hazard Exposure Reporting and Analytics web tool (HERA; Wood et al., 2023).*

WATER QUALITY

The combined impacts of SLR and elevated groundwater and extreme storms will increase the frequency of saturation of contaminated sites (e.g., military bases, commercial facilities, remediation sites, and industrial manufacturing or transportation hubs) along the shoreline, with waste solution migration, physical erosion, and saltwater intrusion (Habel et al., 2024). Pollutants mobilized by the rising water include heavy metals, pesticides, herbicides, organic pollutants, radioisotopes (radioactive material), and volatile organic compounds. Severe environmental and human health exposures may result, especially if contaminants combine and transform into more hazardous or more mobile material (Cushing et al., 2023). The mitigation measures at contaminated sites vary widely in their effectiveness and protective measures may be needed.

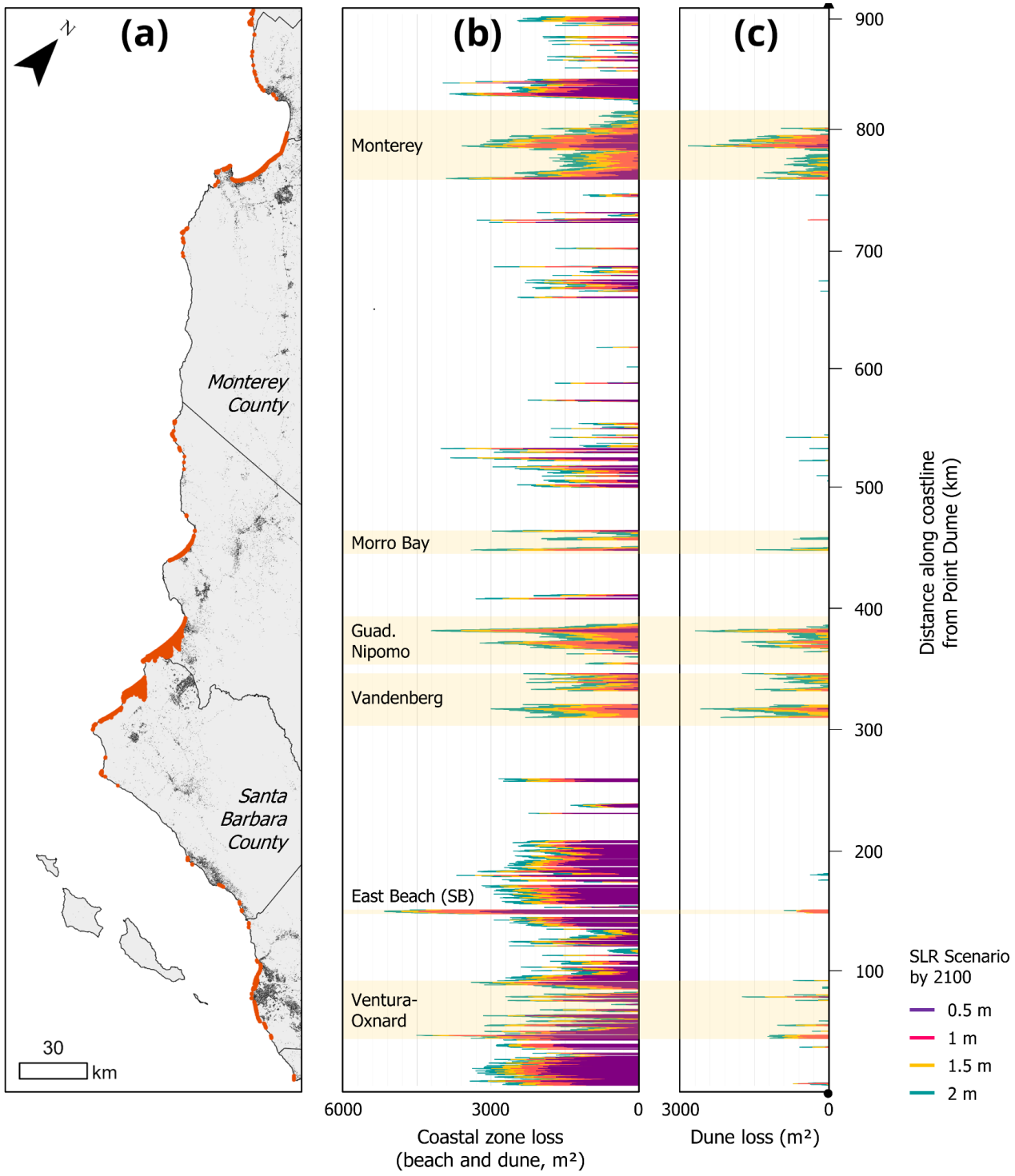
Many toxic waste sites vulnerable to flooding are near disadvantaged communities (DACs) and low-income neighborhoods that tend to have larger cumulative pollution burdens and fewer resources for mitigation and adaptation (Cushing et al., 2023). Further research should address the interrelationships between SLR, storm events, elevated groundwater levels, and the well-being of surrounding communities, and include scientific guidance on contaminated sites to inform decision-making.

CLIMATE IMPACTS TO SHORELINES

Beach and dune systems in the region (**Figure 18a**) are projected to undergo loss with intermediate-low rates of SLR (see also *Section 3.5.2 Sandy Beaches*).

Potential loss rates are generally greatest from the Santa Barbara Channel to Point Dume, and in Monterey Bay (**Figure 18b**). The loss of dune ecosystems (**Figure 18c**) is more sporadic to the south, and for higher projections of SLR because of generally higher dune elevation compared to their adjoined beaches. Appreciable dune losses with intermediate or higher amounts of SLR (>3.3 feet [1 m]) could occur in localized areas, including Ventura/Oxnard, East Beach/Santa Barbara, Vandenberg Space Force Base, Guadelupe/Nipomo Dunes, Morro Bay, and Monterey Bay.

At intermediate SLR (3.3 feet [1 m] by 2100), Davidson-Arnott and Bauer (2021) suggest most sandy beach-dune coasts would only migrate inland < 131 feet (40 m), depending on the availability of sand on adjoined beaches. On some *high-energy* coasts (particularly central and Northern California), this is less than current inland migration from extreme storms and beach-dune rebuilding phases but could be problematic on developed coasts like Ventura/Oxnard, Santa Barbara, Carpinteria, Pismo Beach, Morro Bay, and Monterey Bay, with limited space for inland migration (“coastal squeeze”), dynamic low-lying barriers, and/or ongoing erosion.

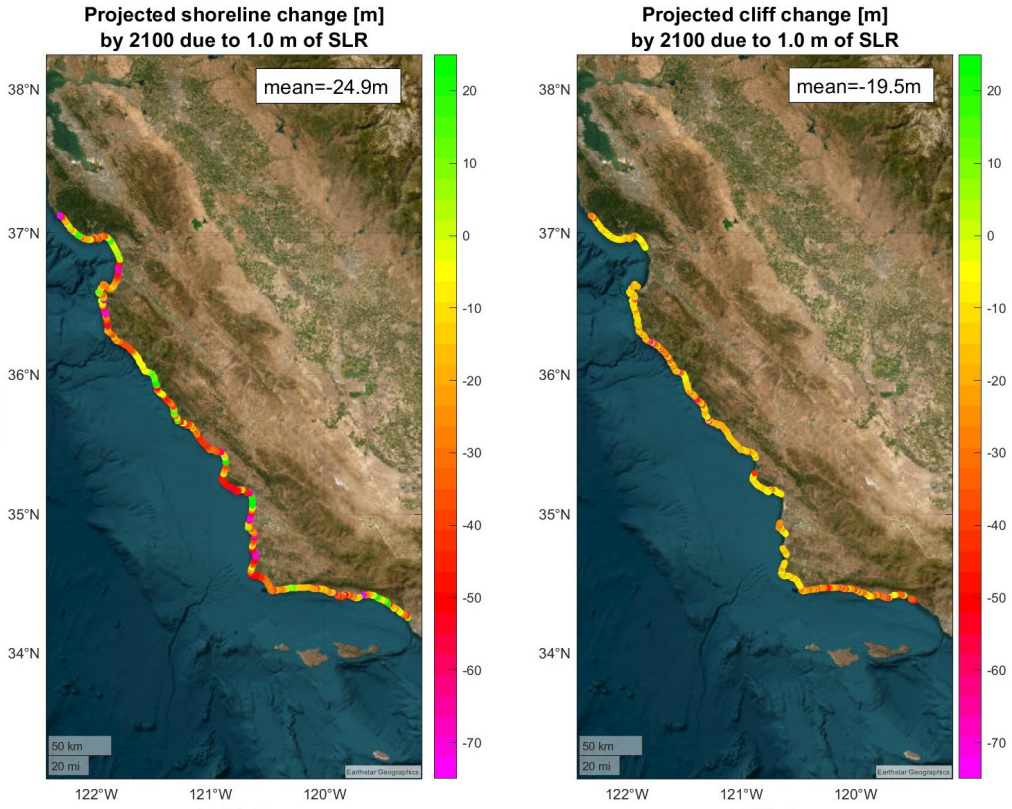


Threats to Coastal Sand Dune Ecosystems Under SLR

Figure 18: *(a) Dune systems (orange) with major complexes highlighted in yellow in graphs of estimated loss (m2) of (b) adjoined beach–dune environments in the coastal zone and (c) dune ecosystems only, as projected by 2100 under four SLR scenarios (Intermediate-Low, 0.5 m; Intermediate, 1.0 m; Intermediate-High, 1.5 m; High, 2.0 m) (OPC, 2024).*

SHORELINE RESPONSES

Connecting how landscape disturbances (e.g., wildfires, floods) and climate variability affect watersheds and ocean shorelines is key to assessing the resilience of beaches to SLR (Warrick et al., 2023). With the Intermediate 3.3 feet (1 m) SLR scenario, in the Central Coast about 73% of shorelines and 70% of cliff systems are projected to retreat by at least 10 m (32.8 feet) by 2100 (**Figure 19**).



Projected Shoreline Retreat

Figure 19: *Projected (a) shoreline retreat and (b) cliff change (Vitousek et al., 2023)*

This retreat could remove proportionate amounts of sandy beaches; sandy beaches backed by dunes already show 70% declines in Central California since the mid-late 1800s. Many beach-dune systems provide flood protection and erosion control for adjoining communities, ecosystems, and critical infrastructure, and provide specialized habitat for endangered, endemic, and migratory species, recreation and tourism spaces, groundwater recharge, sinks for coastal carbon and nutrients, and SLR protection (Martínez et al., 2008; Barbier et al., 2011).

Cliff systems will erode inland with net offshore loss of material. However, coastal dunes can rebuild via exchanges of sand from the nearshore to the beach (littoral delivery) and back to the dune by windblown (aeolian) processes (Walker et al., 2017; Hesp and Walker, 2022). Over decades to centuries, dune-backed coasts can act as both a source and sink of sediment and could respond very differently than bluff-backed coasts to SLR. If the rate of SLR is small compared to water level variations (e.g., from waves, storm surges, or El Niño), and if the rate of sand supply remains

relatively steady, then beach-dune morphodynamics could maintain a similar beach width, nearshore slope, and dune size while migrating upward and inland with SLR (Davidson-Arnott, 2005; Davidson-Arnott & Bauer, 2021). As SLR rates accelerate and/or sediment supply conditions change, there is a risk that onshore sand transport and aeolian processes may not keep pace.

Central Coast beaches are typically narrowest, steepest, and coarsest in the winter when the waves are largest (Aubrey et al., 1980; Warrick et al., 2025). Earth-observing satellites (e.g., CoastSat; Vos et al., 2019) can track cycles of coastal change (Barnard & Vitousek, 2023). Satellite data shows that beach erosion extents over the 2022–23 and 2023–24 winters closely resembled those during the 2015–16 El Niño event along the Central Coast. In-situ observations (observations situated in the original place) and satellite photos showed more than 10 m (32.8 feet) of coastal dune erosion during the 2022–2023 and 2023–2024 winters (Emerson, 2024). Monitoring and predicting coastal landscape changes for dunes and cliffs remains difficult due to longer timescales and sparse observations, but new datasets (e.g., Rader et al., 2018; Swirad & Young, 2022; Hilgendorf et al., 2021, 2022) can clarify linkages between littoral forcing and coastal landscape responses offshore.

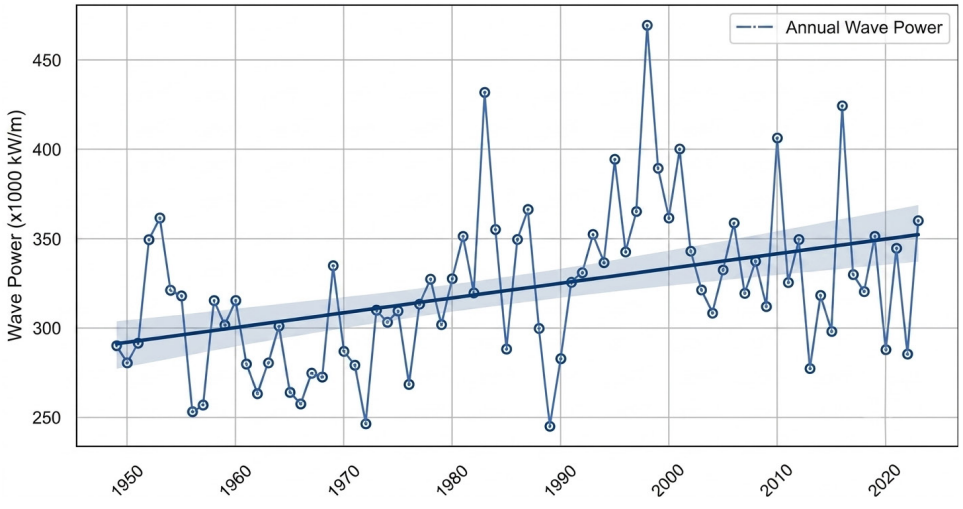
2.2.8 Extreme Coastal Storm Events

Synthesis Author: *Patrick Barnard*

Contributing Authors: *Ryan Anderson, Jenny Dugan, Charles Lester, Crissy Pickett, Borja Reguero, Stefan Talke, and Ian Walker*

TRENDS

Wave height and power in the Central Coast have increased since 1950 (**Figure 20**). Wave energy during storms has increased +7% per decade and the mean direction of high wave energy events has shifted 7° per decade (Erikson et al., 2022).



Historical Increases in Wave Power

Figure 20: *Mean annual wave power offshore of Santa Cruz (Reguero et al., 2019)*

KEY IMPACTS

Historically, the more hazardous events along the Central Coast were short-term extreme events with very large waves during high astronomical tides, augmented by elevated sea levels during El Niño events. Storm events in 1997–98, 1982–83, 2015–16, 2023, and 2024 damaged oceanfront property, caused severe erosion, and disrupted transportation (described in detail in **Appendix A2.2.8.1**).

ADAPTATIONS

Coastal storm damage over the past 150 years has been well documented, but after major damaging events in three consecutive winters, mitigation and/or adaptation planning has accelerated in multiple locations, including shoreline armoring as well as nature-based adaptation strategies. Seawalls, revetments, and other shoreline armoring have been used to protect development from wave runup and extreme storms (**Figure 21**) including miles-long rock revetments in Ventura County and small sea cave fills in Santa Cruz County.



Shoreline Structures on the Central Coast

Figure 21: *Shoreline structures on the Central Coast. (Photos: C. Lester)*

Engineered vertical seawalls and emergency rock placements protect infrastructure, shoreline access, and homes built on beaches or close to the bluff edges. Shorter, more developed shorelines, like Ventura County's, are more armored relative to counties with longer, less developed shorelines like Monterey (**Table 2**; Griggs & Patsch, 2019).

Table 2: *Armoring of Shorelines within the Central Coast*

County	Santa Cruz	Monterey	Santa Barbara	San Luis Obispo	Ventura
Total shoreline miles	42	111	92	110	41
Percent shoreline armored	24.4	5.8	7.3	11.7	57.2

Seawalls and revetments allow development and infrastructure to stay along the coast longer, but they have varying lifespans, high maintenance costs, and environmental impacts (Griggs, 2005; Gittman et al., 2016; Munsch et al., 2015). Sometimes they cover the beach, eliminating recreational space and blocking lateral public access, especially at higher tides. They may change the local wave environment, exacerbating erosion on adjacent properties, and replace natural shorelines with concrete and unnatural rock. Seawalls and other coastal structures such as groins might also disrupt natural sand movements on beaches. Seawalls also reduce bluff erosion and the supply of sand required to maintain beach form, function, and resilience.

Hard coastal structures (e.g., seawalls) can cause a "coastal squeeze"—the gradual inundation of beaches unable to migrate landward against an armored backshore with SLR (see *Section 3.5.2 Sandy Beaches*). This is the primary driver of beach loss projections by 2100 wherever the shoreline is armored, such as urban Santa Cruz County, Cayucos and Pismo Beach in San Luis Obispo County, and Faria Beach in Ventura (Vitousek et al., 2017b). Beach loss impacts are discussed further in *Section 3.2.2 Climate Impacts to Water Security and Sustainability*.

Nature-based adaptation strategies to combat beach loss include oyster reefs; dune, wetland, and seagrass restoration (see *Section 3.5 Marine Ecosystems*); and beach nourishment and sand retention (Lester, 2005; Ward et al., 2021; Beheshti et al., 2021; Lester et al., 2022). Hybrid solutions such as buried revetments and other green-grey options (hybrid reefs) may provide both ecological amenities and "last line of retreat" protection. These strategies may be important as the mean high tide elevation increases and the probability of exceeding the toe of dunes, bluffs, and structures increases (Lester, 2021). Green infrastructure can outperform seawalls (**Appendix Figures A2.9, A2.10**). Conservation and restoration projects can provide the same level of flood protection as seawalls in certain locations, but up to eight times the carbon sequestration, stormwater pollution reduction, recreation, and threatened species habitat (Woods Institute, 2026).

The California Coastal Commission (CCC) attempted to minimize the direct physical impacts of seawalls by requiring vertical seawalls as opposed to wider revetments, and by imposing impact fees to support beach access elsewhere. Their grant program and statewide guidance to address SLR prioritized implementation of nature-based solutions. About two-thirds of local governments in jurisdictions along coast have completed SLR vulnerability assessments, and about a third have completed adaptation strategies. Some local coastal programs (LCPs) now include these strategies (Lester et al., 2022). The City of Santa Barbara's LCP, for example, requires that avoidance, nonstructural solutions, or other softer solutions "shall be implemented" or "shall first" be implemented where feasible, making clear the prioritization of softer solutions with fewer impacts over hard shoreline protective devices when feasible and appropriate (CCC, 2025).

CoSMoS-Adapt is a new approach for evaluating the costs and benefits of coastal adaptation solutions emphasizing Nature-based Solutions (Reguero et al., 2026) designed to reduce coastal hazard risk due to SLR and storms, with Santa Cruz and Ventura as pilot study areas for the Fifth Assessment. While seawalls provide the greatest absolute risk reduction benefits, dune restoration delivered the most cost-effective coastal adaptation solution. The CoSMoS-Adapt framework is designed to be applicable across all of California's coastal regions.

Box 4: *Adaptation Efforts in the City of Santa Cruz*

The City of Santa Cruz's 2018 first vulnerability assessment, existing conditions evaluation, projections, analysis of future conditions, and alternatives analysis resulted in the 2021 West Cliff Drive Adaptation and Management Plan and beach-focused report. Its updated LCP had a new Beaches and Bluffs Chapter and a smart coastal change monitoring network (a tidal gauge, cameras, and drones) and decision support tool. The West Cliff 50-Year Vision (2024) and West Cliff 5-Year Roadmap (2025) included infill walls and bridge repair to address storm damages, and the City is implementing riprap repairs and relocation of West Cliff Drive away from the coast. A Living Shoreline, Nature Based Solutions, and Sand Management Feasibility Study (2024–2025) led to recommendations for stormwater improvements to reduce bluff runoff, integrate step-pools and tidepool blocks into the riprap repairs, and construct a pilot vegetated dune, funded through construction and to be complete by 2029. The City continues to explore intertidal and offshore artificial reefs and other grey-green solutions to preserve the coastline. See **Appendix 2.2.8.2** for more information on adaptation efforts in the City of Santa Cruz.

2.2.9 Ocean Conditions

Synthesis Author: *Mercedes Pozo Buil*

Contributing Authors: *Nathan B. Spindel, Gretchen Hofmann, Mark Carr, Jennifer Caselle, and Joshua Smith*

In the California Current System (CCS), north-south winds alongshore drive upwelling of deep water from the seafloor, bringing cold, nutrient-rich waters to the surface where they support primary productivity that forms the base of the food web for ecosystems and the state's major fisheries. The CCS is projected to experience significant climate-driven changes that will impact the ocean's physical and biogeochemical properties (**Appendix 2.2.9**), altering ecosystems.

SEA SURFACE WARMING

Average sea surface temperature (SST) has increased in recent decades (IPCC, 2023a) and is accompanied by frequent, longer, and more intense marine heat waves (Oliver et al., 2018). Marine heat waves are defined as discrete periods of prolonged anomalously warm water at particular locations (Oliver et al., 2021). Though generally measured at the sea surface, there may also be "bottom" marine heat waves on the seafloor (see *Section 3.5.4 Kelp Forests*).

While marine heat waves are naturally occurring oceanographic events, their frequency and magnitude are accelerated by rising global temperatures (Laufkötter et al., 2020; Marcos et al., 2025). Marine heat waves have had severe biological and economic impacts (*Section 3.5 Marine Ecosystems*; Smith et al., 2021, 2023). The largest recorded marine heat wave ("The Blob") occurred in the northeastern Pacific Ocean from 2014–2016 (DiLorenzo & Mantua 2016; Jacox et al., 2016). This marine heat wave was unprecedented in magnitude and scale and caused range shifts in coastal biodiversity (Free et al., 2023; Sanford et al., 2019), causing complex impacts on California's kelp forests ecosystems (see *Section 3.5.4 Kelp Forests*; Reed et al., 2016; Michaud et al., 2022) and fisheries (see Section 3.5.5). Since this event, the number of smaller, less ecologically significant marine heat waves has also significantly increased (**Figure 22**; Xu et al., 2022; Nardi et al., 2025).

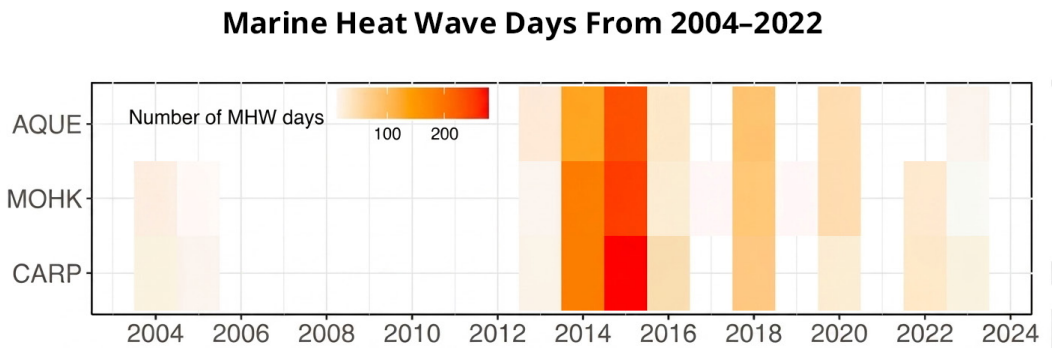


Figure 22: *Number of marine heat wave days from 2004–2022 at Arroyo Quemada (AQUE), Mohawk Reef (MOHK), and Carpinteria Reef (CARP) in the Santa Barbara Channel.*

Worsening marine heat waves may be explainable by the increases in SST (Xu et al., 2022), which are projected to continue under future climate change (**Figure A2.11b**). Sea surface temperatures are projected to rise 1–2°C (1.8–3.6°F) under low emissions or 1.5–3.5°C (2.7–6.3°F) under high emissions by 2100 (Pozo Buil et al., 2021; Bograd et al., 2023). Future warming is projected to make the ocean more stratified, reducing mixing between surface and deeper waters (Xiu et al., 2018; Howard et al., 2020; Pozo Buil et al., 2021).

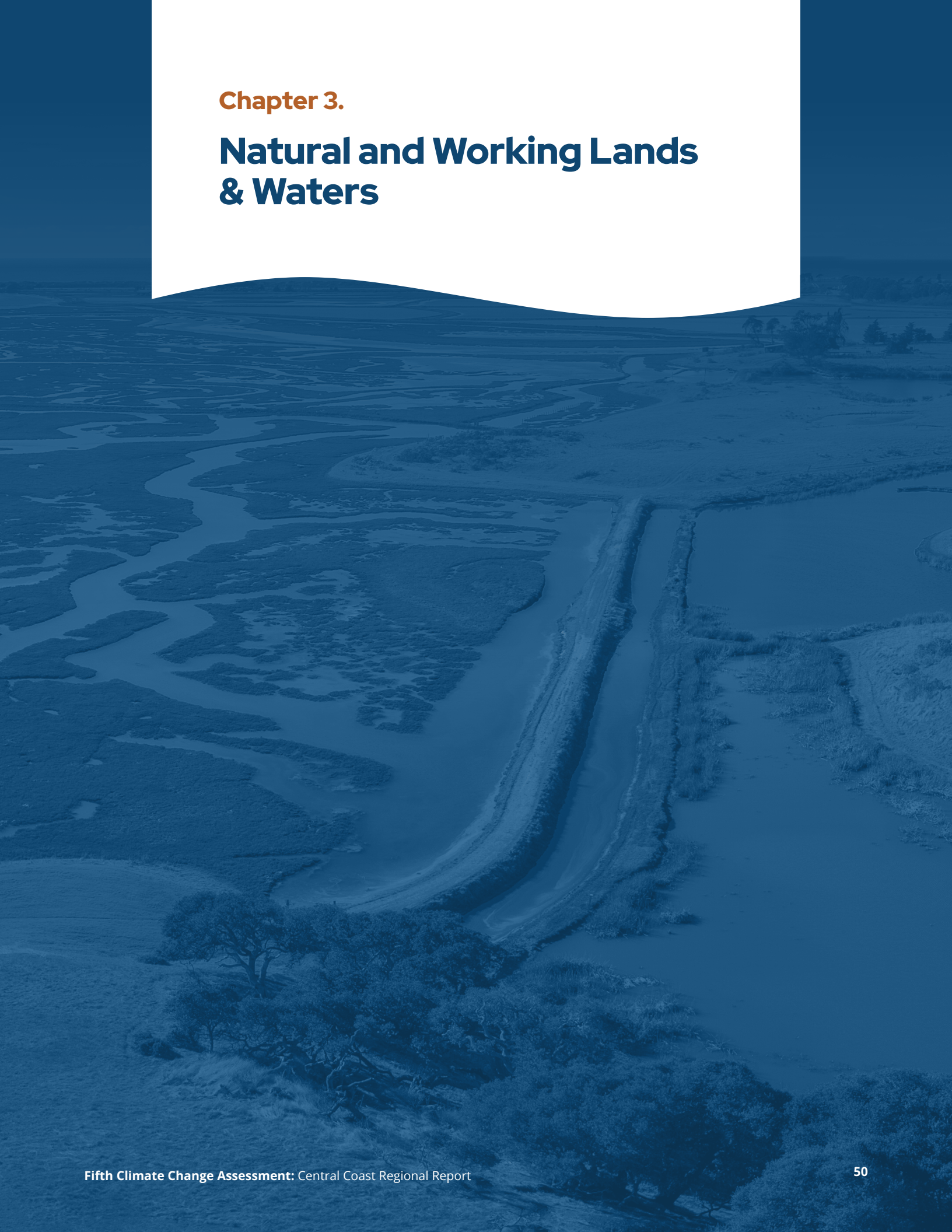
PRODUCTIVITY AND ACIDIFICATION

North-south winds alongshore drive upwelling of deep water from the seafloor, bringing cold, nutrient-rich waters to the surface where they support primary productivity, ecosystems and fisheries. Along the Central Coast, some models project weakening of north-south winds, which is likely to reduce upwelling of cold, nutrient-rich waters **(Appendix 2.2.9**; **Figure A2.11a**; Pozo Buil et al., 2021; Jacox et al., 2024). Offshore waters will likely see declining oxygen and pH alongside increasing nutrients at depth. In coastal areas, projections diverge: some models show a declining oxygen trend while others show increases (**Figure A2.12c, d**). In these model projections, future nitrate nutrient availability depends more on the chemistry of upwelled source waters than on upwelling strength itself (Jacox et al., 2024). Models do not agree on how these changes will combine to affect future primary productivity, especially for high-emissions scenarios, but two of three models project declining productivity off the Central Coast (**Figure A2.12e**), driven by weaker upwelling-favorable winds, stronger stratification, and/or reduced nitrate supply (Xiu et al., 2018; Howard et al., 2020; Pozo Buil et al., 2021).

Models also project ocean acidification (a decline in pH), creating conditions that dissolve the calcium carbonate shells and skeletons of many marine organisms. By the 2040s, the near-surface waters of the central CCS are expected to drop below the current lower range of natural pH variability, becoming corrosive to organisms that form shells with aragonite (the crystalline form of calcium carbonite; Hauri et al., 2013).

Chapter 3.

Natural and Working Lands & Waters



Key Messages

Water:

- Water supplies for agricultural irrigation, municipalities, rural communities and well owners will be reduced; some wells will go dry.
- Water quality will be impacted, including by potential increases in saltwater intrusion, which is already a challenge for the region.
- Under the 2015 Sustainable Groundwater Management Act (SGMA), many water agencies are reducing demand and enhancing groundwater recharge and storage.

Agriculture:

- There will be shifts in crop production, increases in plant disease and pest pressures, an acceleration of soil organic matter loss and reduction of soil carbon reserves.
- Potential adaptations include water-limited farming, increased compost application, and cover cropping to help increase organic matter levels in soils.
- Farmworkers pointed to drought as a significant impact to their livelihood, with a need for better benefits, and healthcare resources to help them adapt to climate change.

Terrestrial Ecosystems:

- Drought and fire, mediated by invasive grasses, are shifting distributions and transitions between grasslands, shrubland, and forests. Restoration burns and tools that select plant species and ecotypes that will be adapted for future climates can foster adaptation.
- Intensifying dry-wet whiplash and cascading impacts are making streams more vulnerable to drying and imperiling recovery of endangered salmonids and amphibians. Restoration of natural flow patterns is rebuilding drought refugia and improving hydrological connectivity.

Ocean Ecosystems:

- Sea level rise imperils coastal habitats, endemic invertebrates, and endangered shorebirds.
- Marine heat waves have already reduced kelp forests up to 80% in some areas, undermining the base of the food web across multiple ecosystems and causing the collapse of a fishery.
- Tidal wetland, seagrass, and dune restoration is underway to improve coastal adaptive capacity, promising multi-benefit ecosystem services including “blue carbon” capture.
- Fisheries are showing complex species-specific responses to interrelated ocean conditions including declines and range shifts. New mechanistic models are improving assessments along with adaptation strategies emphasizing cross-institutional collaboration.

Land Use and Conservation:

- Land conversion will release greenhouse gases. A hotter, drier climate is predicted to accelerate loss of annual cropland that is already being replaced with perennial cropland.
- Many conservation initiatives are being led by Native American Tribes in the region, who have secured first-ever land back campaigns and major Marine Protected Areas.

3.1 Land Use

Synthesis Author: *Nathan Von Schmidt*

Half of the region's population of more than 1.5 million people is concentrated in urban hubs like the Santa Cruz, Monterey Peninsula, Salinas, San Luis Obispo, Santa Maria, and the Santa Barbara coastal plain. Population growth in these urban areas is above the state average (Census Bureau, 2021). Most of the rest of the population lives in lowland agricultural communities. Over 90% of the region's land and waters are natural ecosystems with significant potential for future growth. This will affect carbon emissions, water supplies, and ecosystems under climate change, underscoring the urgent need for coordinated management planning.

Forecasts of land-use change for the Central Coast region (excluding Ventura County), which assumed recent historical rates of development continue from 2021 to 2061, found that annual cropland would decline by 502 km2 while perennial cropland expanded by 549 km2 and developed areas (i.e., urban/exurban and industrial) would grow by 370 km2 (Von Schmidt et al., 2022, 2023). Overall, 417 km2 of natural habitats would be lost. Five scenarios assessed how SGMA may affect development (see *Section 3.2 Water*). An alternative model (Wilson et al., 2024) projected that compared to a warm/wet climate, a hot/dry climate would increase loss of annual crops (169%) and pasture (28%) due to fallowing. A scenario of more infill development still forecasts the expansion of that development into cropland and natural lands by 185 km2, plus 218 km2 of infill development in existing developed areas. Importantly, Wilson et al. (2024) forecasts did not account for how local SGMA implementations may alter land-use patterns by limiting pumping, which Von Schmidt et al. (2022, 2023) found were key to achieving regional water sustainability (see *Demand Reduction in Section 3.2.3 Adaptations*). All forecasts project increases in water demand, declines in annual agriculture, and growth of perennial agriculture, especially high-value vineyards, which will have profound impacts on communities and ecosystems including the release of significant amounts of greenhouse gases from land conversion (Sleeter et al., 2019), increases in water demand (Von Schmidt et al., 2022, 2023), and habitat loss.

3.2 Water

Synthesis Authors: *Esther Conrad, Ruth Langridge, Jordi Vasquez*

Contributing Authors: *Michael Boswell, Sarah Fletcher, Lauren Giggy, Joshua Kouri, Piret Harmon, Brian Lockwood, Casey Meusel, Christina Richardson, Jenny Skerker, Rob Swartz, and Margaret Zimmer*

3.2.1 Overview

The Central Coast Region is California's most groundwater-dependent region. Groundwater overdraft and degraded water quality, including saltwater intrusion (SWI), are major concerns. Climate change will exacerbate impacts (**Table 3**). The Central Coast relies primarily on local water sources and agriculture is the predominant user. Urban water use is approximately 15% of total use and has decreased over time with water conservation (CNRA, 2020).

Table 3: *Hydrometeorology Changes and Impacts to Central Coast Water Supplies*

HYDROMETEOROLOGY CHANGES	IMPACTS TO WATER SUPPLIES
Rising temperatures and increased evapotranspiration; changes in precipitation (e.g., extreme droughts and floods); hydrologic volatility (e.g., timing of extreme events)	Changes in streamflow and runoff; reduced surface water storage in reservoirs; reduced groundwater recharge and storage; degraded water quality
Sea Level Rise	Increased saltwater intrusion
Wildfire & Debris Flows	Degraded water quality, infrastructure damage

GROUNDWATER

Approximately 80–90% of annual water use in the Central Coast region is groundwater, and groundwater accounts for approximately 86% of the public water supply in the Central Coast Hydrologic Region (CNRA, 2020). Eight groundwater basins in the report's Central Coast region are identified by DWR as critically overdrafted, and continuing current practices would probably cause significant overdraft-related impacts: Santa Cruz Mid-County, Pajaro Valley, 180/400 Foot Aquifer (Salinas River watershed), Paso Robles Area, Los Osos Area, Cuyama Valley, Oxnard, and Pleasant Valley (DWR, 2020). Well data in areas within some of these basins show declines of over 50 feet (15.25 m) over the past 20 years (DWR, 2025). Data on cumulative groundwater level and storage trends are not aggregated for the entire report region. However, that data is calculated by individual Groundwater Sustainability Agencies (GSA) for their basin and found on the SGMA portal.

SURFACE WATER

Surface water includes local river supplies, reservoir storage and imported water. Roughly 20 surface reservoirs have storage greater than 5,000 AF totaling more than 1.5 million AF of storage. Some of the largest reservoirs recharge groundwater (DWR, 2021). Imported water is a small percentage of that total (DWR, 2021a). The Central Valley Project (CVP) provides up to 43,800 acre-feet per year (AFY) for San Benito County (SBCWD, 2021), and the State Water Project (SWP) provides up to 90,000 AFY for San Luis Obispo, Ventura, and Santa Barbara counties (DWR, 2024a).

WATER QUALITY

Water quality concerns include fecal contamination, low dissolved oxygen, and excess nutrients. Groundwater contaminants include nitrates (largely from agriculture), arsenic, and salinity (CNRA, 2020). Over 25% of on-farm domestic wells exceed the nitrate safe drinking level. Over 130 public and small water systems and over 3,000 domestic wells, particularly in Monterey County, have unsafe nitrate levels, affecting over 14,000 people (CCRWQCB, 2025).

RECYCLED WATER, STORMWATER CAPTURE, DESALINATED WATER

Regional water agencies are developing recycled and reused water sources, for example, Central Coast Blue, a recycled water project, will develop a sustainable water supply for Pismo Beach and protect the Santa Maria Groundwater Basin (Central Coast Blue, 2025). The region has a limited number of desalination plants, the largest of which serves the City of Santa Barbara. Desalination of brackish groundwater is underway in Ventura County (DWR, 2024b).

3.2.2 Climate Impacts to Water Security and Sustainability

GROUNDWATER AVAILABILITY

Altered precipitation and evaporative demand (Eto) rates will affect the timing and amount of recharge (Kuang et al., 2024) and reduce surface water availability. This could increase pumping and reduce groundwater storage—a critical drought buffer. Increased coastal storms, flooding and SLR will exacerbate SWI, impacting infrastructure, water quantity and quality, and ecosystems.

Notably, wet years can temporarily mitigate negative drought effects, but it is more difficult to discern immediate results of a wet year on groundwater storage due to the time lag in data and the relatively slow rate at which groundwater recharge occurs. Shallow wells in unconfined aquifers (without impermeable strata that impede the downward movement of water) may recharge relatively quickly, but deeper wells with more complex subsurface conditions can be much slower to respond to wet conditions. Areas that have experienced decades of overdraft require far more than a single wet year to recover lost groundwater storage (DWR, 2024e).

Examples of climate change impacts to groundwater storage include:

The Cuyama Groundwater Basin in San Luis Obispo and Santa Barbara counties, where climate change and increased pumping could also decrease groundwater storage (CBGSA & Woodard & Curran, 2025).

In the Salinas Valley, a major agricultural hub, the overdrafted 180/400 Foot Aquifer's cumulative groundwater elevation change from 1940–2020 shows dry years with declines and storage dropping below minimum thresholds during the severe 2016 drought (**Figure 23**; SVBGSA & Montgomery and Associates, 2022). Groundwater pumping is projected to increase in the subbasin by 12% (SVBGSA & Montgomery and Associates, 2025), potentially negatively affecting future groundwater storage.

Climate change and drought also contribute to unstable water supplies for state small water systems, domestic wells, and self-supplied sources where wells tend to be shallower than those serving larger systems and are at greater risk of running dry. These communities are less able to afford well drilling or repairs, in part because they cannot distribute costs across a large population like larger systems (SWRCB, 2026). DWR's Dry Well Reporting system shows that some household wells went dry between September 2014 and May 2025 in the Central Coast region (**Figure A3.2.1**)(DWR, 2026b).

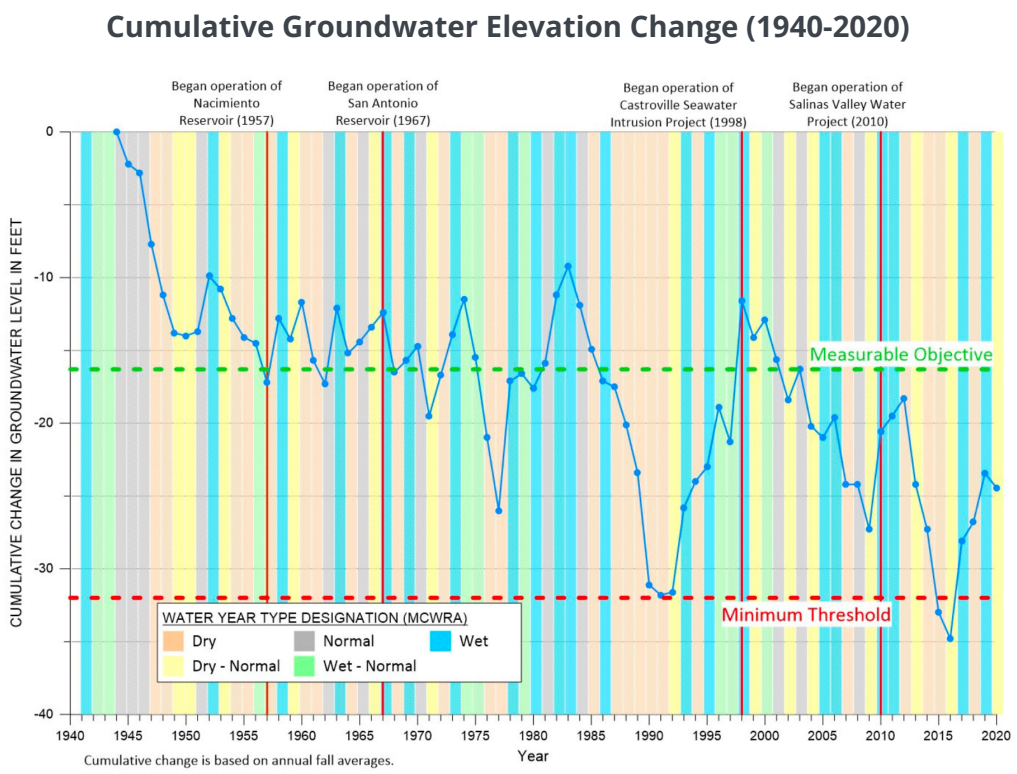


Figure 23: *Cumulative Groundwater Elevation Change Hydrograph with Selected Measurable Objective and Minimum Threshold for the 180/400-Foot Aquifer* Subbasin (SVBGSA & Montgomery and Associates, 2022).

WATER AFFORDABILITY

Water costs are increasing, especially during droughts, as volatility, infrastructure damage, and reduced reliability create an affordability crisis. Low-income households are disproportionately affected by rising rates needed for conservation, system upgrades, and treatment (Skerker et al., 2024). Monterey County ranks highest in the state for the number of water systems with high water affordability burdens, and Santa Barbara County ranked in the top 10 (SWRCB, 2025a). Droughts force water providers to invest in additional supplies or enact expensive, short-term emergency measures. These costs are frequently passed on to households, increasing water bills, which is particularly burdensome for low-income households (Rachunok & Fletcher, 2023; Nayak et al., 2023). Drought intensity, rather than drought length, has the greatest impact on affordability as high-intensity droughts can prompt additional mitigation measures such as temporary water sourcing or demand curtailment (Rachunok & Fletcher, 2023).

SURFACE WATER AND CONVEYANCE

The daily evaporation rate for reservoirs has increased 0.3 mm (0.01 in) per day over each decade from 1981–2022 (Zhao et al., 2025) and losses are projected to be over 6% across California reservoirs by mid-century (2040–2059) under CMIP6 projections (Zhao et al., 2023). SWP deliveries may decrease by up to 23% by 2043 across the entire system, indicating potential reductions in Coastal Branch imports (DWR, 2024a). More intense precipitation (Swain et al., 2018) may exceed

soil infiltration capacity, while increasing flooding, debris flows, and the sedimentation of rivers and reservoirs (East et al., 2024; see *Section 2.2.5 Sediment Hazards and Resources*). Lower recharge may reduce dry season streamflow (see *Section 3.4.4 Woodlands and Forests*; Richardson et al., 2020; Zipper et al., 2021). Warming and drying rivers can have decreased dissolved oxygen (Zhi et al., 2023; Datry, 2017), and reduced freshwater availability could also impact coastal ecosystems (Richardson et al., 2024a; Michael et al., 2017).

WATER QUALITY

Saltwater Intrusion

See also *Section 2.2.7 Sea Level Rise.*

As sea levels rise, saltwater intrudes inland, increasing salinity in coastal aquifers and surface waters (Ferguson and Gleeson, 2012; Jasechko et al., 2020), accelerated by groundwater overextraction (Su et al., 2025). Saltwater intrusion (SWI) along the Central Coast from Aptos to Monterey occurs down to a depth of 1,000 feet (Goebel et al., 2017). SWI degrades drinking water supplies, agricultural irrigation and yields, wetlands (O'Donnell et al., 2024), and infrastructure (Habel et al., 2023). In the lower Salinas Valley, SWI has been documented since 1944 and has expanded 8 miles inland (**Figure 24**).

Saltwater Intrusion in the Lower Salinas Valley 180-Foot Aquifer

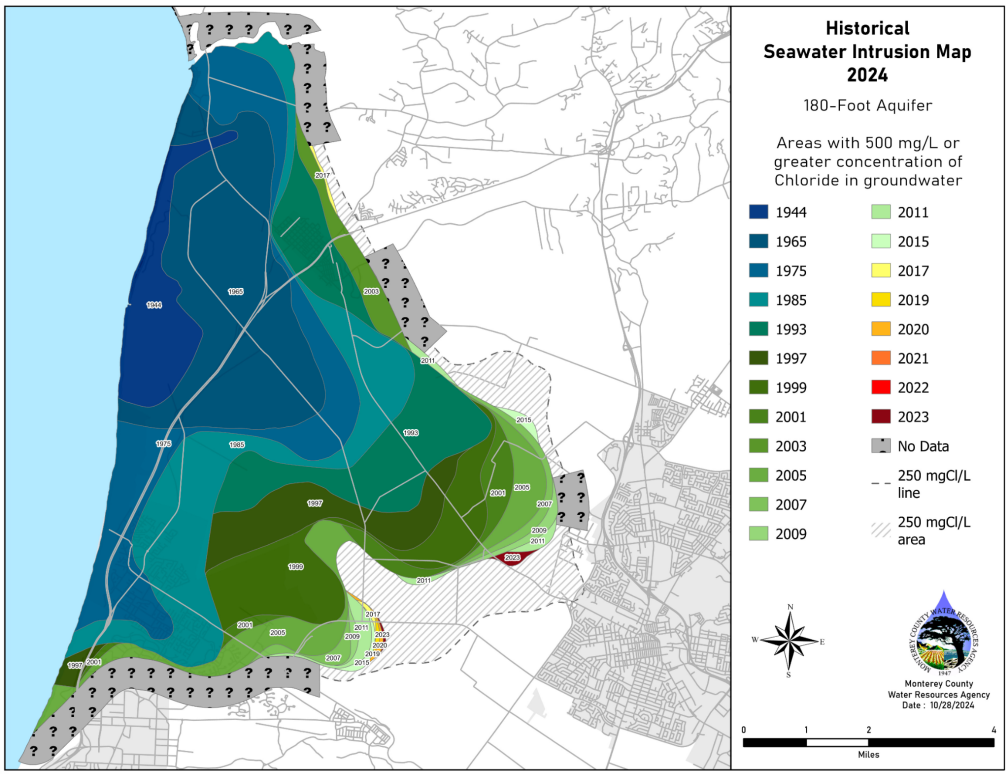


Figure 24: *Saltwater intrusion in the Lower Salinas Valley 180 Foot Aquifer (Monterey County Water Resources Agency [MCWRA] 2025).*

The Pajaro River watershed (Kim et al., 2025; Hanson et al., 2014; PV Water & Montgomery and Associates, 2022; PV Water & Carollo, 2014), Los Osos basin and Oxnard and Pleasant Valley basins have also experienced SWI.

Wildfire and Storm Events

Wildfires can affect water quality (Paul et al., 2022; Proctor et al., 2020; Smith et al., 2011; Raoelison et al., 2023) with implications for water supplies (Solomon et al., 2021) and ecosystems (Bixby et al., 2015). Monitoring data from watersheds affected by the 2020 CZU fires revealed significant changes in stream water chemistry, particularly during high-flow storm events (Richardson et al., 2024b). Dissolved organic carbon concentrations (DOC) increased by 1.4- to 5.2-fold, and suspended sediment concentrations increased by 2.3- to 20.1-fold compared to pre-fire levels (see **Appendix 3.2.2.4**). High-density polyethylene water mains were melted and damaged, likely contributing to detections in nearby streams and VOC increases in drinking water that led to boil advisories (San Lorenzo Valley Water District, 2020).

Soils can be less permeable to water for up to four years after wildfire, with resulting stormflows directly damaging water treatment plants, facilities, and reservoirs (Proctor et al., 2020). When plumbing infrastructure burns or becomes depressurized, water distribution systems can become contaminated with hazardous VOCs , leaving communities without safe drinking water until systems are tested and repaired (Proctor et al., 2020; Draper et al., 2022).

AGRICULTURE

See also *Section 3.3 Agriculture.*

Agriculture will be impacted by higher temperatures that will increase crop demand for water, further stressing water supplies (Williams & Abatzoglou, 2025). In coastal areas, SWI can increase treatment costs or limit suitability for agricultural and community use (Su et al., 2025). Increasing perennial crops that cannot be fallowed could also make the region more vulnerable to drought (Medellín-Azuara et al., 2024).

ECOSYSTEMS

See also *Section 3.4 Terrestrial Ecosystems* and *Section 3.5 Marine Ecosystems.*

SLR will affect tidal marshes that are important for water quality (Zhi et al., 2023; Datry, 2017; Richardson et al., 2024a), and a single year of extreme drought can decrease grassland and shrubland vegetation productivity almost 40% in the Central Coast (Smith et. al., 2024).

3.2.3 Adaptations

THE SUSTAINABLE GROUNDWATER MANAGEMENT ACT

The 2014 Sustainable Groundwater Management Act (SGMA) significantly changed how groundwater is managed. The SGMA Basin Prioritization (updated in 2019) classified 94 basins and/or sub-basins as high- and medium-priority (DWR Basin Prioritization, 2026a). Under SGMA,

these basins are required to form Groundwater Sustainability Agencies (GSAs) and develop Groundwater Sustainability Plans (GSPs) to manage and use groundwater without causing undesirable results (California Water Code §10721[v]) including "chronic lowering of groundwater levels and significant and unreasonable reduction of groundwater storage, seawater intrusion, degraded water quality, land subsidence, and depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water" (California Water Code §10721[x]). GSAs must incorporate climate change and sea level rise into projected water budgets (DWR, 2018); establish quantitative minimum thresholds for undesirable results (e.g., SWI); and define measurable objectives to ensure the basin will avoid undesirable results (DWR, 2016). In the Central Coast region, there are 51 GSAs responsible for implementing SGMA in 25 groundwater basins (CCWQCB, 2022; DWR, 2021). The GSAs are focusing on new and expanded water recycling projects for recharge, irrigation, SWI barriers, and direct potable reuse. Demand management includes groundwater allocations, pumping fees, and land fallowing (DWR, 2022a). Strategies by GSAs to reach sustainability and adapt to climate change are highlighted below in *Water Supply Enhancement* through *Urban and Agricultural Water Conservation*, followed by examples from three GSAs managing groundwater basins.

ADJUDICATED GROUNDWATER BASINS

In adjudication, a court generally defines and determines water rights for users and provides court-supervised basin management to implement the Judgment, usually by a court appointed Watermaster. Adjudicated basins are not required to comply with SGMA core goals of sustainability and equity. For new adjudications after 2015, the state can intervene (AB 1390, 2015; SB 226, 2015). After 2023, there are limited requirements for new adjudications to consider water use and accessibility for small farmers and DACs (AB 779, 2023). Court judgments provide the legal requirements for water management by the Watermaster, and in almost all cases, judgments do not include any explicit discussion of climate change. This represents a significant management gap. The Central Coast region includes five adjudicated groundwater basins: Seaside, Santa Paula, Goleta, Los Osos, and Santa Maria, with Santa Maria including three separate adjudicated areas (Northern Cities, Nipomo Mesa, and Santa Maria Valley). In some adjudicated groundwater areas, and specifically for all the Central Coast adjudicated basins, Watermasters move beyond narrow judgment requirements and provide some discussion of climate change impacts on water supplies and potential adaptations (Langridge et al., 2026).

WATER SUPPLY ENHANCEMENT

Recycled Water

Concerns over drought resulted in an increase in recycled water production in the region, growing from an approximate 7,000 AF in 2019 to nearly 41,000 AF in 2023 (SWRCB, 2025b). Monterey One Water blends recycled water with ground and surface sources for irrigation use. Pure Water Monterey has added indirect potable reuse capacity of about 3,500 AFY since 2020 (Gile et al., 2020). Similarly, Santa Cruz's Pure Water Soquel will use advanced purification techniques to replenish the groundwater basin, enhancing drinking water supplies while also providing a barrier to prevent seawater intrusion (SCWD, 2025). The City of Oxnard has major new indirect potable

reuse projects being planned in the cities of Carpinteria and Ventura (WateReuse Association, 2020). Contaminants found in untreated or inadequately treated wastewater that is used as recycled water in agriculture, for example, organic pollutants, pathogens, and heavy metals, are a concern (Trotta et al., 2024; Kahn et al., 2025).

Stormwater Capture

With more intense storms and increased runoff, communities are capturing flood waters to reduce flood risk and provide water for recharge (DWR, 2022b, 2024d). In the Central Coast (excluding Ventura County), the estimated potential for stormwater capture and reuse in urban areas ranges from 20,000 AF in dry years to 140,000 AF in wet years (Cooley et al., 2022). Most of the Central Coast has developed Stormwater Resource Plans to guide development of stormwater capture projects using a watershed approach (SWRCB, 2024), supported by the Central Coast Low Impact Development Initiative. In urban environments, many projects operate at small scales, but in addition to adding to water supplies and reducing flood risk, other benefits include water quality, and habitat restoration (Cooley et al., 2022). For example, the 21st Street Complete Green Street in the City of Paso Robles captures creek runoff through a central vegetated channel and impervious surface runoff through bioretention planters (CCLIDI, 2023).

Box 5: *Rainwater Harvesting*

A team of UCSC scientists, artists, engineers, and students are studying the use of stored rainwater as a resource for growing food close to home. In natural landscapes, rainwater soaks into the porous ground, gradually making its way into aquifers and water sources. In built environments, rainwater streams off hard rooftops into impermeable, paved streets, washes pollutants and trash into sewers and waterways, and can cause flooding. Harvesting rainwater can help divert some of that water into sustainable systems. This multi-year project is studying the agricultural potential of rainwater harvesting and developing educational resources to help guide individuals who would like to build their own sustainable garden irrigation systems.

Desalination

Desalination of seawater or brackish groundwater can offer drought-resilient water supplies, but is costly, energy-intensive, involves lengthy permitting processes, and raises environmental concerns (Huang, 2025; Pezzetti et al., 2024). To expand desalination—one of the goals under the State of California's water supply resilience strategy—the state has streamlined permit processes and offered grants (CNRA, 2022; DWR, 2024f).

Currently, the City of Santa Barbara operates the region's largest seawater desalination plant, producing about 3,000 AFY, approximately 30% of the city's water supply (City of Santa Barbara, 2022). A small plant operates in Sand City near Monterey. A proposed major desalination project by Cal American Water (CalAm) meant to supply potable water to Monterey County has had a controversial history but was conditionally approved by the California Coastal Commission and subsequently backed by the California Public Utilities Commission. It is strongly opposed, however, by the City of Marina and other local agencies and groups who point to the expansion of the local Pure Water Monterey project as providing an eco-friendly and less costly near-term solution (CA Coastal Commission, 2022). Brackish groundwater desalination is taking place at larger scales in Ventura County with four major facilities currently producing nearly 18,000 AFY (Pezzetti et al., 2024).

Moving forward, smaller-scale, decentralized desalination facilities may help minimize cost while enhancing drought resilience (Zaniolo et al., 2023).

STORAGE ENHANCEMENT

Recharge

The recharge of groundwater basins using surface water, particularly excess flows in high rainfall years, is an important climate resilience strategy, which avoids increased surface water losses through evaporation, reduces flood risks, generates co-benefits such as habitat restoration (CNRA, 2022), and increases groundwater storage that can serve as a drought reserve (Langridge & Von Schmidt, 2020). Aerial electromagnetic surveys have been completed for the Monterey Bay area, Salinas Valley, Los Osos, Paso Robles, and Santa Maria Valley groundwater basins to identify areas with high potential for recharge (Dlubac et al., 2024). Major projects that are either operational or under construction involve injecting recycled water into groundwater basins for later potable reuse in the Santa Cruz and Monterey Bay areas (SCWD, 2025; MPWMD, 2025). Multi-benefit projects that focus on floodplain and ecosystem restoration also contribute smaller amounts of groundwater recharge. One example is a multi-benefit land repurposing initiative in Salinas Valley, which includes stream channel restoration and invasive plant control and recharge suitability mapping (MCRCD, 2020; SVBGSA, 2025). In the Pajaro Valley, groundwater recharge benefits were incorporated into the Pajaro River Flood Risk Management project (Grimm & Serra-Llobet, 2025), and the Recharge Net Metering Program provides incentives for recharge (Bruce et al., 2023).

A challenge for groundwater recharge is the availability of surface water and the lengthy process to obtain or modify rights to divert. The state's temporary permits and a process for allowing diversions without a permit during a flood emergency have enabled more recharge in the Central Coast region (Sustainable Conservation, 2025).

Forecast-Informed Reservoir Operations (FIRO)

FIRO forecasts atmospheric rivers to better anticipate and manage surface water reservoirs under large storm events. The Monterey County Water Resources Agency (MCWRA) will use this tool to optimize reservoir releases to recharge groundwater and maintain ecosystem benefits (MCWRA, 2025).

DEMAND REDUCTION

To achieve groundwater sustainability in different regions, demand-based water management is key (Purkey et al., 2008; MacDonald, 2010; Joyce et al., 2011; Mehta et al., 2013; Johannsen et al., 2016). Escriva-Bou et al. (2020) show that achieving groundwater sustainability under climate uncertainty requires significant reductions in consumptive use even with aggressive recharge.

In the Central Coast, Von Schmidt et al. (2022, 2023) explored coupled forecasts of land-use, climate, and water systems to 2061 under four management strategies to assess vulnerability to overdraft (**Figure 25**). Water supply enhancements planned under local GSPs were insufficient to eliminate overdraft in most currently overdrafted basins. Demand regulation was able to eliminate overdraft in most GSAs, but it could cause "leakage" of new development into groundwater basins not regulated by SGMA, creating trade-offs. Overlaying the forecasts with social and ecological

vulnerability measures showed that demand caps dramatically decreased agricultural, domestic, and ecological vulnerability to water shortages. There was a modest loss of prime farmland and conversion of natural areas to crops as agriculture moved from intensively cultivated groundwater basins to relatively underdeveloped basins. However, reduction in water vulnerability was an order of magnitude greater, and strong land-use planning (i.e., preserving natural lands) reduced this trade-off (Von Schmidt et al., 2022).

This research demonstrates how integrated adaptation planning by institutions can help jointly meet multiple goals with only limited spatially localized trade-offs. Thus, a one-size-fits-all approach may not be optimal (Okamoto et al., 2020). Integrating land-use planning and demand regulation and applying management strategically to fit local conditions could reduce trade-offs and produce mutually beneficial outcomes. Moreover, the dramatic ability of caps on water use to jointly reduce vulnerability of agriculture, communities, and ecosystems highlights how demand management approaches to reach SGMA groundwater goals could potentially transform an unsustainable pattern of development into a resilient one.

Groundwater Demand Management and Vulnerability to Overdraft

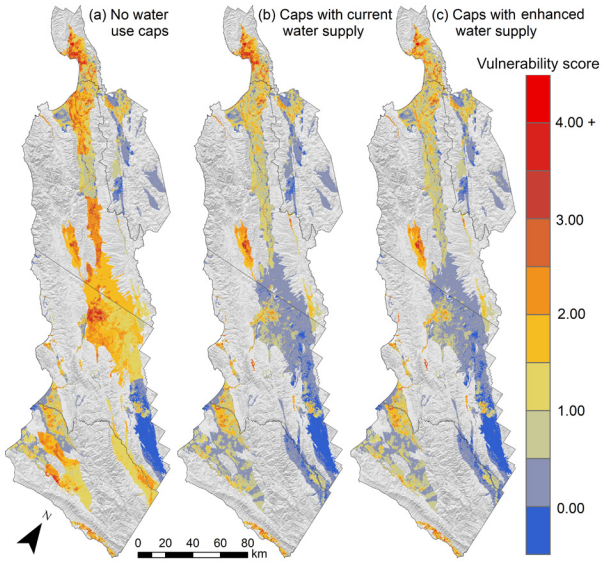


Figure 25: *Change in the sum of nine agricultural, domestic, and ecological vulnerability measures by 2061 for scenarios of (a) no water use caps (pre-SGMA); (b) water demand caps within GSAs that aim to limit total water to current total sustainable supplies; (c) higher caps with new GSP water supply enhancement measures. Adapted from Von Schmidt et al. (2023).*

URBAN AND AGRICULTURAL WATER CONSERVATION

To address climate change-driven water supply declines, communities invested heavily in urban water conservation. Average water use in the Central Coast Hydrologic region is among the lowest in the state (Cooley et al., 2022). Parts of the Monterey Peninsula and the community of Los Osos in San Luis Obispo County have prohibitions or strict limits on new construction to address severe water shortages.

GSAs are taking steps to reduce agricultural water use in the Central Coast region. In the Pajaro Valley, for example, by combining long-existing tools like soil moisture sensors and water flow meters with newer cell tower technology, growers can receive updates on their smart phones about water use (Sustainable Conservation, 2025). The Stewardship Index for Specialty Crops has farmers track water use and gauge it against how much water their crops actually need (Stewardship Index for Specialty Crops, 2025). However, while GSAs are developing strategies to reduce agricultural water use, analysis of GSP projects and management actions in the region reveals a heavy emphasis on increasing supply despite substantially higher costs (Conrad & Larson, 2025). This represents a gap in the region's climate resilience.

WATER SHORTAGE ADAPTATIONS

Preparedness for severe shortages under drought is particularly critical in some basins. In the Goleta Water District in Santa Barbara County, a 1991 ordinance limits water uses to maintain a "drought buffer" (Langridge et al., 2018). Other local jurisdictions are building preparedness in response to state requirements. Urban Water Management Plans, prepared by urban water suppliers every five years, must include a Water Shortage Contingency Plan (DWR, n.d.). In 2022—the third year of a drought—only 5 out of 33 suppliers in the region 5 out of (DWR, 2022a).

In 2018, state legislation addressing the vulnerability of small water systems to drought led to new guidance for small suppliers on planning for drought contingencies. In 2021, SB 552 required counties to develop Drought Resilience Plans requiring some small suppliers to prepare contingency plans (DWR, 2021b, 2022). Santa Cruz County completed its plan in 2025 and other Central Coast County plans are in progress at the time of this writing. SGMA also requires GSAs to consider the needs of drinking water users and attend to negative impacts, including dry wells and water quality issues (DWR, 2023b). Some GSAs now offer free well testing, report dry wells, and develop programs to support domestic users whose wells have gone dry (Zappelli, 2025).

COLLABORATIVE PROGRAMS

Examples of multi-jurisdiction collaborations at watershed and groundwater basin scales include *Pure Water Monterey* which uses regional-scale collaboration to collect agricultural, processing and urban runoff for advanced purification and potable reuse (Gile et al., 2020); *Pajaro Valley Water Management Agency* (PV Water) who partners with DWR on the Pajaro River Watershed Resilience Plan to identify climate vulnerabilities and develop watershed performance metrics and indicators, and adaptation strategies (PV Water, 2025); *SVBGSA* who works with the MCWRA to share groundwater data, implement monitoring programs, and fund critical infrastructure improvements, eliminating redundancy and streamlining local management efforts to organize and undertake projects that generate multiple benefits (Grimm et al., 2025).

ADAPTATION STRATEGY IMPLEMENTATION

As the entities responsible for bringing major groundwater basins into sustainability, GSAs in the Central Coast region play a critical role. Below are examples of three regional GSA approaches.

Salinas Valley Basin Groundwater Sustainability Agency (SVBGSA) coordinates the GSP implementation for six Salinas Valley subbasins, engaging communities and partners in their programs. They are modeling and monitoring SWI (Montgomery and Associates, 2024) including the Castroville SWI Project in the critically overdrafted 180/400 Foot Aquifer subbasin to increase the use of recycled and surface water for irrigation and feasibility studies for restoring brackish groundwater. Recharge initiatives include storing excess surface water in aquifers for future use, floodplain restoration and Aquifer Storage and Recovery (ASR) in the Eastside and Forebay Aquifers; and enhancement of groundwater monitoring networks in the Langley, Monterey, and Upper Valley subbasins.

Pajaro Valley Water (PV Water) used US Geological Survey (USGS) simulations on the updated Pajaro Valley Hydrologic Model (2022) to incorporate the effects of projected SLR, precipitation,

and temperature changes into PV Water's projected water budgets. Projections show reduced groundwater storage and increased groundwater pumping after 2040, likely due to a drier climate (PV Water, 2021, 2022). Adaptations include water conservation, expanding recycled water deliveries and groundwater recharge, including the College Lake Integrated Resources Management Project and the Watsonville Slough System Managed ASR projects (PV Water, 2022), and collaborating with DWR on the Pajaro River Watershed Resilience Program.

Santa Cruz Mid-County Groundwater Agency (MGA) residents receive ~40% of their supply via surface water and ~60% from groundwater. The basin lacks surface storage to capture water during intense rainfall events, and saltwater intrusion may be exacerbated by historical groundwater overdraft. MGA uses multiple climate change scenarios to model long-term (>50 year) projected water supply and demand conditions to evaluate operations of existing and planned projects (MGA, 2019). The Soquel Creek Water District's groundwater recharge project, Pure Water Soquel, will recharge purified recycled water into the aquifer (SCWD, 2025), and the City of Santa Cruz's ASR Program will recharge potable surface water during wet conditions.

3.3 Agriculture

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Contributing Authors: *Tapan Pathak, Mark Bolda, Stefanie Kortman, Abby Ostovar, and Ruth Langridge*

Agriculture in California's Central Coast region is a vital part of the state's economy, producing many high-value small fruits and vegetables such as strawberries, lettuce, wine grapes, broccoli, and artichokes. Monterey, Santa Barbara, and San Luis Obispo are the top three grossing counties in crop production, totaling over $7 billion, with strawberries and lettuce producing the largest share of the revenue (County of Monterey, 2023; County of Santa Barbara, 2023; County of San Luis Obispo, 2023). The region's unique microclimate shaped by its proximity to the coast creates ideal conditions for its high value crops.

3.3.1 Climate Impacts

Increasing temperatures in the Salinas Valley exceeding 110°F (43.3°C) for 5–20 days in most years may affect agriculture as photosynthesis is impaired above 104°F (40°C) (Venios et al., 2020). Combined with more intense droughts and higher evapotranspiration (ET) rates, the water available to farmers for irrigation will decrease (Ikendi et al., 2024) and increased pumping will be needed to sustain the same crops independent of additional efficiency gains. There will be decreases in crop yields and increases in pests and disease, impacting the agricultural economy (Jha et al., 2024). Some crops may become less suitable to areas where they are currently grown, requiring adjustments in farming practices or crop choices (Pathak et al., 2018).

SLR and SWI can result in water with elevated salinity, causing salt buildup in the topsoil and crop damage (Orloff, 2025). In the Salinas Valley Watershed's upper two aquifers, municipal and agricultural wells were drilled deeper to access freshwater, age-dated to 25,000 years old, potentially reducing long-term groundwater storage (Montgomery and Associates, 2024).

More intense storm events and flooding, exacerbated by the filling of floodplains and wetlands, can also damage agricultural production and infrastructure. Reduced wetland areas, fallowed fields, and intensive agriculture have negatively impacted water quality with elevated nitrates, salts, and pesticides in the water. Integrated management practices to control nutrient and water use is one adaptation to reduce polluted runoff. Precision irrigation management can help minimize both runoff volume and nutrient discharge to water bodies.

CROP PRODUCTION

Rising temperatures under climate change will necessitate a shift in cropping patterns, but fog complicates temperature predictions for the Central Coast, moderating temperatures and allowing for certain crops, especially berries, to thrive (see *Section 2.2.2 Coastal Low Clouds and Fog*). In some of the most productive agricultural areas, summer fog occurs during the peak growing season of economically important crops such as strawberries. Strawberry crops grown near coastal Watsonville have 50% higher water-use efficiency and 70% higher light-use efficiency during summer fog events (Baguskas et al., 2021; Oliphant et al., 2021). Integrating coastal fog into water use calculations could reduce water use on farms and potentially increase climate resilience (Baguskas et al., 2018, 2021). Simulating crop physiological responses to fog occurrence is an important step to predict how different crops may be affected by changes in fog and inform climate adaptation.

Farmers in the Central Coast region face significant challenges from extreme heat that can negatively impact crop growth and yield. Avocado trees require warm, moderate temperatures, ideally between 60°F and 85°F (15.5°C and 29.4°C); beyond these thresholds the production of avocados declines. Many small fruits and vegetables produced in the region can be adversely affected by extreme temperatures (Pathak et al., 2018). Wine is currently the third-most produced commodity in Santa Barbara County and wine sales comprise nearly a 10th of the county's economy (Lee, 2017). The County's premium wine industry could see climate change impacts to grape varieties that can only thrive in specific temperature ranges. If grapes that can tolerate higher temperatures are not available, the decline in suitable land could be up to 20%.

PLANT DISEASES AND PESTS

Higher temperatures could amplify plant disease and pest pressures. Warmer winters, increasing temperature extremes, and more variable precipitation (including drought and unseasonal rainfall) are affecting the distribution, survival, and virulence of plant pathogens while also altering host susceptibility and disease dynamics (Burdon & Zhan, 2020; Juroszek & von Tiedemann, 2013; Singh et al., 2023). Common diseases such as Verticillium wilt, Botrytis fruit rot, and Downy mildew continue to pose significant risks. Previously minor or geographically limited diseases, including *Pythium* wilt, Fusarium wilt, and Powdery mildew are becoming more widespread. Elevated temperatures intensify the severity of Fusarium wilt in lettuce (Paugh & Gordon, 2019). Viruses such as Impatiens necrotic spot virus (INSV) are re-emerging as serious threats (Hasegawa & Del Pozo-Valdivia, 2023; Juroszek & von Tiedemann, 2013). These shifts are often driven by climate-induced changes in vector populations, soil and plant microbiome composition, and plant stress physiology (Gallego-Tévar et al., 2024; Hossain et al., 2024). In addition, recent reports of

Globisporangium uncinulatum infecting artichoke and fennel—crops previously thought to be unaffected—highlight the evolving nature of pathogen-host interactions under changing climate conditions (Koike et al., 2024a, 2024b).

As temperatures rise, many insect species are projected to experience earlier onset of activity in the growing season and more rapid completion of their lifecycles. This means pests could reproduce more frequently and in greater numbers, intensifying their impact on economically vital produce. The acceleration of insect lifecycles not only extends the period during which crops are vulnerable but may also allow new or previously minor pests to emerge as major threats. Warmer (milder) winters could further reduce natural mortality rates for overwintering pest populations, compounding the challenge. Understanding climate-driven pest behavior changes can enable growers, agronomists, and policymakers to develop and implement adaptive pest management strategies (Pathak et al., 2018; Jha et al., 2024; Trumble & Butler, 2009).

REGIONAL CHALLENGES

The Central Coast's agricultural economy is intertwined with other regions. The magnitude and duration of rising temperatures at higher elevation inland nurseries in Northern California could negatively affect the production of daughter plants that are planted later for fruit production on the Central Coast. Some modeling studies suggest that cropping patterns could shift to allow new valuable crops to be grown in the region. More research is needed to understand how climate impacts will affect crop patterns (Marklein et al., 2020).

GREENHOUSE GAS EMISSIONS, SOIL DEGRADATION, AND CARBON SEQUESTRATION

Agriculture is a significant contributor to greenhouse gas (GHG) emissions through nitrous oxide (N_2O) from fertilizer use and manure management. Cropland soils represent a major source of nitrous oxide (N_2O), accounting for about 60% of California's N_2O emissions (UCANR, 2025) and around one-third of total agricultural emissions statewide (CARB, 2025). While carbon dioxide (CO_2) is also an emission from fuel consumption and soil carbon depletion, N_2O is nearly 300 times more impactful than CO_2 in global warming potential.

Rising temperatures and warmer soils enhance microbial activity and can potentially increase N_2O production when moisture and nitrogen are sufficiently available (Verhoeven et al., 2017). Prolonged dry periods punctuated by irrigation or occasional seasonal rainfall create episodic pulses of microbial activity, leading to N_2O bursts (Barrat et al., 2020). Farmers may intensify irrigation practices under drought, inadvertently creating conditions conducive to elevated N_2O emissions. Additionally, sporadic intense rainfall after prolonged drought can cause abrupt, substantial denitrification events, further exacerbating emissions (Kennedy et al., 2013). CO_2 emissions from farm operations may also rise due to increased groundwater pumping and energy-intensive irrigation methods under drier conditions. Crop shifts toward drought-resistant varieties could alter emissions profiles and, along with other adaptive strategies, potentially mitigate agricultural GHG outputs.

Increased temperatures, drought, and intense rainfall are also expected to accelerate microbial decomposition and soil organic matter (SOM) degradation (Lal, 2004; Smith et al., 2008; Barrat et al., 2020), reducing soil carbon reserves (Davidson & Janssens, 2006). Rapid rewetting after drought episodes can trigger substantial SOM decomposition, reducing fertility and releasing additional GHGs (Barrat et al., 2020). Reduced SOM adversely affects soil structure, leading to more runoff and increased downstream flood risk along with reduced groundwater recharge, and reduced water retention (Acevedo et al., 2022). This can lead to increasing water inputs, as well as nitrogen leaching and N_2O emission risks, particularly following rainfall or fertilizer applications (Van Groenigen et al., 2010). Losses in natural soil fertility from the loss of organic matter may also lead to greater reliance on synthetic nitrogen fertilizers, further exacerbating N_2O emissions and creating a challenging feedback loop (Stehfest & Bouwman, 2006). Efforts to support increased organic matter levels in soils are critical to reduce reliance on synthetic fertilizers and increase water retention. Increased compost applications and cover cropping can help increase organic matter levels in soils.

CHANGING LAND USE

Changing land use may increase climate change impacts. Over the last few decades, the Central Coast region's perennial acreage has increased mainly from the conversion of rangelands to irrigated vineyards (Wilson et al., 2020). This can potentially make the region's agriculture more vulnerable to drought as perennial crops are not easily fallowed and reduce the ability of a grower to respond to and remain flexible during drought years. Further, the conversion of rangelands to vineyards increases water demand, except in the rare cases where dry farmed viticulture is practiced. Recent investments in agricultural land by the financial sector, for example, the Harvard University's endowment management firm's purchase and partial conversion of 8,000 acres of rangeland into irrigated vineyard in the Cuyama Valley, could increase the region's vulnerability to water shortages absent adaptations (Fairbairn et al., 2021).

FARMWORKER LIVELIHOOD CHALLENGES

Along with farmers, farmworkers (**Figure 25**) also face economic, health, and environmental challenges under climate change that compound existing vulnerabilities. Increased exposure to extreme heat, pesticides, contaminated water, and air pollution, as well as changes in farm economics, are issues that will disproportionately impact the livelihoods and health of these communities

In a survey to understand how the community of Pajaro Valley is being affected by climate change and to seek solutions that support the wants and needs of the community,

Box 6: *Farmworker Perspectives*

In September 2025, report authors met with farmworkers in the coastal city of Davenport (Santa Cruz County), who discussed their concerns related to climate change. They noted that climate change reduces work and opportunities and consequently their wages and living expenses, especially as increasing food prices and reduced incomes converge. One worker stated that "drought affects everything," with everyone suffering when there is less water. Drought not only reduced water availability, but it also increased dust and pollution which farmworkers said significantly impacted their health. Healthcare concerns were paramount, as the farmworkers reported lacking insurance coverage through their work. They also indicated that better wages, benefits, and healthcare are resources that would make a difference, particularly as climate impacts, including drought, heat, and floods, increase.

agricultural workers described experiencing increased temperatures (38%), heat waves in spring and fall (26%), and more frequent drought (29%). Approximately three-quarters (74%) experienced symptoms from extreme heat at work such as fainting or dehydration. They strongly favored solutions directly mitigating climate change and reducing the community's carbon emissions. Suggestions to address these issues included compensation for workers during unsafe conditions, whether from high heat or poor air quality, and improved regulations by Cal/OSHA (Division of Occupational Safety and Health) to keep farmworkers within safe heat standards. They expressed a need for more outreach efforts, tools, resources, and education to help them adapt to climate change (Barrera et al., 2019).

Farmworkers in Pajaro Valley



Figure 26: *Pajaro Valley Farmworkers (Photo: Amaya Edwards, Santa Cruz Local, 2025.*

3.3.2 Adaptations

Agricultural adaptations to climate change include shifting to drought-tolerant crops like agave, implementing water-saving irrigation, improving soil health, using soil moisture sensors to inform irrigation, planting cover crops, utilizing hedgerows to manage water and pests, investing in renewable energy to improve resilience, and implementing water-limited farming.

WATER-LIMITED FARMING

A range of strategies to address potentially reduced water availability for irrigation include fallowing lands. This could improve future groundwater storage and provide increased water supply security and sustainability in the long-term. However, fallowing land could also result in short-term economic impacts, particularly for small farmers and farmworkers.

Water-limited cropping systems are being examined as an alternative to fallowing. These systems could keep land in production with only a fraction of the applied water relative to a typical irrigated summer annual crop or perennial crop (Peterson et al., 2022), providing benefits with similar or only slightly more
water consumption including reduced dust pollution risk and better water infiltration and soil quality relative to idled land. For example, varieties can be used that can be sown early, enabling producers to leverage deep soil moisture and early season rains. Additionally, certain crops such as the early girl tomato can be dry-farmed and receive a premium from buyers. Technological advances, ranging from precision seeding machinery to precision irrigation can enable dryland production even as the climate becomes hotter and drier (Asseng & Pannell, 2012).

AGRICULTURE ASSISTANCE PROGRAMS

Climate-smart agriculture initiatives, such as the State Water Efficiency and Enhancement Program (SWEEP) and the Healthy Soils Program supported by the California Department of Food and Agriculture, offer financial incentives for farmers to implement water-efficient irrigation systems and soil health practices. Additionally, partnerships with institutions like UC Cooperative Extension are facilitating research and the adoption of climate-smart techniques tailored to local crops. Some state and federal programs will compensate growers for the public benefits created by water-limited crops and regional planning that considers water-limited crop management among the suite of alternatives available for lands transitioning out of regularly irrigated production. These efforts aim to enhance resilience against climate impacts, reduce greenhouse gas emissions, and promote sustainable farming practices in the region.

Organizations such as the Community Environmental Council connect farmers, ranchers, and land stewards in San Luis Obispo, Santa Barbara, and Ventura counties to climate-smart agriculture incentives and resources through their program Central Coast AgLink. They offer free, personalized support by helping to connect farmers with resources, such as state and federal grants and low-cost compost, and programs designed to enhance soil health and biodiversity, conserve water, and build climate resilience. The Center for Farmworker Families in Santa Cruz County is one of several organizations that work to improve the lives of farmworker families under the challenges of climate change. They provide food, household items, clothing, and other essential products and services to address the immediate needs of farmworker families, particularly during drought when work is more limited. Their Campaign for Organic & Regenerative Agriculture (CORA) brings together concerned residents from the Pajaro Valley and the Monterey Bay region to work toward an environmentally and socially just agricultural system.

Resource Conservation Districts (RCDs) in San Luis Obispo, Santa Barbara, and Ventura counties formed the Central Coast Soil Hub to increase capacity to assist local farmers in practices that increase soil carbon while adapting to increasing wildfire risks, drought, flooding, and rising temperatures. Part of a statewide network, this hub provides staff training, farmer and rancher education, peer-to-peer networking, and incentive payment programs (CARCD, 2024).

Improvements are needed to increase climate resilience including early flood control, enhanced on-farm groundwater recharge, heat stress mitigation, improved soil health practices, and community preparedness education. Robust partnerships and increased collaborations between government agencies, community organizations, academic institutions, and the private sector are needed to enhance preparedness and resilience in the region.

3.4 Terrestrial Ecosystems

3.4.1 Tribal Food Sovereignty

Synthesis Author: *Nathan Von Schmidt*

The loss of access to Tribal food systems due to colonialism is a pressing issue for Tribal food sovereignty, defined as the right of Tribal communities to define, control, and sustain their own food systems, including growing and preparing foods that are healthy and culturally appropriate

(Abdul et al., 2024). Central Coast ecosystems have provided California's Native American Tribes with culturally important foods and construction materials (reviewed in **Appendix 5.4.1**). Cultural burns were key to cultivating native food crops (Timbrook, 2007). Over 90% of Tribal members can face food insecurity, with major barriers to sovereignty, including lack of rights to land or water, lack of infrastructure, and food programs that don't prioritize Tribal decision-making (Sowerwine et al., 2019). For example, fire prohibition, land conversion to cropland and invasive grass-dominated rangeland, and loss of foraging access to ancestral lands contributed to the loss of once-important traditional seed foods for the Chumash (Timbrook et al., 1982).

Many Tribes are currently regaining access to ancestral lands via partnerships with parks and private landowners (see *Section 3.6.1 Stewardship by California Native American Tribes*). The Amah Mutsun are mapping shifting species distributions and investing in stewardship of areas most resilient to climate change (Sigona et al., 2024). They are also working in Pinnacles National Park to combine remnant cultural knowledge with archaeological studies, uncovering how Tribes successfully adapted to climate changes in the pre-colonial period by diversifying and shifting food crops (Sigona et al., 2024).

3.4.2 Grasslands

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Grasslands currently cover 40% of the Central Coast (Andreozzi et al., 2023) and support carbon storage, groundwater recharge, and vast wildflower blooms (Eviner, 2016; Johnsen et al., 2020). Regionally, grasslands can be categorized into two habitat types (Keeler-Wolf et al., 2007). Coastal prairie grasslands occur in areas with coastal fog and are characterized by native perennial grasses with scattered annual and perennial forbs (Ford & Hayes, 2007). Fog supports longer growing seasons and higher productivity compared to inland grasslands (Baguskas et al., 2016b, 2018; Emery, 2016; Bartolome et al., 2002). Reduction in summer fog could threaten the persistence of many native species (Johnstone & Dawson, 2010; McLaughlin et al., 2017).

Inland grasslands are more arid, with more variable rainfall, perennial grasses that go dormant in the summer (Bartolome et al., 2002; Eviner, 2016; Keeler-Wolf et al., 2007), wildflower blooms in the spring–summer (Keeler-Wolf et al., 2007), and oak species. They are susceptible to warmer, drier conditions and variability in precipitation timing (Williams et al., 2019).

CLIMATE CHANGE IMPACTS

Central Coast grasslands will experience varied climate change effects based on their proximity to the coast, species composition, and annual vs. perennial dominance (**Appendix A3.4.2**; Diffenbaugh et al., 2015; Williams et al., 2019). Grasslands are already degraded by non-native grasses (D'Antonio et al., 2016; Eviner, 2016). Annual forb occurrence (i.e., wildflower blooms) is related to the timing and amount of rainfall, and interactions with invasive species (D'Antonio et al., 2016; Eviner, 2016). Increasing variability under climate change could increase variability of germination and mortality of native species, allowing invasive species to gain a foothold in certain years and decreasing grassland biodiversity (Harrison et al., 2024). Plant communities are shifting toward species associated with warmer and drier conditions (Zhu et al., 2024), and rarer species

will be disproportionately impacted by climate change (Prugh et al., 2018). Warming and drought are expected to result in phenological shifts and mismatch in grassland communities that could negatively impact ecosystem services (Wolkovich et al., 2012).

ADAPTATION AND RESTORATION

Cultural burning has been practiced by California's Native American Tribes to promote grassland species diversity, improve animal forage productivity, increase ease of access, and limit shrub encroachment and fuel accumulation (Keeley, 2002; Diekmann et al., 2007). Tribes are conducting cultural burns to restore grasslands (see *Section 2.2.4 Wildfire*).

Prescribed burning is increasingly employed to reduce fire risk, enhance native plant diversity, and manage aboveground biomass (Taylor et al., 2024a, 2024b). Fire removes biomass to create gaps with light and space for native forbs to germinate, prevents woody encroachment, and increases geophyte biomass (Anderson, 2018; Bråthen et al., 2021; Muramoto et al., 2024).

Targeted conservation grazing can help mitigate some climate impacts by reducing tall-stature non-native annual grasses, which enhances native grass, wildfire, bare ground, and annual forb abundance (Hayes & Holl, 2003; Huntsinger et al., 2007; Stahlheber & Antonio, 2013; Evans et al., 2023). The efficacy of grazing may decrease as climate changes accelerate. Surveys of coastal prairies over 15 years found that native annual forbs were more abundant in grazed than ungrazed sites but were still declining (Hayes & Holl, 2003; Lesage et al., 2022). This diversity loss may be due to aridification favoring non-native annual grasses (Zhu et al., 2024). Adjusting grazing management plans for these areas will greatly help continued multi-use.

Many practitioners are anticipating climate change in restoration plans to mitigate its impacts (Havens et al., 2015; Luong et al., 2023). The most common is creating seed pools (Bucharova et al., 2019; Havens et al., 2015) that include increased species diversity and utilize genotypes believed to be adapted to potential future climates (Bucharova et al., 2019; Hodgins & Moore, 2016). Increasing genetic diversity can enhance population persistence in the face of variable environmental conditions (Havens et al., 2015), but issues associated with seed sourcing can complicate restoration. For example, the California poppy (*Eschscholzia californica*) may exhibit home-site advantage (Ryan & Cleland, 2021), while a commonly used restoration bunchgrass species (*Stipa pulchra*) does not (Nolan et al., 2023).

Restoration practitioners are generally successful at achieving pre-defined native cover targets, but they have tended to use the same seven species for revegetation across the state (Luong et al., 2023). They prefer perennial species that are more likely to meet compliance standards, and avoid species that are sensitive or understudied because they may not establish and support compliance (Lesage et al., 2018, 2020). These management decisions may combine with aridification to homogenize communities and reduce their resilience to climate change (Holl et al., 2022). Maintaining native richness will require ongoing management, regional collaboration, and long-term financial support (Luong et al., 2023). The California Grassland Restoration, Action, Science and Stewardship Network (GRASS Net) is providing a web forum and a restoration plant selection tool that optimizes species for local climate and soils, with an ecoregion filter to connect practitioners, diversify species use, and scale up restoration.

3.4.3 Shrublands

Synthesis Author: *Laurel R. Fox*

Chaparral and coastal sage scrub (CSS) are two ecological communities dominated by low shrubs. CSS is found at lower elevations and nearer the coast, while chaparral occurs in lowlands near the coast, at higher elevations, slightly inland, or further inland, though near the coast some species overlap both communities (Emery et al., 2018; Keeley & Davis, 2007). Chaparral shrubs are generally drought tolerant (Jacobsen et al., 2007; Maherali & DeLucia, 2000; Maherali et al., 2004), while CSS shrubs are largely drought-deciduous (Hanes, 1977; Rundel, 2007). Both communities may be intermixed with grassland and woodland and can shift into them based on fire and other factors (**Appendix S3.4**).

CHAPPARAL

Chaparral predominates in California and contains most of the state's plant biodiversity and endemic species (**Appendix 3.4.3**; Harrison, 2013). Chaparral species are drought tolerant and depend on fire to regenerate. Recent changes in temperature, drought, fire, and biotic interactions have led to chaparral conversion into other types of communities. The ~18% of Central Coast chaparral near the coast has >90% of the region's endemic species (Vasey et al., 2012; Vasey et al., 2014) and greater differences in species composition across sites than inland sites. The coastal climate is milder than inland due to summer fog and low clouds which ameliorate temperatures, increase soil moisture, and provide sources of direct water uptake for some species (Johnstone & Dawson, 2010; Potter, 2016a; Vasey et al., 2012).

Historically, severe droughts in the 2010s resulted in significant dieback throughout the Central Coast region (**Appendix 3.4.3**). Annual plants, which make up most chaparral biodiversity, do not survive or reproduce well in dry years (Fox et al., 2006). Browsing by deer and small mammals reduces populations more than drought in some species (Fox, 2007). Climatic stress may also increase negative effects of herbivory and fungal disease, though herbivory may also reduce effects of severe climate stress. **Appendix A3.4.3** reviews biotic interactions under drought. Fire frequency, increasing under climate change (see *Section 2.2.4 Wildfire*), directly alters chances of plant survival and seedbank recruitment, affecting species composition and conversions among the dominant vegetation types. Without fire, chaparral converts to woodland, but increasing fire frequency and intensity transitions it to grassland (Callaway & Davis, 1993; Van Dyke et al., 2001). Effects of drought and fire are synergistic: After fires, more chaparral may convert to grasslands at low elevation and on hotter, drier southwest-facing slopes (Dewees et al., 2022).

COASTAL SAGE SCRUB

CSS is dominated by more drought-deciduous shrubs (compared to chaparral) and has many rare species (Cleland et al., 2016). Even small declines of winter rains can have strong, negative effects on overall productivity (Alexander et al., 2023). Along the Big Sur coast, declines in growth

of CSS vegetation coincided with the four dry periods from 2000–2015 (Potter, 2016b). CSS species require fire for long-term maintenance (Cleland et al., 2016) but may convert to grassland with intense or frequent fires, with grazing, or with nitrogen deposition.

Responses of plants to climate change are modified by adaptations to different local climates in which each population evolved. For example, when California Sagebrush (*Artemisia californica*) from Northern to Southern California were grown at a common site in Southern California, plants from northern sites had lower and more variable growth rates and were less well-defended against herbivorous arthropods, compared to those originating closer to the southern growing site (Croy et al., 2021; Pratt & Mooney, 2013). Human land use changes are likely to have stronger effects than climate change at some sites (Riordan & Rundel, 2014). In areas with minor land use changes like the northern Central Coast, CSS habitats may expand under climate change, while further south, CSS communities are much more likely to contract because of habitat loss due to both climate change and increasing land conversion.

3.4.4 Woodlands and Forests

Synthesis Author: *Morgan Abbott*

Contributing Authors: *Blair McLaughlin, Suzanne Lipton, Brooke Rose, and Shane Dewees*

The Central Coast contains diverse coastal and blue oak woodlands, foothill pines, montane hardwoods, conifer forests, and world-famous groves of the tallest living trees, coast redwoods.

OAK WOODLANDS

As temperature and drought increase, climatically suitable habitat is expected to contract for many California oaks (McLaughlin et al., 2026). Projected models of habitat suitability by 2055 for six Central Coast foundational oak species (Rose et al., 2023; data also accessible via the Coast Live Viewer) show that under a warm/dry future (business-as-usual emissions scenario), climatically suitable oak habitat generally contracts at lower elevations and persists or expands at the higher elevations of the northwest Santa Lucia Mountains, the Santa Cruz Mountains, and the Transverse Ranges. Big Sur generally maintains or increases suitable oak habitat. In contrast, the Diablo range is a hotspot of loss of climatically suitable habitat for many oaks. Different species are predicted to lose some of their current climatically suitable Central Coast habitat, but the degrees of loss and gain vary (see **Appendix 3.4.4** for species- and subregion-specific patterns of change).

Oak seedlings are generally more climate sensitive than adults, so declining climate suitability will likely first impact recruitment while adults may remain in relict populations. Because of low acorn dispersal distances and long generation times, oaks may be limited in reaching newly suitable habitat through natural dispersal.

COAST REDWOOD

The Central Coast is the extreme southern extent of the coast redwoods range, where populations have already shown higher sensitivity to drought than more northern stands (Sillett et al., 2022). Coast redwood is predicted to lose portions of its climatically suitable habitat by mid-century at

the southern distributional edge, particularly the high elevation populations in the Santa Lucia range. The Santa Cruz Mountains remain suitable habitat. Redwood forests and other regional conifers like bishop pine rely heavily on summer fog (Johnstone & Dawson 2010; Baguskas et al., 2016a). Fog levels appear to have decreased in some areas (Johnstone & Dawson, 2010), but overall, fog response is unclear under climate change (see *Section 2.2.2 Coastal Low Clouds and Fog*).

ADAPTATION AND RESTORATION

Regional woodlands and forests are adapted to frequent low-intensity fire. Many Central Coast Tribes, such as the Muwekma Ohlone Tribe, are restoring cultural burning to the region's forests. The Esselen Tribe of Monterey County is restoring cultural burning to Rancho Rico in Big Sur (Tuitele-Lewis et al., 2025) and partnering with non-governmental organizations (NGOs) to acquire land along the Little Sur River and co-steward lands near Rana Creek Ranch, where Cappanay, one of the largest Esselen village sites, is located. Anticipated benefits include climate resiliency, riparian restoration, oak regeneration, food sovereignty, and youth education (ETMC, 2020).

3.4.5 Riparian Areas and Freshwater Wetlands

Synthesis Authors: *Albert Ruhí and Rose Mohammadi*

Contributing Authors: *Anjana Parandhaman, Eric P. Palkovacs, and David Herbst*

Seasonal precipitation drives the flow regimes of the region's 17,000 miles of rivers and streams. Unregulated streams exhibit high flows in winter and low to zero flows in the summer or early fall, interspersed with flashy storm flows. In the south and interior, more arid conditions lead to extended dry riverbeds, with many systems only reconnecting after strong rainfall. Water diversion is widespread and only a few major rivers have few or no dams.

INTENSIFYING EXTREMES IN RIVERS AND STREAMS

Climate change is increasing the magnitude of flooding events, and the extent and duration of intermittency during the dry phase (Dettinger, 2011; Carlson et al., 2024), with streams drying up for the first time on record. Before 2000, San Lorenzo Creek was rarely intermittent, but since 2010, zero flows have occurred most days of the year (Carlson et al., 2024). For the San Lorenzo River, wet year frequency has not changed but dry years are 70% more common relative to pre-1975 (**Figure A3.2**). This extreme dry-to-wet volatility is likely to worsen (see *Adaptations to Drought* in *Section 2.2.1 Extreme Precipitation and Temperature*).

Hydroclimate change combined with excessive groundwater pumping (see *Section 3.2 Water*) is also altering riparian ecosystems. Thermal regimes are now often >20°C (68°F) in the lower Salinas River (MCWRA, 2018), surpassing steelhead sub-lethal limits. Other changes include shrinking perennial stream reaches, simplified river channels due to flooding regulated main-stems, and altered groundwater-surface water interactions, with water tables (and surface flow) falling quickly in multi-year droughts (MCWRA, 2015; Mohammadi et al., 2025).

Cascading disturbances such as fire-flood-debris flow sequences after record droughts (Power et al., 2024) are also affecting riparian ecosystems. Higher intensity wildfires can damage aquatic habitats by removing the tree canopy (raising stream temperature) and increasing runoff and

erosion (resulting in landslides and altered channel structure). The CZU Fire in 2020 burned much of the best salmonid habitat in Santa Cruz and increased sedimentation in key freshwater rearing areas (NMFSWCR, 2023). Sediments scour and bury stream bottoms, impacting benthic invertebrate food resources for fish. Altered food webs of burned streams, with increased algal density and decreased terrestrial vegetation inputs, often have more grazers and fewer detritivore invertebrates (Cooper et al., 2015). After initial post-fire recovery, stream community composition is driven primarily by stream drying (Cooper et al., 2021).

Riparian corridors are biodiversity hotspots, providing thermal and moisture refuges that support rare and endemic species (Cartwright et al., 2020). Prolonged droughts and declining water tables (e.g., 2022 in **Figure 27a,b**) can push trees beyond resilience thresholds (**Figure 27c**), leading to widespread vegetation dieback. Young trees are especially sensitive to shifts in the timing of flow events (**Appendix 3.4.5**). Over time, water stress alters plant communities from dominant, drought-intolerant cottonwoods and willows to drought-tolerant species including invasive species like tamarisk (Perry et al., 2012). Studies of whiplash from drought to unusually wet years show local flow intermittency may increase dryland riparian ecosystems' vulnerability to drought and shorten the growing season (Mohammadi et al., 2025).

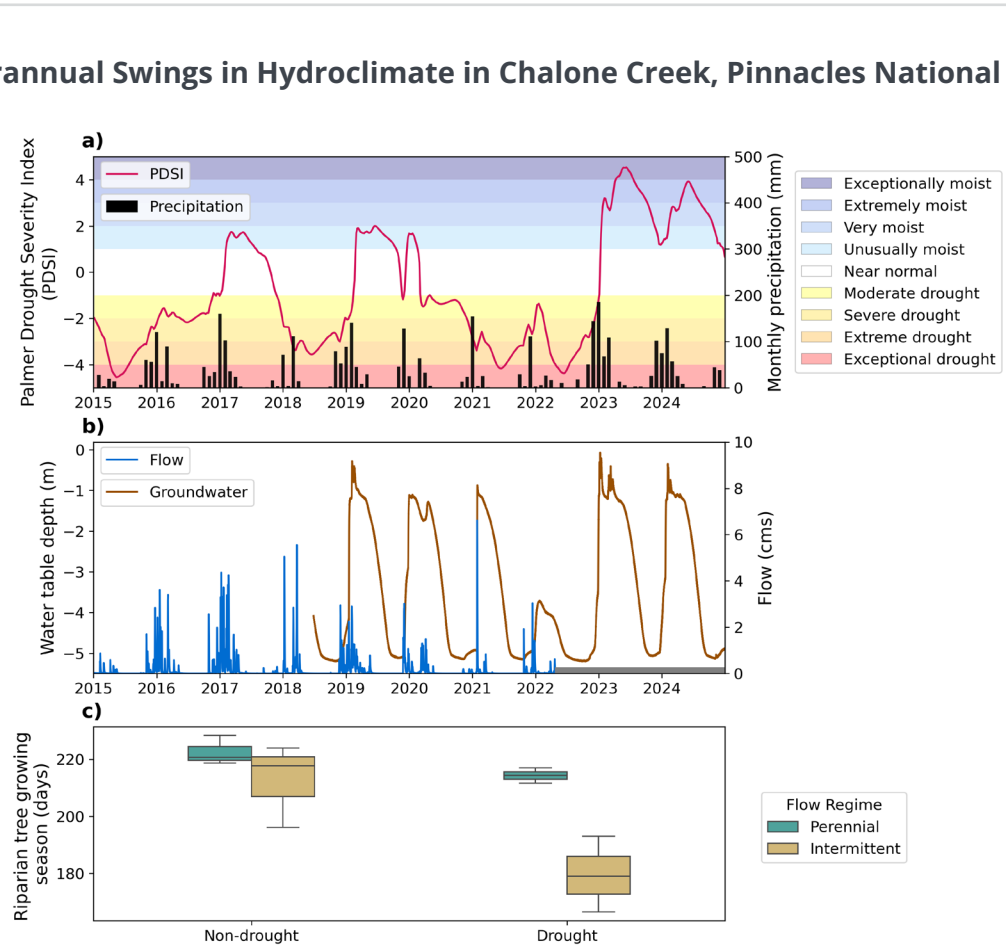


Figure 27: *Interannual swings in hydroclimate in Chalone Creek, Pinnacles NP. (a) Monthly precipitation and PDSI (a dryness measure; color bands show drought levels). (b) Water table depth and modeled streamflow fluctuate seasonally with the wet season, but peaks are lower in drought. (c) Changes in moisture shortened riparian tree growing seasons by up to 37 days.*

CLIMATE IMPACTS ON WILDLIFE

Invertebrate communities in Central Coast streams have varied adaptations to seasonal flooding and drying (**Appendix 3.4.5**; Lytle & Poff, 2004; Bonada & Resh, 2013; Fournier et al., 2023). They often rely on small, perennial, groundwater-fed refuges that are fragile "keystone" habitats critical for recolonization after drought. As drought progresses, riffle habitat is typically lost first, leaving disconnected pools that persist longer but with harsher conditions that can shift community composition favoring taxa with greater drought resistance and recolonization abilities (**Appendix 3.4**; Bonada et al., 2006). Aquatic predators in these habitats may rely on terrestrial prey inputs (al Jamal et al., 2025), altering terrestrial food webs.

The Santa Cruz long-toed salamander, California red-legged frog, and foothill yellow-legged frog have been extirpated from parts of their historical range and are federally listed as threatened or endangered. Both frogs use ponds or shallow, slow-moving stream reaches for breeding after spring flooding. More variable precipitation may disrupt the timing between key environmental cues and reproductive behaviors. Droughts can remove important breeding and dry-season refugia (Rose et al., 2023). The salamander is endemic to only 23 breeding ponds in the eastern Monterey Bay area (USFWS, 2019; Camara et al., 2019; Savage, 2008) and is threatened by habitat loss from development and invasive species. Climate change may drive pond desiccation during drought and SWI under SLR; both impair breeding success. Fragmented upland habitat limits gene flow, reducing genetic diversity and the species' ability to adapt to these changes (Camara et al., 2019). Conservation emphasizes habitat restoration, increased connectivity, and invasive species removal. A captive breeding program aims to enhance genetic diversity by crossing individuals from genetically distinct populations and releasing larvae into restored ponds.

Climate change will exacerbate challenges to regional salmonid persistence and recovery. Many populations of native Coho salmon and steelhead are in significant decline or extirpated (**Appendix 3.4**). They rely on cool, well-connected freshwater habitats for spawning and juvenile development. Higher water temperatures risk mortality from heat stress, food limitation, and disease (Sloat & Reeves, 2014; Sloat & Osterback, 2013). Cold-water refugia fed by springs are critical sanctuaries during extreme heat events (Herbold et al., 2018), but connectivity and quantity of refugia will diminish with groundwater declines. Summer increases in the duration or severity of low flows could raise stream temperatures above salmonids' tolerances (Grantham et al., 2012; Howe, 2024). In winter, intensified flooding from storms may lower survival of early life stages by scouring redds or displacing juveniles. Lastly, the Monterey roach lives in river systems around Monterey Bay and is vulnerable to potential streamflow reductions under climate change (Moyle et al., 2013). Drought can favor non-native predators like green sunfish, which prey on or compete with native roaches (Bêche et al., 2009).

ADAPTATION AND RESTORATION

Climate adaptation is focused on restoring river connectivity by removing obsolete dams when possible, managing regulated rivers to keep functional hydrograph elements, and avoiding groundwater overpumping (often alongside restoring riparian habitat). A mix of actions that restore hydro-ecological processes and functions rather than physical form (Palmer & Ruhi, 2019) can help, particularly in drought. The California Environmental Flows Framework helps

identify functional-flow prescriptions that re-create winter seasonal pulses and spring recessions to which native species are adapted (Stein et al., 2021). For example, a Salinas River reservoir-reoperation proposal would shift dam releases to better imitate natural cycles while still meeting recharge and supply objectives (Montgomery and Associates, 2021). Along valley floors, studies of the regeneration of the rare sycamore-alluvial woodland community in Pacheco and Upper Coyote Creeks illustrate the benefits of re-establishing flood releases that deliver sediment and water to floodplain habitats, where sycamores and other riparian trees can establish and could buffer riverine habitat against hotter, drier conditions (Beagle et al., 2017). Beaver-dam analogs may enhance aquifer recharge and increase drought refugia for fish and amphibians; the Beaver Restoration Program and community-led Beaver Brigades promote installation of these structures. Many fish passage projects are also underway (**Appendix 3.4.5**).

3.5 Marine Ecosystems

3.5.1 Estuaries and Tidal Wetlands

Synthesis Author: *Glen MacDonald*

Contributing Authors: *Karen Thorne, Jonathan Pilch, Kerstin Wasson, Monique Fountain, Dan Brumbaugh, and Kevin O'Connor*

Estuaries, semi-enclosed aquatic ecosystems where freshwater meets the ocean, vary based on the degree of enclosure and the dynamics of the marine and freshwater inputs. As most of the Central Coast region has narrow coastal plains abutted by hills, most of its 173 estuaries (**Figure 28**) are small.

Estuaries and associated wetlands provide endangered species habitat, protect against coastal erosion, biofilter pollutants, and sequester "blue" carbon at greater rates than terrestrial ecosystems (zu Ermgassen et al., 2021). Productive and sheltered from the disturbances of the open coast, they are key foraging and nursery areas for wildlife including fisheries species (Allen et al., 2006; Hughes et al., 2014). Climate impacts on estuaries will compound with significant existing challenges: 85% of tidal wetlands on the coast have been lost (Brophy et al., 2019), and many that remain are heavily altered and degraded by human activities (**Appendix 3.5.1**). Estuarine seagrasses have declined due to coastal development, overfishing, pollution, and rising sea surface temperature (Valdez et al., 2020). They provide key climate adaptation services (wave attenuation, carbon sequestration, and mitigation of ocean acidification), help stabilize sediment, and are nursery habitat for fisheries (Beheshti et al., 2021).

CLIMATE IMPACTS ON ESTUARIES

SLR, warming, ocean acidification, and changes in sedimentation and freshwater input under climate change affect estuarine ecosystems in multiple, interactive ways (Cloern et al., 2011; Thorne et al., 2024), with potential widespread impacts to wetland-dependent wildlife (Rosencranz et al., 2019) and local economies (Barbier et al., 2011; Hallegatte et al., 2013).

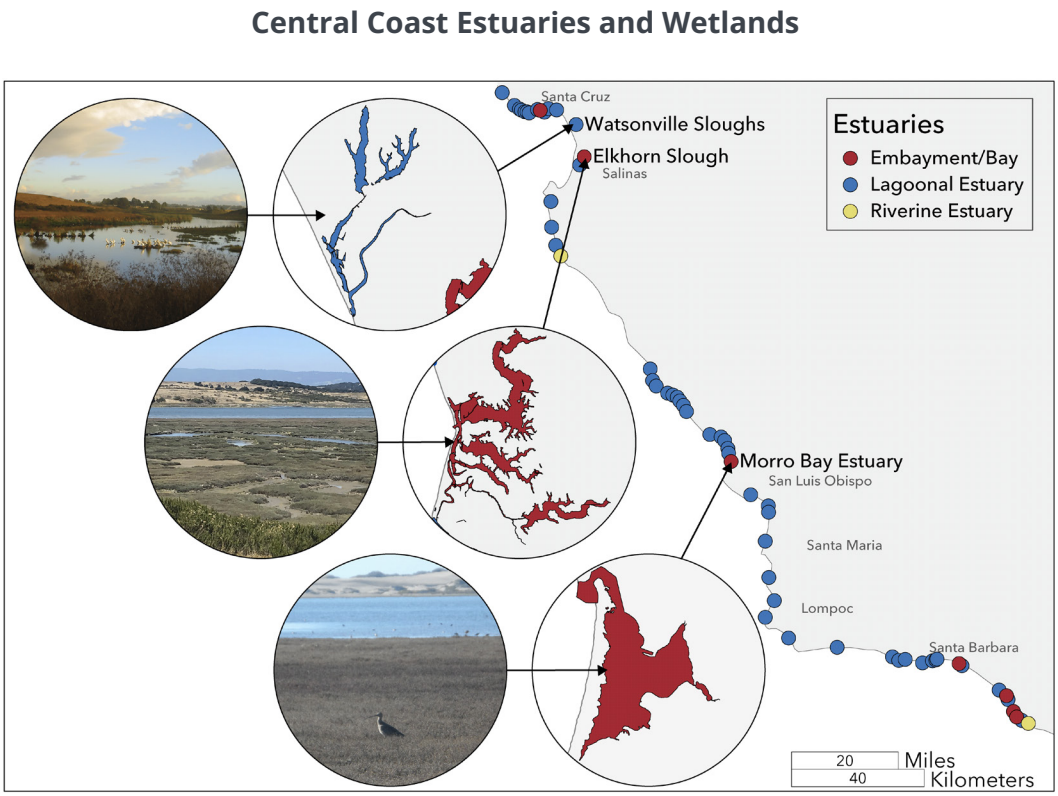


Figure 28: *Central Coast estuaries and wetlands, with details of three case studies described in Climate Adaptive Restoration of Estuaries in Section 3.5.1 Estuaries and Tidal Wetlands.*

Tidal wetlands can adapt to slow rates of SLR by building up their soil elevations (accretion) relative to local water levels via below-ground organic production and surface sediment accumulation (Baustian et al., 2012; Kirwan et al., 2016; Schuerch et al., 2018; Saintilan et al., 2022). Intermittently closing estuaries are more resilient to SLR when they receive sediment pulses from storms in the watershed (Thorne et al., 2021). Accelerating SLR rates mean wetlands need to build elevations rapidly to not drown (Cloern et al., 2016; Schuerch et al., 2018). Central Coast estuaries, constrained by steep topography and human development, have some of the least amount of upland migration space in the US (Thorne et al., 2018; Holmquist et al., 2021; Osland et al., 2022). Coastal development has also altered soil accretion (Wasson et al., 2019; Curtis et al., 2021; Anisfeld et al., 2017). Many wetlands lack the sediment supply and migration space with mid to high SLR and will likely drown (**Figure 29**; Thorne et al., 2016, 2018, 2025; Wasson et al., 2019; Holmquist et al., 2021; Brand et al., 2022), transitioning from high marsh to flooding-tolerant low marsh (Janousek et al., 2019) and then to unvegetated mudflats (Schile et al., 2014). This loss of wetlands to accelerating SLR will reduce their ecosystem services like carbon sequestration (Takekawa et al., 2011; Baustian et al., 2021) and protection of the coast from waves and storm flooding (Wamsley et al., 2010; Costanza et al., 2021).

In addition to SLR, warming waters facilitate hypoxia that harms fishery species (**Appendix 3.5.1**; Hughes et al., 2015; Jeppesen et al., 2018). Acidification will impact many invertebrates that form calcium carbonate skeletons/shells, including cultivated Pacific oyster (Barton et al., 2015), raising

concerns for oyster aquaculture in sites such as Morro Bay. The native Olympia oyster appears more tolerant and is used in restoration aquaculture efforts, which may be expanded, for example in Elkhorn Slough (Zabin et al., 2016; Wasson et al., 2020). Worsening wildfire can also affect marshes, with habitat recovery being a multi-year process (Brown et al., 2020).

CLIMATE ADAPTIVE RESTORATION OF ESTUARIES

Restoration of tidal marsh and seagrasses within estuaries offers multiple ecosystem service benefits but requires both strategic adaptation to SLR and mitigation of other existing local stressors like water quality impairment and impoundment. Below, we highlight four case studies on restoration of degraded estuaries, which are described in more detail in **Appendix 3.5.1**.

The Watsonville Sloughs System: Levee setbacks and floodplain restoration in Pajaro Valley aim to reduce flood risk, foster long-term productivity of farmland, and restore habitat, water quality, and groundwater recharge areas. NGOs are engaging underrepresented communities by providing students paid climate-focused internships and workforce development programs.

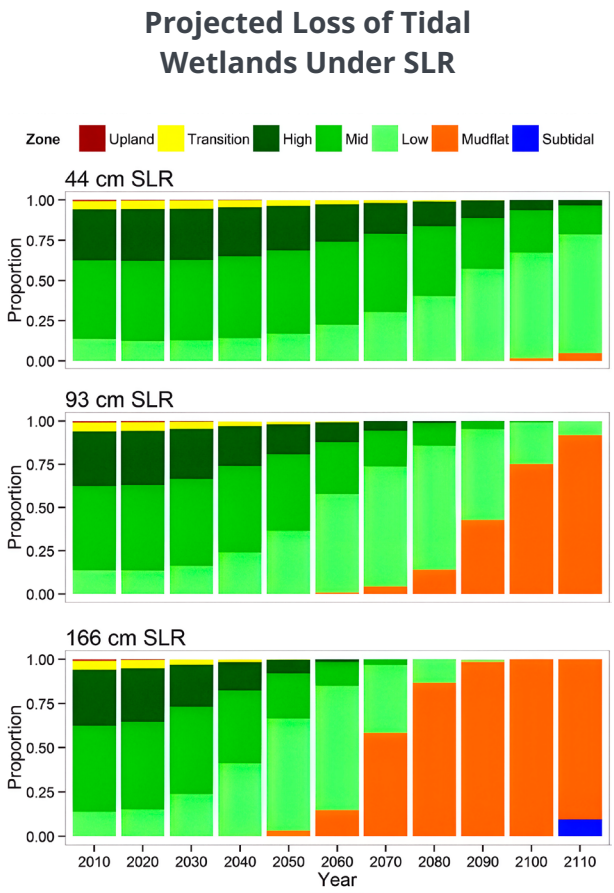


Figure 29: *Model predicted changes in the Morro Bay tidal wetlands under 17 in (44 cm), 37 in (93 cm), and 65 in (166 cm) of SLR scenarios for 2110 (Thorne et al., 2016).*

The Elkhorn Slough: The Central Coast region's largest salt marsh is drowning due to subsidence from groundwater overdraft, decomposition driven by nutrient pollution, and diking that restricts tidal exchange, further reducing water quality and biodiversity (Hughes et al., 2011; Ritter et al., 2008; Van Dyke & Wasson, 2005). Removing dikes to restore tides can increase climate resilience and water and habitat quality. While 95% of seagrass (eelgrass) was lost, it has recovered as supported by restoration plots with documented return of fish habitat and water quality (Beheshti et al., 2021). Oyster restoration with aquaculture has been successful (Wasson et al., 2020). Hester Marsh was made "climate-ready" by adding soil to build the estuary's highest marsh (Haskins et al., 2021), able to withstand 20 in (50 cm) of SLR (Fountain et al., 2020); they found plantings were sensitive to drought and that investing in first-year plantings of larger, hardier species in a mosaic design could improve restoration outcomes (Wasson et al., 2025).

The Moro Cojo Slough: Restoration of 34 acres (14 ha) of adjacent former farmland is enhancing climate resilience, benefiting both agriculture and conservation. A five-pond reservoir system reduces downstream flooding, captures sediment, treats agricultural runoff, and provides habitat.

Sediment removed from agricultural drainage ditches will reinforce berms. Periodic drying of the wetland aims to promote native species.

The Morro Bay Estuary: Long-term salt marsh persistence is uncertain due to limited upland migration space and accelerating SLR and storm flooding (Barnard et al., 2017; Thorne et al., 2016, 2018, 2024, 2025). The Morro Bay National Estuary Program partners with local communities and governments to protect and restore the watershed and develop nature-based adaptation strategies to preserve, restore, and monitor eelgrass, tidal wetland, and transition zone habitats, including sediment enhancement and eelgrass planting (MBNEP, 2024).

3.5.2 Sandy Beaches

Synthesis Author: *Jenifer Dugan*

Contributing Authors: *Kriss Neuman and Dan Robinette*

Beaches and dunes cover half the Central Coast's shores. They buffer waves, filter seawater, recycle nutrients, and provide habitat for rich endemic invertebrate communities, endangered wildlife, and fish (**Appendix 3.5.2**), and they will be profoundly altered by climate change (Vitousek et al., 2017a, 2017b). Sandy beaches generally lack attached plants and their food webs rely on subsidies of organic matter from the ocean and kelp ecosystems (*Section 3.5.4 Kelp Forests*).

CLIMATE IMPACTS

Sand is moved by winds, waves, currents, and tides. Precipitation changes, worsening storms, and SLR increase beach erosion and alter accretion (Warrick et al., 2025; Griggs et al., 2005), making beaches steeper and coarser, and impacting biodiversity and coastal food webs (Schoeman et al., 2014; Vitousek et al., 2017a, 2017b). Beaches with space to retreat landward and sufficient sand supply (often those backed by dune fields) can adjust to SLR and maintain ecosystem integrity (Schoeman et al., 2014; Myers et al., 2017), but this is likely to reduce dune extent. Where landward retreat is constrained by cliffs, armoring, or development, sand-limited beach ecosystems and their services will disappear. For example, 78% of the beaches east of Point Conception in Santa Barbara County are bluff-backed; just 50 cm (1.64 feet) of SLR there will significantly reduce the critical upper beach zone (land to high tide), reducing biodiversity and ecological function (Myers et al., 2017). Impacts are projected to be severe on urbanized coasts where armoring and development constrain shoreline retreat with SLR ("coastal squeeze" see also *Section 2.2.7 Sea Level Rise* and *Section 2.2.8 Extreme Coastal Storm Events*; Schlacher et al., 2007). Armoring in the upper beach zone is predicted to cause more rapid loss of upper/mid-beach zones where areas of armored and bluff-backed beaches already reached a climate tipping point (Barnard et al., 2021).

IMPACTS ON WILDLIFE

Habitat loss potential is greatest and will manifest sooner for upper beach zones, including biota (at-risk species listed in **Table A.3.1**) and ecological function (Dugan et al., 2008; Hubbard et al., 2014; Jaramillo et al., 2021). This zone supports >45% of the intertidal invertebrate species of beaches, including many endemic species that lack planktonic larval stages, leaving limited

capacity to disperse and recolonize beaches (Dugan et al., 2003, 2008; Hubbard et al., 2014). Some vulnerable species play key roles in processing kelp wrack and nutrient cycling, fueling the food web (Lastra et al., 2008; Emery et al., 2021; Dugan et al. 2011). Because beaches rely on subsidies from other marine ecosystems like kelp forests, climate change impacts on those ecosystems can also strongly affect beach food webs (Walter et al., 2024). Warming is expected to shrink body size for major sandy intertidal arthropods (wrack consuming talitrid amphipods, suspension-feeding hippid crabs, and scavenging isopods) which could impact survival, reproduction, and ecosystem productivity (Jaramillo et al., 2017).

Sandy beaches and their surf zones are feeding and nursery areas for a variety of fish (Gold et al., 2023). Species that support important recreational shore fishing, such as barred and redtail surfperch, rely on beach invertebrates from intertidal zones as prey (Schooler et al., 2024; Madden et al., 2025). Open sandy beaches' upper zones are critical spawning habitat for beach-nesting fish, such as the California grunion and smelt species (Martin, 2015), all traditionally harvested by coastal Tribes in the region (Gobalet & Jones, 1995). SLR and beach habitat loss threaten foraging resources, nursery, and nesting habitat for fish, impacting Tribal food sovereignty.

Central Coast beaches provide key migratory and wintering habitat for shorebirds, a declining group (Koleček et al., 2021; Piersma & Lindström, 2004; Hubbard & Dugan, 2003; Neuman et al., 2008). Shorebirds are most diverse and abundant on beaches with plentiful invertebrate prey and kelp wrack (Dugan et al., 2003, 2015; Emery et al., 2025) and are sensitive to changes in wrack (Walter et al., 2024). Half of California's Western Snowy Plovers, a federally listed threatened species, nest on the region's beaches (**Appendix 3.5.2**). These habitats were degraded by development, recreation, disruption of accretion, and human-associated predators such as ravens and coyotes (Strong et al., 2021). The food web that supports plovers relies on kelp wrack (Dugan et al., 2003; Emery et al., 2025), and donor kelp forests are dying off due to warming oceans (see *Section 3.5.4 Kelp Forests*). Monterey Bay habitats could shrink 52% under 200 cm (6.6 in) of SLR (Neuman et al., 2021). Beach "coastal squeeze" is anticipated to jointly increase predation and flooding risk in storm surges (Neuman et al., 2021, 2024). Increasing temperature and rainfall correlates to increased predation rates of nests. Protection of nesting sites resilient to SLR can aid conservation efforts (Neuman et al., 2019).

California least terns are endangered seabirds that breed on sandy beaches and coastal river-mouth spits (Thompson et al., 1997; Sin et al., 2024). Prior recovery is now imperiled by poor breeding success which is likely due to declines in small nearshore fish prey in the core of their range in Southern California (**Appendix 3.5.2**; Robinette al., 2020), where >70% declines of nearshore fish (Koslow et al., 2015) have been linked to inshore upwelling, warmer waters, and zooplankton declines (*Section 2.2.9 Ocean Conditions*; Siegelman-Charbit et al., 2018). Shifts in anchovy distributions offshore and north (Howard et al., 2020) mean terns may have to travel farther offshore to forage. CCR's two main breeding sites have dunes with room for coastal retreat, so they may become important for terns if southern breeding habitats continue losing fish or are lost to SLR as predicted (Vitousek et al., 2017a). If the Central Coast is to be a climate refuge for least terns, research on facilitating emigration (e.g., via social attraction) is needed.

ADAPTATION STRATEGIES

Beach adaptation is reviewed in *Section 2.2.7 Sea Level Rise*. Chumash Tribal members advocate for the preservation and restoration of natural coastal ecosystem processes and sand supply to conserve sandy beaches (**Box 7**). Coastal dunes provide additional nature-based adaptation options. Reducing direct disturbance of vegetation by vehicles and excessive foot traffic can promote dune formation (Anders & Leatherman, 1987). Restoring coastal dunes by removing invasive species (e.g., iceplant and European dune grass) and restoring native vegetation can allow natural dune profiles to develop and enhance resilience and speed for dune recovery following erosion from storms (Hilgendorf et al., 2022). Pilot studies show pairing unirrigated seeding with ending beach grooming and installation of fencing can recover dunes, vegetation, and associated wildlife even in heavily used beaches (Johnston et al., 2023; Emery et al., 2024).

Box 7: *Chumash Conservation of California's Coast*

Author: *Nathan Von Schmidt*

Sea cliff erosion from SLR and worsening storms are eroding sacred gathering sites of ytt Northern Chumash Tribe, which date back 10,000 years and have ongoing ceremonial practices. Tribal members monitor and document changes to save them. Vulnerable beaches and dunes include many of the Tribe's richest resources and most sensitive habitats. At Morro Bay Rock, suggested adaptations include buffering the causeway, removing it to allow the coastline to shift, or either reinforcing the beaches with imported sand (preferred but expensive) or using infrastructure like manmade guards to prevent erosion. At Tstyiwi (Pecho Creek), the Tribe worked with Pacific Gas & Electric (PG&E) to convert former agricultural land to a coastal grassland restoration project and education site. This preserved the cultural and archaeological resources by reducing cliff and creek bank erosion while improving water and habitat quality.

The Santa Ynez Band of Chumash Mission Indians are also assessing coastal erosion threats to coastal village sites and cultural keystone places as part of the Fifth Assessment's original research portfolio. Their detailed vulnerability analysis combines community-participatory Chumash ecological knowledge with coastal hazard modeling to develop a matrix of adaptation planning measures and a geospatial database for strategizing future climate response.

3.5.3 Rocky Coasts

Synthesis Author: *Peter Raimondi*

Contributing Author: *Daniel Orr*

CLIMATE IMPACTS

Rocky intertidal shores ("tidepools") are subjected to stressors from terrestrial and marine environments, with many exacerbated by climate change. They have high biological diversity, with many species found only in this narrow band of coastal habitat (just 2 sq. miles [5 sq. km] of California's coast) (Raimondi & Smith, 2022). High water temperature, particularly during marine heat waves (see *Section 2.2.9 Ocean Conditions)*, is linked with the spread of disease in marine organisms such as black abalone (Raimondi et al., 2002; Burge et al., 2014). Marine heat waves are associated with lower stability of the ecological community, likely due to the loss of key foundation species like California mussel (Miner et al., 2021) that hundreds of organisms depend on for habitat, shelter, and food (Lamy, 2020; Suchanek, 1992). Critically, Marine Protected Areas (MPAs) facilitate faster recovery from these impacts (**Figure 30**).

Like marine heat waves, more frequent and severe atmospheric heat dome events and sustained severe wind events can result in heat, desiccation, stress, and loss of foundation species including rockweeds and mussels (Whitaker et al., 2024; Miner et al., 2025).

Protected Areas Facilitate Ecosystem Recovery from Marine Heat Waves

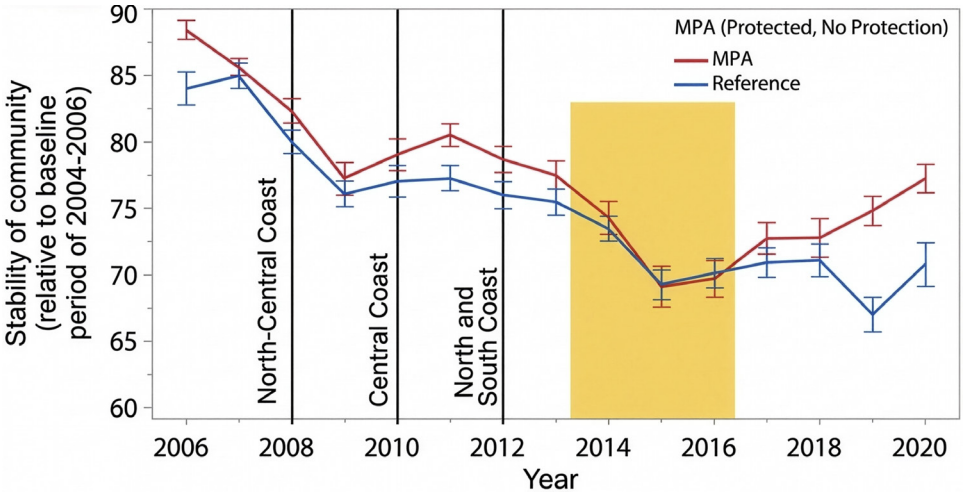


Figure 30: *Pattern of ecological community stability (y-axis) over time (x-axis) at sites within all California Marine Protected Areas. Protected areas recovered more quickly from the 2014–2016 marine heat wave (orange bar). Vertical lines show when Areas were established in each part of the region.*

Increasing storm intensity may increase disturbance to the intertidal zone, and increasing storm frequency may reduce species' ability to recover post-disturbance (Harley et al., 2006). In Monterey Bay, increases in abundance in southern species and declines in northern species indicate already occurring shifts under climate change (Sagarin et al., 1999). The shells of many rocky intertidal invertebrates could be harder to build and maintain in more acidic waters. Larval stages may be particularly vulnerable (Kroeker et al., 2013). Sediment from debris flows (see *Section 2.2.5 Sediments Hazards and Resources*) has already buried critical habitat for endangered black abalone in Big Sur.

IMPACTS ON WILDLIFE

Black oystercatchers are shorebirds that structure intertidal ecological communities by preying on mollusks and other marine animals (Wootton, 1993; Garza, 2005). They are of high concern because they have a small global population and rely on rocky shores, a narrow, sparse habitat that is vulnerable to SLR and worsening storms (Tessler et al., 2007, 2014; Weinstein et al., 2014; Senner et al., 2016; Weinstein et al., 2024). Good nesting habitat is even more restricted to sites high on rocks (safe from waves) and offshore (without human disturbance), and in the Central Coast chick fledging rates are only 74% of what is needed for population stability (**Appendix 3.5**; Weinstein et al., 2024). Nesting may also be impacted by short-term climate events (e.g., marine heat waves) that impact the availability of their invertebrate prey (Hipfner & Elner, 2013). Protecting preferred nesting habitats could help.

3.5.4 Kelp Forests

Synthesis Author: *Mark Carr*

Contributing Authors: *Kriss Neuman, and Dan Robinette, Jennifer Caselle, and Joshua Smith*

Kelp forests are among the most productive and species-rich ecosystems of California. Kelp provides productivity, structure, and shelter to support high biodiversity at all levels of the food web. Kelp subsidizes offshore and coastal ecosystems with kelp detritus (see other subsections throughout *Section 3.5 Marine Ecosystems*) and supports recreation and major commercial fisheries (**Appendix 3.5.4**; Schiel & Foster, 2015; Carr & Reed, 2016). Kelp forests are central areas for hunting marine mammals, fishing, and shell fishing for the Chumash, especially in the Santa Barbara Channel. The Chumash harvest kelp for cultural use in seaweed dances and traditional food and medicine, and giant kelp is commercially cultivated today (Erlandson et al., 2026; Gill, 2015; Landberg, 1963). Chumash groups like the Tomol Society are rebuilding traditional boats and reasserting Tribal management, revitalizing their maritime culture, growing Tribal capacity for marine science and restoration, and developing collaborations among Chumash Tribal bands and the National Oceanic and Atmospheric Administration (NOAA).

MARINE HEAT WAVES AND OTHER CLIMATE IMPACTS

In the past decade, kelp forests declined 25–57% along the Central Coast and decreased in density. This was largely due to the 2014–2016 marine heat wave (see *Section 2.2.9 Ocean Conditions*; Beas-Luna et al., 2020; Bell et al., 2023; Ortiz-Villa et al., 2025; Giraldo-Ospina et al., 2025a, 2025b), which reduced the production of drift algae and led to overgrazing by sea urchins. Extensive kelp forests were transformed to remnant forests interspersed with "urchin barrens" dominated by encrusting coralline algae and high densities of sea urchins (**Figure 31**; Smith et al., 2021, 2024). This decreased species diversity and shifted ranges of coastal biodiversity (Reed et al., 2016; Michaud et al., 2022; Beas-Luna et al., 2020). The highest declines of 70–80% were around the Monterey Peninsula (Bell et al., 2023; Smith et al., 2024). Canopy coverage in many areas along the coast is still ≤20% of pre-heat wave coverage (Giraldo-Ospina et al., 2025a, 2025b).

Degraded Kelp Forests Turn into Urchin Barrens



Figure 31: *Canopies of (a) giant kelp and (b) bull kelp vs. (c) urchin barrens. (Photos: P. Webster)*

Kelp forests also often experience "bottom" marine heat waves, elevated temperatures on the seafloor (Amaya et al., 2023; Chan et al., 2024). These expose kelp and seafloor invertebrates to high temperatures during their reproductive periods (Chamorro et al., 2023). Gradually increasing ocean temperatures also have caused northward shifts in kelp forest species distributions, changes in the ecosystem's species composition and functional structure (Beas-Luna, 2020), and decreased productivity (Schiel & Foster, 2015). Increased storm frequency and swell energy can directly impact the seasonal longevity, annual productivity, and structure of kelp forest communities (Ebeling et al., 1985; Dayton et al., 1992; Reed et al., 2011; Castorani et al., 2018). Higher runoff and sedimentation during projected heavier precipitation (Huang & Swain, 2022) may impair algal photosynthesis and scour or smother early life stages.

Changes in coastal upwelling under climate change (see Section 2.2.9 Ocean Conditions) could alter the location, timing, and degree of influx of nutrient-rich water essential for kelp productivity. To date, coastal upwelling has increased (Sydeman et al., 2014; Garcia-Reyes et al., 2015; Bograd et al., 2023). Lastly, as water depth increases with SLR, changing light availability may shift kelp inshore, potentially reducing kelp forest area if cliffs limit inshore movement.

ADAPTATION AND RESTORATION

Once kelp is lost, recovery is difficult. Marine Protected Areas can contribute to kelp forest resilience by limiting fishing and therefore mortality of species like California Sheephead that, along with the federally listed southern sea otter, help control sea urchin populations, enabling kelp persistence and stability (Caselle et al., 2017; Eisaguirre et al., 2020; Smith et al., 2021; Kumagai et al., 2024; Nicholson et al., 2024). Protection of areas that produce sufficient drift to prevent sea urchin outbreaks may also allow resistance (Rennick et al., 2022; Smith et al., 2024).

Pioneering restoration work is investigating the efficacy, costs, and feasibility of potential approaches such as grazer suppression through urchin reductions and predator reintroductions, and kelp outplanting including stress-tolerant kelp genetic variants. Tribes are working to create new research and conservation frameworks like the Tribal Marine Stewards Network (see *Section 3.6.1 Stewardship by California Native American Tribes*). For example, ytt Northern Chumash are seeking funding to restore kelp forests imperiled by warming through a collaborative Marine Protected Area and are not conducting traditional hunting of sea otters to restore the balance among kelp, urchins, and otters.

3.5.5 Fisheries

Synthesis Author: *Nathan B. Spindel*

Contributing Authors: *Cheryl Logan, Jerome Fiechter, Barbara A. Muhling, and Michelle María Early-Capistrán*

The arrival of the Chumash in the Santa Barbara Channel was the earliest known human occurrence in California, with records dating back 13,000 years. As their fishing techniques developed over millennia, a complex trade system also developed with the first currency in California, and possibly all of the Americas (Gamble, 2020). Today, California's coastal ecosystems continue to support major commercial, recreational, and Tribal fisheries. Annual commercial fisheries landings averaged $179 million from 2014–2024. Over the same period, recreational fishing license holders purchased an annual average of 270,000 ocean enhancements worth $1.4

million (CDFW, data).

OBSERVED CLIMATE IMPACTS

Rapid changes in the ocean and target species have impacted fisheries and fishing communities. Fishery species have responded differently to the rising sea surface temperature (SST) and severe marine heat waves: some moved north (e.g., Pacific sardine, market squid), while others lost habitat (e.g., red sea urchins, red abalone), declined in abundance (e.g., Chinook salmon) (Chasco et al., 2022; Cavole et al., 2016), or sometimes increased (Northern anchovy and some rockfish) (Free et al., 2023; Muhling et al., 2020). Heat wave-driven harmful algal blooms closed several shellfish fisheries, causing financial losses to coastal communities (Free et al., 2023; Moore et al., 2020). These redistributions created new conflicts and opportunities, which adaptive, place-based governance paired with climate-informed stock assessments (Free et al., 2023) could help with.

Changing prey availability compounds challenges from rising SST. Pacific sardine populations failed to recover during recent marine heat waves, possibly due to reduced food availability during early life and adult stages (Koenigstein et al., 2022). Interactions between SST and food availability shape the foraging behavior and timing of latitudinal migrations of predators (Dodson et al., 2020). Some tuna and swordfish prey have moved deeper due to increased light penetration, becoming less accessible (Iglesias et al., 2023, 2024). Fishery species are at risk of "metabolic meltdown" if higher temperatures both reduce energy intake rates and increase metabolic energy costs (Huey & Kingsolver, 2019). Climate-driven kelp forest declines collapsed the recreational red abalone by both reducing their food availability and forcing movement to shallower, warmer waters with higher mortality (Rogers-Bennett & Catton, 2019, 2022).

Climate change may alter the strength, frequency, duration, and phenology of upwelling events in the CCS. Increasing upwelling could expose nearshore fish to lower oxygen levels and more acidified, CO2-rich water. Rockfishes make up a large part of the West Coast commercial and recreational groundfish fishery valued at >$300 million annually (NOAA, 2024b). Rockfishes' species-specific behavioral and physiological responses to climate stressors are being studied (**Appendix 3.5**) (Mattiasen et al., 2020; Hamilton et al., 2017, 2019; Davis et al., 2018; Cline et al., 2020). Climate-informed management could account for some rockfish species being more resilient to long-term change than others (Hamilton et al., 2019) and would integrate climate impacts on growth and fecundity into species-specific stock assessment models (Sandquist, 2025).

PROJECTING CLIMATE IMPACTS

New models (**Appendix 3.5.5.2**) project sardines' prey availability will remain high enough for regional growth, but their population may still shift northwards by 2100 in response to warming (Fiechter et al., 2021; Smith et al., 2021; Koenigstein et al., 2022). Uncertainty in the timing and extent of these range shifts is largely driven by the projected amount of upper ocean warming (Fiechter et al., 2021). In contrast, if coastal upwelling and productive conditions become more restricted to nearshore areas (as in the 2014–2016 marine heat wave), it may favor species and life stages that exploit this environment such as juvenile salmon (Vasbinder et al., 2025).

Population viability projections often rely on measured lethal thresholds, overlooking key sub-lethal impacts like on egg production (Okamoto et al., 2025) and underestimating how severely

and suddenly populations respond to stressors like warming (Braschler et al., 2021; Tratter Kinzner et al., 2019; Rezende et al., 2020). More research is needed on how multiple climate stressors (e.g., warming, acidification, and deoxygenation) interact to affect marine species and ecosystems (Kroeker et al., 2017, 2023; Liu et al., 2025; Kindinger et al., 2022).

Ecosystem and fishery responses to climate change will be difficult to predict as the CSS exhibits strong alongshore and temporal variability in key properties (e.g., oxygen, pH, krill) (Fiechter et al., 2018, 2020; Cheresh & Fiechter, 2020; Pozo Buil et al., 2021; Cheresh et al., 2023; Fiechter et al., 2026). The key impacts on species are likely to be from increased exposure to extreme and rapidly changing conditions, which can cause quick, hard-to-predict changes in growth, survival, reproduction, and distribution (Kroeker et al., 2020).

FISHERY ADAPTATION STRATEGIES

Fishers may adapt to shifting availability of fishery species by changing target species or fishing grounds and diversifying livelihoods and technology (Galappaththi et al., 2022; Quezada et al., 2024; Samhouri et al., 2024). Responding to the 2014–2016 marine heat wave, California's Dungeness crab fishery combined these two strategies, yielding higher profits than either approach alone (Liu et al., 2023). More complex networks of fishery resource use can also be an adaptation strategy (Fisher et al., 2021). Impacts on fishery reliant communities will depend on their economic and social vulnerability (Quezada et al., 2024; Smith et al., 2021).

As species move, interactions with or bycatch of protected species can also increase (Santora et al., 2020). For example, aggregations of >15,000 turtles off the Channel Islands during recent El Niño events, likely in part due to climate-driven shifts of endangered hard-shelled turtles northward, led to dynamic fisheries management policies and time-area closures to prevent turtle bycatch (Eguchi et al., 2018; NOAA, 2024c, 2024d; Early-Capistrán et al., 2018, 2024). Climate change also imperils the endangered and declining leatherback sea turtle, which has a historical critical habitat "hotspot" in Monterey Bay (**Appendix 3.5.5.3**).

New strategies and habitat protection can facilitate climate adaptation. The Northern Chumash Tribe, ytt, is developing a climate-informed aquaculture plan in their first land back campaign, Alexander Ranch in San Luis Obispo County. The Tribe will restore the site for an aquaculture hatchery for commercial aquaculture and restoration of species of concern like black abalone. The Tribe is partnering with researchers to develop better techniques for black abalone hatcheries. Marine Protected Areas may also enhance resilience to marine heat waves by accelerating recovery of fish diversity and buffering functional shifts in some communities (Ziegler et al., 2023), though they do not consistently confer resistance or recovery across ecosystems (Smith et al., 2023).

3.6 Land and Ocean Conservation

Synthesis Author: *Brenda Elisa Rubio Estrada*

The Central Coast Region has a strong conservation legacy, with 1.5 million acres of protected lands, about 20% of the region (State of California, 2025) including the iconic Big Sur coast and Carrizo Plain National Monument, the state's largest remaining native grassland. Community-led efforts are at the forefront of conservation for climate adaptation, connecting Tribal stewardship, agricultural and ranching economies, and sustainable single-tree selection forestry.

3.6.1 Stewardship by California Native American Tribes

California Native American Tribes' cultural knowledge, traditional ecological practices, and place-based stewardship continue to shape and enrich regional conservation efforts in partnership with other organizations. In the Central Coast region, the Amah Mutsun Tribal Band and Land Trust are leading crucial efforts to conserve habitats at Juristac (**Appendix 3.6.1**) and revitalize cultural burning practices (see *Section 2.2.4 Wildfire*, **Box 2**) at sites like Quiroste Valley and the renamed *tarenmak numan awnicminmak komeypuyni* ("springs where the turtles come to rest") property, which enhance ecological health and reduce fire risk (AMLT, 2020). The Salinan Preservation Association is restoring an adobe wall that protects the resting place of over 2,000 Salinan ancestors at Mission San Antonio Cemetery at Fort Hunter Liggett. Weather erosion has already damaged the site, raising concerns about worsening storms under climate change.

New intertribal research and conservation networks are strengthening Tribal maritime presence and partnerships. The Tribal Marine Stewards Network, which was founded in 2022 and includes the Amah Mutsun Tribal Band and the Santa Ynez Band of Chumash Indians, is promoting 18 initiatives, including training to facilitate Native Science, monitoring, restoration, food sovereignty, and co-management agreements with state and federal agencies to reclaim stewardship of their coastal territories. The Santa Ynez Band of Chumash Indians does this through their partnership with Ocean Origins, an NGO focused on building Tribal Nations' stewardship capacity by fostering partnerships between marine scientists and Indigenous communities. An example is the 2024 designation of the 5,600 mi2 Chumash Heritage National Marine Sanctuary, a co-stewardship framework between NOAA and the Santa Ynez Band of Chumash Indians. It is the first US marine sanctuary proposed by a Tribal group (the Northern Chumash Tribal Council) to protect marine ecosystems and sacred cultural sites (NOAA, 2024e).

3.6.2 Challenges to Conservation and Frameworks for Moving Forward

Persistent gaps in institutional capacity and insufficient, short-term funding inhibit implementation of nature-based solutions to combat existing climate change threats (CNRA, 2021). Underinvestment in long-term land stewardship (only 14% of California's conservation spending vs. 62% for land acquisition) (LAO, 2022) risks the ecological integrity and climate benefits of protected lands and limits workforce development opportunities. A lack of leadership coordination and "green tape" hinder integration of conservation plans with housing, food and water security, and wildfire resilience plans. For example, Carmel River Floodplain Restoration and

Environmental Enhancement (FREE), a project to re-establish natural hydrological connections, has been stuck in development by over 19 agencies for over 15 years.

Meaningful partnerships with Tribal communities and prioritizing Indigenous sovereignty, self-determination in land management, and Traditional Ecological Knowledge is necessary to achieve equitable stewardship and climate adaptation. But, challenges remain in building respectful, informed, and trustworthy relationships, often stemming from the historical trauma of land dispossession and the impacts of colonization perpetuated by current conservation models (ITEP, 2025). The fast-paced grant funding can conflict with the time required to build reciprocal relationships. Limited capacity of Tribal communities to participate, over-extended requests for engagement, and landowner resistance in ceding stewardship responsibilities also hamper Tribal groups' participation in conservation to meet state goals.

California agencies have developed climate resilience and land conservation frameworks to support local efforts, providing technical guidance and funding pathways (reviewed in **Appendix 3.6.2**). Initiatives are conserving and improving regional connectivity between core natural areas (**Box 8**) so species can track their shifting suitable areas under climate change (McGuire et al., 2016). Regional initiatives like the Natural and Working Lands Climate Mitigation and Resiliency Study (AMBAG, 2024) inform long-term climate work by inventorying and linking land conservation and carbon stocks in adaptation strategies. Multi-benefit projects can enhance carbon goals, biodiversity hotspots, and connectivity while providing recreational, agricultural, rematriation and Tribal engagement, and public health benefits. However, not all goals may be compatible within a single project (e.g., when recreation harms sensitive habitat).

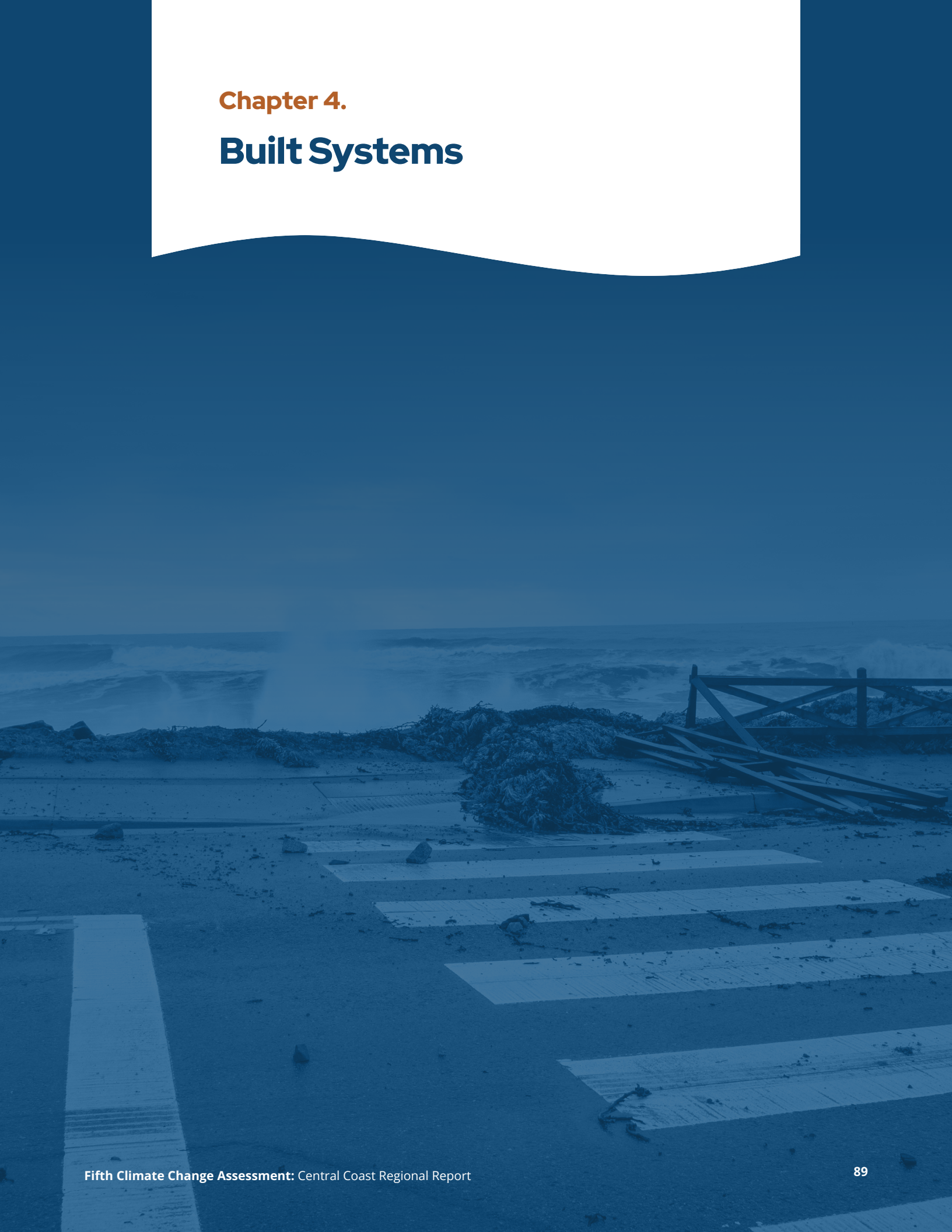
Box 8: *Connectivity Conservation Initiatives*

Major funding initiatives show the power of cross-sector collaboration for regional connectivity:

- The Land Trust of Santa Cruz County is developing a plan to protect and enhance habitat while improving transportation infrastructure across the Santa Cruz to Gabilan Ranges.
- The Greater Monterey County Integrated Regional Water Management is strategically acquiring and repurposing lower Salinas Valley's least viable, most flood-prone portions of irrigated agricultural lands.
- The San Andreas Wildlife Corridor aims to protect nearly 600,000 acres (240,000 ha) from Santa Barbara County to the San Francisco Bay. The Nature Conservancy's acquisition of Las Piletas Ranch (13,500 acres [5,460 ha]) is a key part of this effort (TNC, 2025).
- The $27 million Carr Lake project created Ensen Park and is restoring 67 acres (27 ha) of wetlands and uplands to provide recreation, biodiversity, and flood resilience in Salinas (BSLT, 2025).

Chapter 4.

Built Systems



Key Messages

Housing:

- Households currently facing high energy burdens will face more challenges as energy costs and cooling needs rise, with major cost burdens for lower- and middle-income households.
- General plans only mandate climate and disaster risk consideration in the Safety Element, not the Housing Element where there is limited discussion.

Energy:

- The Central Coast region is a leader in developing clean energy: Central Coast Community Energy (3CE) is helping to advance electric vehicles, EV chargers, new electric school buses, offers of rebates for agriculture-worker transport businesses, and electrification equipment and no-cost technical assistance for agriculture.
- Public Safety Power Shutoffs (PSPS) under hot, dry, windy conditions may cut off people's access to important appliances that keep people cool, keep food safe and store critical medicine, as well as electric-powered medical devices, with negative health impacts, particularly for more vulnerable individuals.
- Distributed solar and storage, along with efficiency and demand response measures, can help reduce ratepayer costs during normal operations by allowing homes and businesses to generate, use, and store some of their own power.

Transportation:

- Transportation infrastructure faces significant exposure to sea level rise (SLR) eroding coastal railways and bridges, intense storms causing mudslides and flooding of highways, and heat waves leading to buckling and rutting of roads. Restoring and protecting natural habitats in the project area can be critical to ensuring the resiliency of transportation infrastructure.

Community Preparedness:

- County climate hazard vulnerability assessments, heat action, and flood emergency planning are being conducted. Energy preparedness research and strategies to develop the capacity for emergency response are more limited.

4.1 Housing

Synthesis Author: *Amanda Fencl*

4.1.1 Overview

Like many regions, the Central Coast is facing a confluence of housing shortages and affordability challenges, with increases in extreme weather events and temperatures affecting renters and owners alike. Homes are the first lines of defense against extreme weather and temperatures, and if they are inadequately prepared or located in high-risk areas, people must respond and adapt to these challenges regardless of their capacity . Many residents are cost-burdened, which affects their housing situation.. Most housing units are owner-occupied (52–68%, depending on the county), where household adaptation responsibilities will fall on property owners. However,

counties also have anywhere from 32–48% of renter-occupied households, which warrant a different set of policy and infrastructural interventions by landlords and local jurisdictions. Additionally, in all counties, more than half of renter-occupied households are cost-burdened (compared to nearly one-third of owner-occupied households), consistent with statewide averages (**Table 3**).

Cost-burdened residents spend more than 30% of their gross monthly income on housing. In many instances, the households are burdened by one or more key housing problems, such as an incomplete kitchen, incomplete plumbing, or overcrowding. Local jurisdictions in the region administer several federal housing assistance programs to approximately 936,000 households. There are also an estimated 10,361 unhoused people living in the region (HCD, 2025b).

Table 3: Housing Cost Burdens. *Percent of households with various characteristic housing needs per county. Data is from 2021 except for the proportion of disabled, elderly, large, or low-income households, which are from 2019. Compiled from the Statewide Housing Plan Dashboard (HCD, 2025b).*

County	Renters	Cost-Burdened Renter	Cost-Burdened Owner	Disabled	Elderly	Large Family	Low Income	Agricultural Employment (FTEs)
Monterey	48%	55.90%	30.10%	49.90%	39.20%	70.70%	73.70%	94,098
San Benito	32%	50.00%	36.50%	50.70%	41.50%	58.30%	71.80%	3,237
San Luis Obispo	38%	56.10%	31.20%	40.40%	36.50%	50.20%	64.10%	8,974
Santa Barbara	47%	56.50%	29.80%	46.20%	37.10%	69.40%	72.00%	32,502
Santa Cruz	40%	53.70%	31.90%	51.50%	39.40%	67.50%	68.60%	14,048
Ventura	36%	59.10%	31.80%	47.40%	40.50%	55.70%	68.20%	36,006

The region is also home to approximately 188,865 agricultural employees (FTE), which is more than a fifth (22%) of the state's full-time equivalent agricultural labor (HCD, 2025b). Farm workers face unique housing burdens: they are typically low-income, disproportionately living in subpar housing with limited access to safe and affordable housing choices (HCD, 2025b).

4.1.2 Impacts

Climate change affects the standards of living for current and future housing. The key climate hazards anticipated to impact California all shape how residents live in existing housing units: higher temperatures and extreme heat events, shifts in flood risk, more severe droughts, worsening wildfires, and coastal flooding and erosion. These same hazards also shape where and how to build in the coming decades. And as with other anticipated climate impacts, lower-income residents will be disproportionately impacted (LAO, 2022).

EXTREME HEAT

Heat is the leading cause of weather-related deaths in California, and more frequent extreme hot temperatures and heat waves are projected (see *Section 2.2.1 Extreme Precipitation and Temperatures*) (IPCC, 2023b). This impacts not only outdoor workers (Licker et al., 2022; Dahl et al., 2019), but also individuals and families through their indoor environment at home. The households that benefit from federal housing assistance have heightened sensitivity to extreme heat with less adaptive capacity (Gabbe & Pierce, 2020). The Central Valley and Inland Empire

communities were found to be more exposed than those on the coast. Indoor temperatures are influenced by housing design (e.g., single family home, apartment, or manufactured housing; Gabbe et al., 2025), access to air conditioning or other cooling options, and access to affordable energy (Gabbe & Pierce, 2024). Residents of manufactured housing in particular are excluded from key tools used to protect people in other housing contexts (Kear et al., 2023), facing outsized exposure to heat (Pierce et al., 2022).

Many homes in the Central Coast lack air conditioning and cooling technologies due to generally lower historic regional temperatures (Langridge et al., 2018). Even where air conditioning is accessible, running it may prove cost prohibitive; scholars have found that seniors, who are typically on fixed incomes, are more likely to keep their homes at unhealthily high temperatures (Gabbe & Pierce, 2024). For many of the region's low income, cost-burdened households, access to cooling and affordable energy is not guaranteed during extreme heat events. Socioeconomic disadvantages often amplify heat-related illness or death risks, particular among seniors and those with pre-existing health conditions or disabilities (Harlan et al., 2019). This will necessitate changes and adaptations to existing housing and ensuring that new units are built with future heat extremes in mind.

WINTER STORMS AND FLOOD EVENTS

Recent severe winter storms and floods have forced the displacement of residents, impacted communities that already had almost no housing vacancies, and limited storm survivors' post-disaster temporary and long-term housing options, with inequitable outcomes at the intersection of these extreme events and housing challenges (Rivera et al., 2022; Rivera, 2025; Romero, 2024). Cost- and rent-burdened households had already been pushed closer to housing insecurity and homelessness. The loss of public housing stock also prolongs disaster recovery for renters (Davlasheridze & Miao, 2021), who already have less political and financial capital and are less eligible for assistance than property owners (Lee & Van Zandt, 2019).

Post-disaster federal housing assistance is typically available through the Federal Emergency Management Agency (FEMA)'s Individuals and Households Program and US Department of Housing and Urban Development block grant-based disaster recovery (CDBG-DR) program (Jones et al., 2025). In 2023, California received a CDBG-DR grant for $362 million, especially for low-income post-disaster recovery prioritizing the "Most Impacted and Distressed" communities (see the 2023 HCD CDBG-DR Draft Action plan) that included Monterey, Santa Cruz, and San Benito counties that were affected by the February 2023 severe winter storms (FEMA declarations DR-4699).

DROUGHT AND WATER SECURITY

There are key interdependencies between housing and water security (Meehan et al., 2020a, 2020b; Rumbach et al., 2025; Deitz & Meehan, 2019). This is particularly clear in mobile home parks, which are disproportionately likely to have water systems with quality or reliability issues (Pierce & Gonzalez 2017). Ensuring water during droughts for a household, whether it is an apartment building or single-family home, is essential, with small water systems of fewer than 15 connections and domestic wells particularly vulnerable to drought impacts household water reliability (DWR, 2025; see also *Section 3.2.2 Climate Impacts to Water Security and Sustainability*). This has implications for the livability of water-insecure homes in the region whether the unit is

renter- or owner- occupied.

WILDFIRE

The region's affordability crisis pushed housing development into the wildland–urban interface, with recent dire consequences (Greenberg et al., 2024). The 2020 CZU Lightning Complex Fire and the 2025 Gifford Fire, among others, had devastating personal and economic impacts for residents and communities (CWFRTF, 2025). Cost-burdened renters and owners have limited capacity to upgrade their properties, reduce vegetative fuel, create defensible space, or carry out other wildfire preparedness strategies (see *Urban Fire Mitigation* in *Section 2.2.4 Wildfire*). Those limitations are compounded by shrinking home insurance coverages. Manufactured homes and their residents are uniquely vulnerable and exposed to wildfire threats (Pierce et al., 2022; Rumbach et al., 2025). Research after the 2025 Los Angeles Fires showed that disasters like major fires can increase risk of homelessness—especially for low-income renters—as fires alter rental markets and can displace people indefinitely (Batko & McTarnaghan, 2025). Wildfires also generate particulate matter that worsens outdoor and indoor air quality. Even with reduced infiltration, the mean indoor particulate matter concentrations can nearly triple during a wildfire event (Liang et al., 2021; Flavelle, 2024), which is particularly burdensome for the least equipped to respond and adapt.

4.1.3 Adaptations

County general plan housing elements emphasize the role of the built environment and housing as opportunities for climate change mitigation and greenhouse gas reduction strategies through policies and programs like "green" construction and energy efficiency. An existing gap is that general plan requirements only mandate climate and disaster risk consideration in the Safety Element, not the Housing Element (LAO, 2022) (**Table 4**).

Table 4. *County General Plan (GP) Housing Element Climate Considerations*

County	Addresses climate risks	General Discussion of Climate
Monterey	Limited	Some (2016): Old inefficient housing stock contributes to "global climate change"
Santa Cruz	Yes, in Appendix	Some (2024): The community panel appendix notes a need to limit coastal development in wildland interface to ensure new housing accounts for climate change, water supplies
San Benito	n/a	None (2016)
San Luis Obispo	No	Some (2020): The City committed to developing a plan to achieve carbon neutrality by 2035, with "green" housing construction
Santa Barbara	Limited	Some (2023): Focused on Climate Action Plan carbon neutrality goals; addresses need to plan for housing in response to climate
Ventura	Limited	Some (2021): Footnote on increasing community awareness about energy conservation, energy efficiency, and climate adaptation

(Source: Banginwar et al., 2023 with authors' analysis)

The Regional Housing Needs Allocation (RHNA) is a legal obligation to build housing. A critical opportunity for decision makers in communities tasked with implementing their RHNA is to ensure new housing units are built to withstand anticipated climate impacts and are located in

places with lower climate-risk profiles (LAO, 2022).

Given the contributions of residential energy use to regional and state emissions inventories and concerns over "carbon lock-in" for new construction, decarbonization and reducing the sources of greenhouse gas emissions are important strategies (Goldstein et al., 2020). Investing in climate adaptation and resilience measures are also essential.

4.2 Energy

Synthesis Authors: *Patrick Murphy and Bethany Kwoka*

4.2.1 Introduction

Climate impacts to energy include: rising temperatures and heat waves that can decrease the efficiency of renewable energy sources while increasing the need for cooling and potentially straining the electricity grid; intense rainfall and wildfires that can damage infrastructure, including transmission and distribution lines, thereby disrupting supply; and reduced precipitation that can impact the production of electricity from sources that rely on water, such as some thermal power plants and hydroelectric facilities (US EPA, 2025a). These are major concerns on the Central Coast (PG&E, 2024). Addressing these impacts offers challenges and opportunities for a just energy transition. This includes an equitable distribution of hazards, costs, and benefits, inclusive decision-making to address the impacts of energy hazards, and adaptive solutions that prioritize the most vulnerable communities (Sovacool et al., 2016).

4.2.2 Energy Generation

Central Coast energy generation relies on a mix of large-scale and local renewable sources, including solar, wind, geothermal, and hydropower, as well as nuclear and gas-powered plants.

RENEWABLE ENERGY SOURCES

The Central Coast region is a leader in efforts to identify and develop clean energy technologies. In 2018, California set a goal of increasing the state's electricity coming from renewable energy resources and achieving zero-carbon electricity by 2045, with 60% of this energy coming from renewable sources. Central Coast Community Energy (3CE) provides electricity to residents in Monterey, San Benito, Santa Cruz, San Luis Obispo, and Santa Barbara counties, and its goal is to be 100% renewable by 2030 (CCCA, 2020) with electricity from clean and renewable sources, primarily solar and wind. 3CE invests in new projects including helping to put more than 1,000 electric vehicles on the road and keep them moving and, in partnership with the California Energy Commission, funding more than 1,000 EV chargers for the region. They have contributed toward seven new electric buses for local schools and now offer similar rebates for agriculture-worker transport businesses. They have also helped Central Coast's agriculture electrify essential equipment such as irrigation, harvesters, boilers, and chillers, as well as offering no-cost technical assistance, and are helping build affordable all-electric housing with a New Construction

Electrification Program that provides incentives for developers as well as farmworker families and residents with supportive housing needs.

NUCLEAR ENERGY

Nuclear energy generation, a low-carbon source, can displace high-carbon fossil fuels and provide reliable power to complement intermittent renewables like solar and wind. However, it has high capital costs and public concerns about safety. The Diablo Canyon nuclear power plant in San Luis Obispo County is now California's only operational nuclear plant and the state's largest single power station. It was slated to close in 2025, but the Nuclear Regulatory Commission ruled that the plant can continue under its current license (Lopez, 2023). California Senate Bill 846 allows the plant to run through 2030 (SB 846, 2022). PG&E has estimated a cost to California rate-payers of $11.8 billion to extend operations through 2030 (Geesman, 2024).

GAS FIRED POWER PLANTS

A few small gas-fired power plants operate in Monterey, Santa Barbara, and Ventura Counties, with a total nameplate capacity of approximately 3,600 MW. The Moss Landing plant in Monterey accounts for 90% of the fossil-fired energy generated in the region and 80% of the power generation CO2 emissions (PSE, 2024). The largest plant, Ormond Beach Generating Station in Ventura County, only operates 2.4% of the time and generates almost a quarter of its energy during periods of high ozone pollution. It is slated to cease operations in 2026, with the resulting decrease in pollution improving health outcomes for the roughly 180,000 people living within a 6-mile radius, most of whom are in SB 535 designated disadvantaged communities (DACs). EF Oxnard Inc and McGrath Peaker Plant also disproportionately operate during high-ozone days. Both plants are located in areas with DACs, and neither are slated for shutdown.

4.2.3 Climate Impacts

ENERGY AFFORDABILITY

Affordability is an important consideration in addressing the impacts of climate change on energy, as Californians pay double the national average for their electrical energy (St. John, 2025). Climate change is already causing utility bills to rise as costs for wildfire mitigation increase with undergrounding of electrical infrastructure and damages from past wildfires caused by utility infrastructure. The region will likely see potential increases in residential electricity consumption for cooling needs, with highest impacts inland like the Salinas Valley (Langridge et al., 2018). While air conditioning is not currently prevalent in these areas, temperature increases will make mechanical cooling necessary for comfort and health. Moreover, in some areas, existing circuit capacities are insufficient to handle the additional load from cooling and will require capacity upgrades (Brockway et al., 2021). Monterey County near San Ardo appears to be of particular concern, with limited remaining circuit capacity.

Costs of new generation and transmission built to serve large loads such as data centers may be passed on to ratepayers (Martin & Peskoe, 2025). A significant portion of energy demand growth

and energy bill increases are and will continue to be driven by increased air conditioning needs due to rising temperatures. Households currently facing high energy burdens will face even greater challenges as energy costs and cooling needs rise and will be acute for lower- and middle-income households.

ENERGY COST BURDENS

The burden of energy affordability can be summarized as the ratio of a household's energy spending to that household's income. A ratio of greater than 6% of gross income or 8.5% of net income after essential expenses is considered energy-burdened (Colton, 2021; Murphy & Kwoka, 2024; Lukanov et al., 2024).

Figure 32a shows the energy cost burden for Central Coast households, broken out left to right by census tract income quintile. For the lowest-income quintile of households in each Central Coast

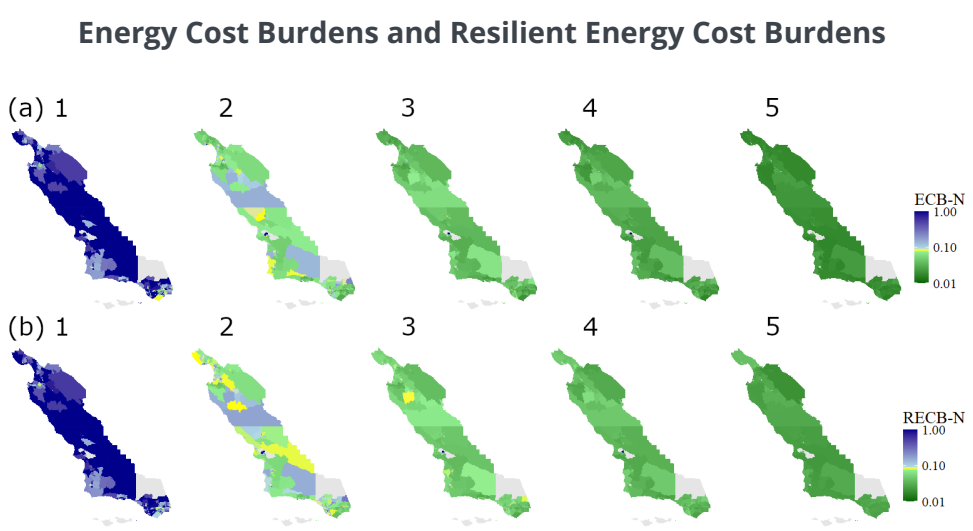


Figure 32: *Central Coast energy cost burdens (ECB) (a) and resilient energy cost burdens (RECB) (b) broken out by census tract income quintile (lowest income 1 to highest income 5). Red indicates over 8.5% of income is spent on energy. Grey areas lacked income data due to low population.*

census tract (1), most areas are highly energy-burdened, spending more than 8.5% of income on energy. Those in the darkest red have negative income after essential expenses. Only in the middle quintile (3) and above do most census tracts drop out of the highly burdened category.

Figure 32b shows "resilient" energy cost burdens, which include the cost of power outages. Considering these additional costs, more households would be considered highly burdened, even in higher income segments, as can be seen in Santa Cruz, unincorporated Monterey County near Soledad, and inland unincorporated Santa Barbara County.

POWER OUTAGES

Localized analyses of Public Safety Power Shutoffs (PSPS) provide a lens to understand potential future climate change impacts on power outages. PSE Healthy Energy's California PSPS Interactive Map summarizes outage frequency and duration data for utility reported PSPS outages from 2013 through 2023 (Kwoka, 2023). **Figure 33** highlights regions where PSPS outages occur on average more than once every three years, where those outages last more than 24 hours, and where the region can expect more than 10 days a year of extreme heat between 2040–2060.

Average Duration of Public Safety Power Shutoff Outages

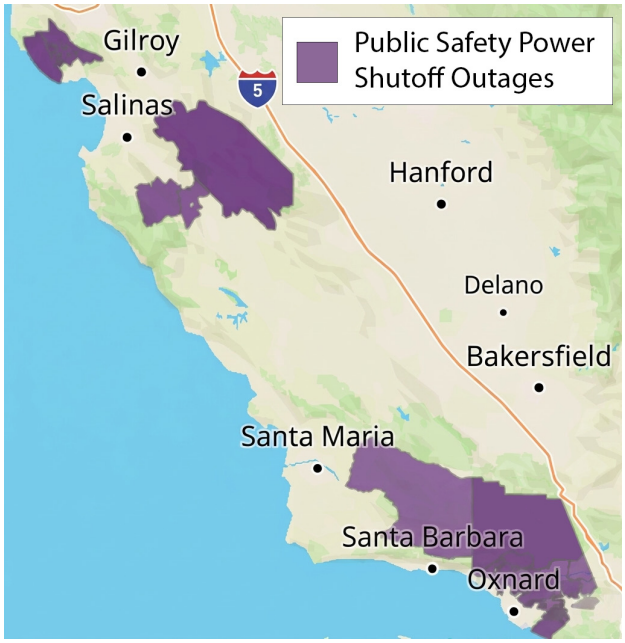


Figure 33: *Census tracts where at least one Public Safety Power Shutoff outage has occurred every three years, outages average more than 24 hours (shading indicates length), and at least 10 days of extreme heat can be expected every year between 2040 and 2060 (Kwoka, 2023).*

Their data shows that Ventura County experienced the most PSPS outages in the Central Coast, with up to five per year on average in some areas. Santa Cruz County also had a high frequency of PSPS outages, with more than one per year on average. Ventura County faces the most challenging intersection of frequency, duration, and the compounding danger of extreme heat. When power is out due to PSPS conditions (hot, dry, windy), grid-powered air conditioning will not be available to mitigate extreme heat health impacts. Similar challenges can also be expected in Santa Cruz County, San Benito County, nearby unincorporated Monterey County near Soledad, and inland unincorporated Santa Barbara County.

As climate change continues to increase the frequency and severity of weather events that cause power outages, the burdens of these outages will also increase. Power outages will cut off air conditioning during heat waves, air filtration during wildfire smoke events, refrigerators and freezers that keep food safe to eat and store critical medicine like insulin, electrically-powered medical devices, and communications equipment. This can have negative health impacts, particularly on more vulnerable individuals. Outages longer than a few hours can also impact people's ability to work or attend school.

4.2.4 Adaptations

DECARBONIZATION

As noted in the Fourth Assessment, reducing GHG emissions requires simultaneously decarbonizing electricity generation and electrifying end uses that currently rely on fossil fuels—and doing so will only increase the importance of electricity for energy services in California (Langridge, 2018). These efforts remain vital for achieving California's climate goals. However,

given affordability and resilience concerns, particularly as the rate of power outages rises due to climate-change driven extreme weather events, pathways must take into account the risks and vulnerabilities inherent in additional reliance on electricity for heating, cooling, and cooking.

DISTRIBUTED ENERGY RESOURCES

While large-scale renewables must be a large part of the decarbonization solution, increased reliance on electricity also increases the need for resilient distributed energy resources (DER). The transition from fuel combustion to electrical heating, water heating, and cooking in homes and other buildings increases needs for resilient electricity. Distributed solar and storage, along with efficiency and demand response measures, can help reduce ratepayer costs during normal operations by allowing homes and businesses to generate, use, and store some of their own power (Lukanov et al., 2022). DERs are then available to provide resilient energy during outages. However, DERs powered by solar input alone may not always be sufficient to meet resilient energy needs, for example, to meet heating energy needs during rainy winter weather. In areas where this is common, alternate backup systems will be necessary; batteries to support multiple days of heating would still be cost-prohibitive, as shown in a recent study on the statewide potential for resilience hubs in California (Murphy et al., 2024; Krieger et al., 2024). Heat pumps and weatherization can make resilient electric heating more attainable, especially in mild climates like the Central Coast.

4.3 Transportation

Synthesis Author: *Amaury Bertaud*

4.3.1 Exposure and Vulnerabilities

Transportation infrastructure faces significant exposure to climate hazards. These include SLR undermining coastal railways and bridges, intense storms causing mudslides and flooding of highways, and heat waves leading to buckling and rutting of roads (LAO, 2022). Central Coast public agencies are wrestling with these impacts. From local streets to highways, and from regional vulnerability assessments to project-specific studies, there are planning and implementation efforts designed to protect infrastructure. Most efforts have focused on the impacts of SLR and flooding on infrastructure, since they are the most destructive and require the largest levels of capital investments. This section will provide a few examples of ongoing and recently completed projects at the different stages of a project's lifecycle.

The first step in adapting to climate change is to better understand what hazards infrastructure is exposed to, and how vulnerable infrastructure is to those hazards. A number of vulnerability assessment projects in the Central Coast that address these questions include:

The Santa Cruz County Climate Adaptation Vulnerability Assessment and Transportation Priorities Report was developed for unincorporated county-maintained roads and the entirety of the Santa Cruz Branch Rail Line. The objective of the assessment was to identify transportation

infrastructure assets in the county that may be vulnerable to climate hazards, and to develop a prioritization list to identify the order in which those assets should have detailed assessments for climate resilience actions and implementation. It was jointly developed by the Santa Cruz County's Regional Transportation Commission (RTC), Department of Community Development & Infrastructure, and Office of Response, Recovery & Resiliency.

A Plan for Climate Resilience by the Santa Cruz RTC, funded by Caltrans, is being developed to conduct a detailed assessment of rail infrastructure. The goal is to verify asset exposure to climate hazards and identify specific transportation vulnerabilities. Santa Cruz RTC noted that the Zero Emission Passenger Rail and Trail Corridor faces significant climate risks due to coastal erosion, flooding, and rising sea levels, especially at four vulnerable locations: Capitola bluffs, La Selva/ Manresa Beach bluffs, Harkins Slough Rail Crossing, and the Pajaro River Rail Bridge. These areas have already shown severe impacts from extreme weather events, including notable erosion rates and flooding. The Plan also aims to identify project concepts for short-, medium-, and long-term resilience while recommending strategies based on cost, feasibility, and benefits, with a focus on supporting transit-dependent and underserved populations.

The County of Santa Barbara's 2021 Climate Change Vulnerability Assessment pinpointed transportation infrastructure as one of its most vulnerable assets. They identified major inland routes that are susceptible to landslides, flooding, and wildfire, along with several important coastal routes that are close to the shore and subject to coastal hazards. These routes serve as bus routes, evacuation routes, and regional economic corridors with few or no alternatives. The communities served by this infrastructure are therefore highly vulnerable to climate risks. Following this effort, the county completed an Evacuation Traffic Modeling Study in 2024. Modeling efforts have shown significant heterogeneity of evacuation risk and vulnerability (Murray, 2025). The county's study developed 15 recommendations regarding transportation network and roadway infrastructure improvements that could improve evacuation efficacy and reduce community risk.

When identifying vulnerabilities at a regional level, coordination is key to developing a common approach. For example, the San Luis Obispo Council of Governments (with sponsorship by Caltrans) is creating a Morro Bay Estuary Climate Resiliency Plan to help local agencies and nonprofits tackle climate change by linking environmental concerns with transportation infrastructure. The plan aims to provide information for general plans focused on resilience along the coastline. The project will assess vulnerabilities and develop strategies to enhance flood resilience, water quality, and ecosystem protection, while positioning the region for potential funding opportunities. It may also improve bike and pedestrian facilities, addressing current mobility limitations, especially for those with disabilities. This plan represents a critical effort to improve and safeguard transportation routes and ecosystems against climate changes affecting Morro Bay and Los Osos, serving both present and future community needs.

4.3.2 Adaptations

Once a transportation network's exposure and vulnerabilities are identified, the next step is to identify potential adaptations to specific vulnerabilities. The Santa Cruz RTC is currently implementing the San Vincente-Waddell Resilience Project (described in **Appendix 4.3.2**).

A key emerging aspect of resiliency for transportation assets is restoring and protecting adjacent natural habitats. For example, The Transportation Agency for Monterey County's Highway 1 Elkhorn Slough Corridor Climate Resiliency Project aims to identify adaptation strategies for Highway 1 in order to improve safety, reduce tidal flooding risk and benefit the Elkhorn Slough and the Monterey Bay Marine Sanctuary. An earlier study (Cheng et al., 2020) identified the deep vulnerability of the Elkhorn Slough to climate change and led to the creation of adaptation strategies for this transportation corridor.

Many other efforts aim to build the resiliency of transportation infrastructure in the Central Coast; most are in planning stages. Implementation will require significant capital investment and coordination among stakeholders. This also represents a significant opportunity for the Central Coast to build the resiliency of the region and to create many co-benefits, such as the restoration and protection of natural habitat located in proximity to transportation assets. At the state level, several efforts are addressing the climate change impacts on transportation infrastructure, including assessing climate-related vulnerabilities and planning for more climate-resilient transportation infrastructure. See **Appendix 4.3.2** for detailed examples.

4.4 Emergency Preparedness

Synthesis Author: *Seth Gustafson*

Contributing Author: *Alyson Hunter*

4.4.1 Overview

In the Central Coast region, cities, counties, and other organizations are increasingly recognizing the need to adapt emergency preparedness plans to the growing threats posed by climate change and are making substantial changes to their emergency response strategies.

Most climate research on emergencies focuses on the increasing likelihood and intensity of emergencies (e.g., Huang & Swain 2022), whereas research on climate and emergency preparedness in California is limited. Schneider (2011) offers insights on climate change from an emergency management perspective. Dettinger et al. (2011) details a USGS project on quantifying multifaceted hazards to improve planning exercises to help emergency preparedness practitioners understand the intersecting and overlapping hazards in future climate change. Bedsworth (2008) offers a mixed qualitative and quantitative approach by surveying public health officials about planning for climate change, concluding that a lack of resources, funding, and coordination will limit agency emergency responses across the state under climate change.

4.4.2 Integrating Climate Change Projections into Emergency Planning

HAZARD MITIGATION PLANS

Many cities and counties in California are incorporating climate change projections into their hazard mitigation and emergency response plans. The California Office of Emergency Services (CalOES) has encouraged local governments to assess the potential impacts of future climate change scenarios and use the results to shape long-term planning, resource allocation, and

community engagement strategies. An example is emergency planning in the City of Marina, a small Central Coast city (about 22,800 residents) proactively integrating climate projections into their planning and other community activities. In the current update of their Land Use Plan, they embrace a form of managed retreat to SLR using particular climate change thresholds as triggers to preemptively respond instead of reactively waiting for damage to occur (EMC Planning Group & Integral Consulting, 2026).

ENHANCED WILDFIRE PREPAREDNESS

With increasing frequency and intensity of wildfires, California localities are developing new fire response strategies. Large and well-resourced cities like Los Angeles, Sacramento, and San Francisco are investing in better early warning systems, such as wildfire alerts, and improving evacuation routes and shelter plans. Several counties have implemented Community Wildfire Protection Plans (CWPPs) to reduce the risk of wildfires through controlled burns, defensible space efforts, and improved firefighting capabilities. To enhance their CWPPs and to pool relatively limited resources, some smaller jurisdictions are using fire modeling tools to identify areas most vulnerable to wildfires and adjust evacuation plans and shelters accordingly. The adjacent small cities of Carmel, Pacific Grove, and Monterey have a 2024 joint community CWPP that covers about 50,000 residents and addresses shared cross-jurisdictional wildfire threats.

HEAT ACTION PLANS

Jurisdictions across the state are developing heat action plans that include establishing cooling centers for vulnerable populations, such as the elderly, homeless, and those with underlying health conditions (see *Section 5.1 Public Health*). Heat action planning across the Central Coast is complicated because temperatures can vary dramatically based on coastal proximity and elevation. Thus, summer daily high temperatures in the Salinas Valley can easily reach over 100°F (37.7°C) for extended periods, while temperatures on the same day on the Monterey coast might remain in the temperate 60°F (15.5°C) range. All Central Coast counties have standard cooling centers and resources as a part of their heat action planning, though the planning and use of these centers is likely to increase. Monterey County developed a Heat Illness Prevention Program applicable to all county areas of the county focusing on individual prevention of heat illness.

FLOODING EMERGENCY PLANNING

Emergency planning for flood events mostly promote general community preparedness, including outreach efforts to improve alerts; broad participation of regional jurisdictions in the National Flood Insurance Program; and encouraging household readiness if flooding does occur. Planning efforts along the Pajaro, Salinas, and Carmel Rivers are broadly representative of the region's flood planning strategies. All three rivers have extensive and well-documented flooding histories where floods destroyed significant infrastructure and agriculture. Though the rivers are close in proximity, emergency preparedness in these watersheds included different strategies and approaches. Emergency preparedness for flooding in the Salinas River primarily focuses on multi-stakeholder vegetation and sediment management, though this process is fraught with

weighing varying priorities of local agricultural interests, water managers, and environmental regulators. In Pajaro, emergency planning of levees is nearing completion after decades of delays and disastrous floods impacting the predominantly low-income and minority Pajaro community. In the Carmel River, a floodplain restoration project with Monterey County and the Big Sur Land Trust, a centerpiece of emergency planning, is using environmental engineering and nature-based solutions to create a more resilient riverine landscape.

COMMUNITY COLLABORATION, ENGAGEMENT, AND EQUITY

Regional emergency preparedness plans in the Central Coast region include equity in response and recovery. Local governments are prioritizing outreach and assistance to marginalized communities, and many plans now specifically address the needs of low-income populations, communities of color, and non-English-speaking residents. Projects such as community resilience hubs offer community-based preparedness and resilience-building efforts to ensure that all communities, particularly those most at risk, are informed, prepared, and equipped for climate-related emergencies.

At the county level, Santa Clara and San Benito counties are drawing on similar physical geography and environmental conditions to offer more integrated and comprehensive climate plans including a Priority Climate Action Plan and a Comprehensive Climate Action Plan. San Luis Obispo County has launched a range of community-focused preparedness initiatives like the Community Emergency Response Team (CERT) and a series of preparedness, recovery, and current information resources aimed at improving emergency planning and recovery for individuals, families, institutions, and businesses in the county.

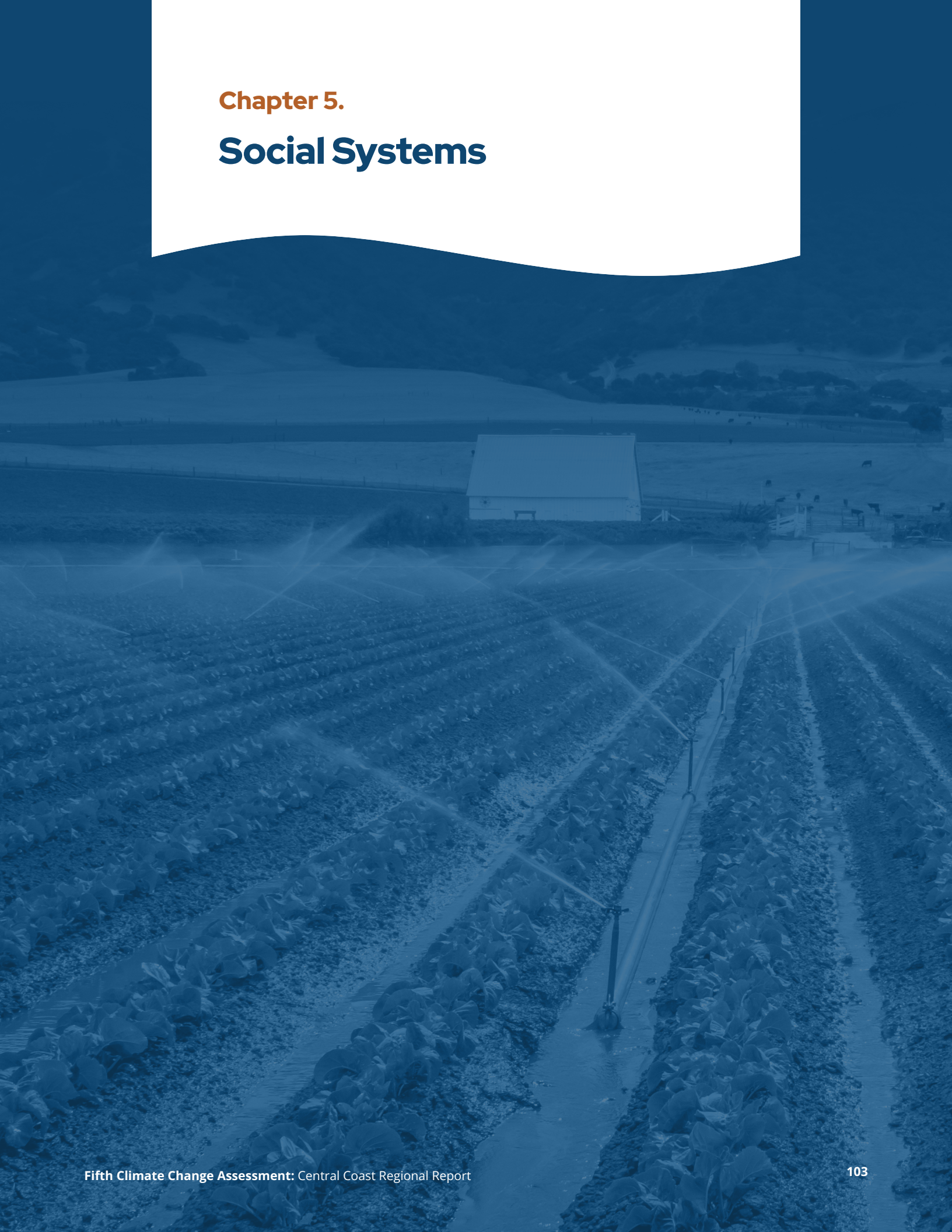
REGIONAL PLANNING WITH TECHNOLOGY

Central Coast cities and counties are also using advanced technologies to improve emergency preparedness, including data-sharing platforms to better communicate risk information, evacuation routes, and shelter locations in real time during climate-related emergencies. Drones, satellite imagery, and predictive models are being used to assess and monitor environmental conditions, enabling faster and more effective decision-making.

At the federal level, a collaboration between NOAA and National Wildlife Service (NWS) climatology and meteorology services with the California King Tides Project has extended the capacities of NWS to help visualize future sea level by observing current highest tides.

Chapter 5.

Social Systems



Key Messages

Public Health

- Direct impacts of climate change on public health include injuries, illnesses, and deaths related to extreme heat; disaster events resulting in air pollution, changes in water quality; and increasing prevalence of certain diseases.
- The combined effects of heat and pesticides in agricultural areas present a greater effect than each alone, exposing agricultural workers who apply the products, those who tend to the crops, and local communities. Alternatives to pesticides include biological, cultural, physical, and natural chemical methods (Integrated Pest Management).
- Infectious diseases from aerosolized pathogens, including valley fever, leptospirosis among berry pickers, legionella bacteria and other enterobacteria.
- Exposure to high concentrations of wildfire smoke cause eye and throat irritation, coughing, shortness of breath, and the worsening of existing heart and lung conditions like asthma and possible reductions in lung function, and pulmonary inflammation.

Economy and Insurance

- Economic losses associated with weather-related extremes have risen with events such as the 2022–2023 winter storms costing an estimated $4.7 billion in losses, much of it along the Central Coast.
- Insurance can be one source of funds to close a financial protection gap—the difference between the total financial resources of households, businesses, or communities and the costs of disaster recovery. Without affordable insurance, many in the region will be financially exposed, with low-income households being disproportionately affected.
- A Protection Gap Entity that brings together different insurance, government, and intergovernmental agencies can orchestrate a multi-faceted approach to financial resilience.
- Costs associated with preparation for and administration of disaster responses need to be compared with the cost of not investing in these projects. This gap manifests in actual higher post-disaster impacts that are frequently not accounted for, as studies primarily focus on the market values of properties to measure adaptation benefits.

Climate Justice:

- Multiple Central Coast organizations with climate justice as a focus are addressing impacts from climate hazards. The most common approaches are post mitigation responses, public outreach and education, community organizing, coalition building, and community organizing. Additional strategies are resources and service provision, planning, data collection, research, education, and workforce development.

5.1 Public Health

Synthesis Author: *Dharshani L. Pearson*

Climate change has a wide variety of human health effects. Some of the most direct impacts include injuries, illnesses, and deaths related to extreme heat; disaster events (such as floods and wildfires); air pollution; changes in water quality; impacts on food and water supplies; and increasing prevalence of certain diseases (LAO, 2022). Some communities are disproportionately susceptible to many of these climate-induced events, and certain individuals face greater vulnerability due to their underlying health status, age, means, type of work, or other characteristics. Targeted strategies can enable adaptation to climate impacts on public health, for example by emphasizing limiting outdoor activity during poor air quality days and using integrated pest management to reduce farmworker exposure to harmful chemicals.

5.1.1 Extreme Heat

Heat-related mortality is projected to be among the most deadly and costly impacts of climate change (Carleton et al., 2022; LAO, 2022). In the Central Coast, average temperatures and the intensity and length of heat waves are projected to increase significantly throughout the century (see *Section 2.2.1 Extreme Precipitation and Temperature*). Agricultural field workers will continue to feel the brunt of direct outdoor heat exposure (López-Carr et al., 2022). Indoor heat also impacts health, particularly for warehouse workers at distribution centers (Cambridge Systematics, Inc., 2024).

The Central Coast is gaining traction as a distribution hub for major online companies (Scully, 2025; Shutt, 2018). As such, the new 2024 California Code of Regulations (Title 8, section 3396) requiring employers to put safety measures in place for indoor work areas that exceed 82°F (27.8°C) can protect workers. However, in coastal areas where average outdoor temperatures are lower, people may be less acclimated to heat and have lower heat thresholds. Many Central Coast homes lack air conditioning systems because of the historically mild climate and because of rising costs, and homeowners may lack funds to upgrade. Even if air conditioning systems are in place, use during summer can present affordability challenges (Thornton, 2024). Older residents and those on fixed incomes or who have pre-existing conditions generally have lower heat thresholds that leave them more vulnerable to health crises when no air conditioning is available during heat waves (Wolf et al., 2023).

5.1.2 Pesticide Volatilization in Agricultural Communities

The combined effects of heat and pesticides in Central Coast agricultural areas present a greater effect than each alone. Chemical pesticides have temperature thresholds above which their potency diminishes (Delnat et al., 2021). To make up for this loss, pesticide sprayers often apply larger volumes to crops, leading to more exposure to harmful chemicals (Ferguson et al., 2019). Additionally, as outdoor temperatures increase, invasive pests that tend to be most hardy against extreme heat display more resistance to less potent pesticides, thus requiring stronger chemicals for elimination (Tirado et al., 2010; Ma et al., 2021). Excess application also causes chemical volatilization, which allows chemical transport over long distances, and depending on wind and other factors, settling in waterbodies (Op de Beeck et al., 2017). This greater volume or potency

of pesticide application exposes agricultural workers who apply the products as well as those who tend to the crops. Furthermore, local communities also face greater exposure than before (Delcour et al., 2015; Houbraken et al., 2016). Applying pesticides during early mornings when temperatures are cooler can reduce the amount needed to limit pests. Additionally, farmers can utilize other strategies to eliminate resistant pests, including biological, cultural, physical, and natural chemical methods, often used in an Integrated Pest Management (IPM) approach.

5.1.3 Infectious Diseases from Aerosolized Pathogens

VALLEY FEVER

The Fourth Assessment identified coccidioidomycosis, or Valley fever, as a health threat to Central Coast residents because of growing environmental hospitability to the disease-conveying fungus (Langridge et al., 2018). People develop Valley fever by breathing in fungal spores found in endemic areas of California. Since 2018, the number of studies focusing on the spread of Valley fever in California, including to the Central Coast, has increased manyfold (Gorris et al., 2019; Pearson et al., 2019; Sondermeyer Cooksey & Pearson, 2022). Symptoms of coccidioidomycosis infections range from mild flu-like symptoms to severe pneumonia, lesions throughout the body affecting multiple organs, and death, and take a severe financial, physical, and emotional toll on some California communities (Pearson et al., 2019; Bajwa & Rongkavilit, 2020); a severe case can cost over a million dollars (Wilson et al., 2019). See **Appendix 5.1** for details on coccidioidomycosis infections in Central Coast counties.

LEPTOSPIROSIS AMONG BERRY PICKERS IN VENTURA COUNTY

Leptospirosis is caused by bacteria and is transmitted through contact with urine of sick animals, including rodents and livestock, with symptoms ranging from mild flu-like symptoms (fever, muscle aches, and headache) to severe illness leading to liver, kidney, and multiple organ failure (Bradley & Lockaby, 2023). Since Leptospirosis thrives in hot and wet environments, cases may rise because of increasing temperatures (Levett, 2001; Bradley & Lockaby, 2023).

Although generally cooler than other areas where leptospirosis thrives, the Central Coast region, with its large agricultural sector, may become more hospitable for the pathogen as climate changes. Specifically, agricultural water, coupled with wetter coastal air along with generally warming temperatures, could favor the leptospirosis bacteria's survival. Furthermore, growing crops inside greenhouses, which induces more humidity, can provide a prime environment for the pathogen to reproduce. Most recently, in Ventura County in 2024, 19 farmworkers developed leptospirosis in the late summer and early fall when both higher temperatures and precipitation occurred. Many of the workers in this outbreak harvested cane berry crops grown in greenhouse structures (Haggerty, 2024).

LEGIONELLA BACTERIA AND OTHER ENTEROBACTERIA

Respiration of the *legionella* bacteria is known to cause Legionnaires' disease, which can lead to severe pneumonia, usually among those who have pre-existing conditions, are older, or smoke (Simmering et al., 2017). This will lead to death if not treated. Pontiac fever is a milder version

of infection with symptoms such as chills and other flu-like symptoms that self-resolve. Higher outdoor temperature can promote bacteria growth, so warming temperatures may exacerbate legionella exposure (Simmering et al., 2017).

Although the risk is small, *legionella* bacteria can also proliferate in contaminated agricultural water systems. High outdoor temperatures can aerosolize the pathogen, leaving both agricultural workers and nearby community members susceptible to infection, especially in windy conditions. Warmer temperatures can also induce more *legionella* bacterial growth in water (Mori & Smith, 2023). Central Coast farmers, particularly in Monterey County, have utilized recycled water for crops since 1998 when the Monterey Regional Water Pollution Control Agency started using tertiary-treated recycled water for irrigation (Olivieri et al., 2020). Although no outbreaks have occurred in the Central Coast region, there is potential for *legionella* contamination via agricultural sprinkler systems (Mori & Smith, 2023). Health officials often identify outbreaks when people develop *legionella* pneumonia, the most serious diagnosis related to infection. However, less serious Pontiac fever cases often go undiagnosed, potentially underestimating true disease impact on agricultural communities (Cramp et al., 2010). People may also develop severe fungal-mediated pneumonia due to coccidioidomycosis, and medical practitioners in the area may miss *legionella*-originating pneumonia, which may present with fewer symptoms.

In addition to *legionella*, other pathogens can enter human respiratory systems through aerosol inhalation from contaminated reclaimed water, including *Acinetobacter* spp. and *Aeromonas* spp., among other species (Harte, 2024). Officials could reduce risk by reevaluating and reducing the permissible number of bacteria allowed in reclaimed water, considering that warming temperature could accelerate bacterial growth.

5.1.4 Wildfire Smoke

Wildfire smoke (see *Section 2.2.6 Air Quality*) contains fine particles and chemicals that cause eye and throat irritation, coughing, and shortness of breath, and worsen existing heart and lung conditions like asthma (Liu et al., 2021). Exposures to high concentrations of PM2.5 can cause persistent coughing, phlegm, wheezing, and difficulty breathing. Exposure to high concentrations of wildfire-related PM2.5 and ozone (wildfire or non-wildfire related) has been correlated with spikes in hospital admissions for asthma, chronic obstructive pulmonary disease, and cardiovascular events, can amplify respiratory health threats from Valley fever (Porter, 2025) and contributes to increased birth complications among pregnant individuals (Jordan, 2025). Short-term exposures (i.e., days to weeks) exacerbate pre-existing respiratory and cardiovascular disease and premature mortality (EPA, 2025b). The effects of persistent short-term exposures are limited to a few epidemiologic studies examining the cumulative effect of wildfire smoke exposure on the health of wildland firefighters. Initial evidence indicates that continuous (i.e., multiple days) occupational wildland fire smoke exposure may have a cumulative effect on lung function. Some studies show a progressive decline during burn seasons (Adetona et al., 2016; EPA, 2025b).

On the Central Coast, wildfires from as far away as Oregon have degraded air quality throughout Monterey, San Benito, and Santa Cruz Counties, causing the concentration of smoke to reach high levels of the Air Quality Index (MBARD, 2025). In July 2025, smoke from the Madre Fire in San Luis Obispo impacted the air quality for communities on the Central Coast, with the Cuyama Valley and

Carrizo Plains areas seeing the biggest impact (Worsham, 2025). Smoke can have disproportionate effects on distinct populations due to physiological and behavioral factors (Holm, 2021). Residents can adapt to wildfire smoke by monitoring air quality, creating clean air spaces indoors, and reducing outdoor activity during smoky conditions (see Smoke Ready California).

5.1.5 Harmful Algal Blooms

Harmful algal blooms (HABs) continue to pose a threat to both human and marine wildlife, particularly sea lions and dolphins. Blooms from the diatom *Pseudo-nitzschia*, often found off California's Central Coast, produce the neurotoxin *domoic acid*, which can accumulate in shellfish, causing Amnesic Shellfish Poisoning (ASP) and other harmful neurologic conditions when consumed by humans. Blooms are especially harmful during spring and summer when waters are warmer (OEHHA, 2023; NOAA, 2024f). Currently, the State of California monitors nine sites for abundance of *Pseudo-nitzschia*, including the Central Coast's Santa Cruz Wharf as well as Santa Barbara County's Stearns Wharf, which generally registers the highest levels of domoic acid in the state (OEHHA, 2023). See the Indicators of Climate Change in California report for more information about HABs.

5.1.6 Cascading Effects: Rural Hospital Closures, Heat, and Pregnancy

Rural farming communities in the Central Coast already have more restricted access to care, particularly in emergencies, than more urban communities. Like the rest of the country, the region suffers from hospital consolidation and closures, such as the struggling Hazel Hawkins Memorial Hospital, the only acute-care hospital still operating in San Benito County (McConville et al., 2025; Hamann, 2025). Because the area already lacks adequate care centers, hospital closures and consolidation increase vulnerability for some residents. With extreme heat expected to increase in both total and consecutive days, more people will likely seek care for heat-related events at emergency rooms already under severe strain. Extreme heat can lead to preterm delivery and other birth complications (Darrow et al., 2024), and pregnant people can suffer complications from climate change-related Valley fever, which is endemic in the Central Coast (Sondermeyer Cooksey & Pearson, 2022; Spinello et al., 2007).

Increases in pregnancy-related emergency care visits due to heat will severely burden already stressed emergency room availability in the summer. Free-standing, certified birth centers with trained practitioners could lessen the burden on emergency room visits during the warm season (Cohen, 2025). At the same time, officials should still anticipate higher future heat-related emergency room visits in years to come and plan for other options, especially in rural areas bordering the Central Valley.

5.2 Finance and Insurance

Synthesis Author: *Kathleen Shafer*

5.2.1 Introduction

In California, the frequency and severity of extreme events continue to grow, increasing associated economic losses. Winter storms in 2022–2023 cost an estimated $4.7 billion in losses, much of it along the Central Coast. The Pajaro River levee collapse put an estimated 5,895 residential structures at risk, with reconstruction value estimated at $2.88 billion (Wells, 2023). Along with extreme events, the potential decarbonization of the economy and litigation based on climate-related damages threaten the insurance business model (Trial by Fire, 2018). As the industry faces these challenges, insurance products are becoming more necessary but less available and affordable. Research by the insurance industry also finds that socioeconomic factors, such as aging infrastructure and increased building replacement costs, are making households less resilient to natural disasters and other economic shocks (Banergee et al., 2024) (see also the Fifth Assessment's "Adaptation Finance" report led by the California Department of Insurance).

5.2.2 Financial and Insurance Protection

While disaster mitigation and prevention are key components of disaster management, an additional emphasis on post-disaster recovery and the resources needed to rebuild and restore communities after a disaster is often lacking. This deepens the financial protection gap (**Figure 34**)—the difference between the total financial resources of households, businesses, or communities and the costs of disaster recovery (Jarzabkowski et al., 2023).

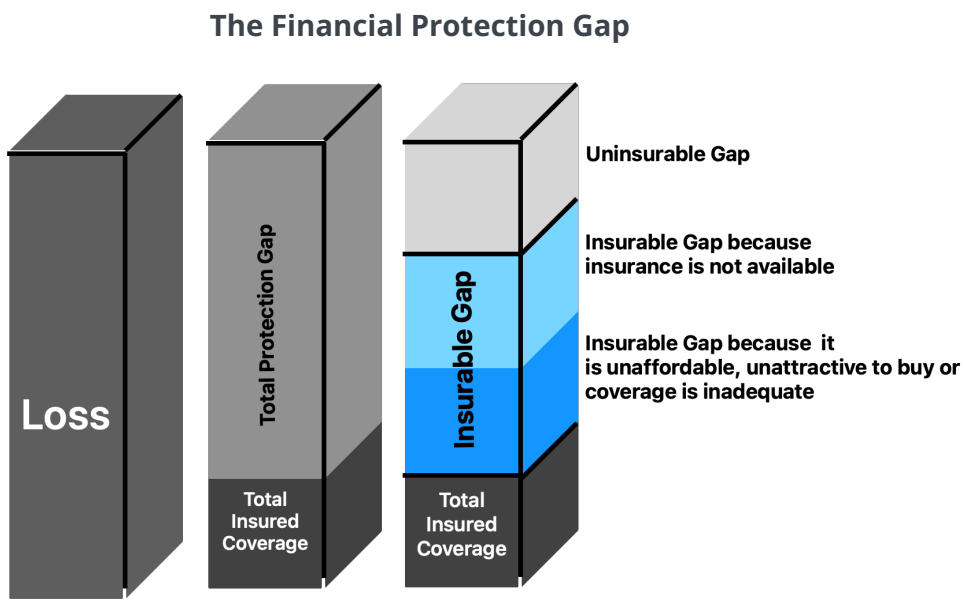


Figure 34: *The protection gap consists of an insurable gap and an uninsurable gap.*

The gap highlights issues affecting recovery, including lack of emergency savings, the economic effects of temporary unemployment, and extra costs that may not be covered by insurance, such as housing, healthcare, and relocation expenses. It emphasizes the interconnectedness of multiple financial vulnerabilities (Jarzabkowski et al., 2023). When communities lack adequate disaster recovery resources, the economic consequences are prolonged and amplified. This creates a cycle where communities are unable to recover from one disaster before facing another, further widening the existing financial protection gap and hindering long-term resilience (You, 2024). The resulting financial burden disproportionately impacts vulnerable populations, limiting their ability to rebuild homes, businesses, and livelihoods (Kousky & French, 2022), and the need to develop cohesive strategies to enhance resilience against disasters and ensure effective community recovery.

Insurance can close the financial protection gap but is becoming more expensive while potential costs from climate-related events are often greater than the insurance coverage available to mitigate losses. After the 2017 Thomas Fire in Santa Barbara and Ventura Counties, insurance often did not cover all losses, especially for the subsequent damage from mudslides and debris flows. Slow rebuilding times, contractor fraud, and lawsuits against the utility for damages not covered by insurance added to post-disaster financial challenges (Trial by Fire, 2018).

5.2.3 Community Impacts

Low-income households face unique post-disaster financial challenges, including increased financial strain, reliance on external aid, and worsening social inequalities (Rhodes & Besbris, 2022). Mothers, often the primary family caretakers, face the added stress and burdens of managing the family's recovery (Kimbro, 2021). Elderly and disabled individuals face increased healthcare costs (Lowe et al., 2013). Undocumented households face an additional layer of vulnerability, as the threat of deportation prevents them from accessing essential aid programs, forces them to depend on limited community support (Méndez et al., 2020), influences evacuation decisions, and limits applying for assistance.

Although these gaps disproportionately affect low-income households, high-wealth individuals and local governments may also encounter considerable financial losses. The broader community suffers from prolonged economic stagnation, diminished viability for local businesses, and increased strain on public services. The repeated impact of disasters on communities can lead to "disaster recovery gentrification" (Lambrou et al., 2025), where areas may be redeveloped in ways that price out original residents. Well-intentioned recovery resources can also include barriers to low-income households. Unequal distribution of risk and recovery capacity widens existing socioeconomic gaps and undermines regional resilience.

The Central Coast region is particularly vulnerable to financial protection gaps. Low-income households, communities of color, and immigrant populations often live in areas susceptible to natural hazards due to historical discrimination and limited housing options (Holzheu & Turner, 2018). These communities typically have fewer financial resources to invest in protective measures, such as home hardening against wildfires or elevating structures in flood-prone areas. When disasters strike, they are less likely to have adequate insurance coverage or savings, forcing them to rely on limited government assistance or go into debt (Collier & Kousky, 2024). Vulnerable groups may encounter additional barriers in accessing recovery resources, including language obstacles, lack of documentation, or limited technological literacy to navigate complex aid

applications. Extreme climate events can also lead to displacement, job losses, and health issues, entrenching cycles of poverty (Cutter et al., 2009; Lowe et al., 2013).

As natural disasters grow more frequent and severe, many property owners and businesses are likely to be underinsured or lack adequate coverage, leading to substantial uncompensated losses (Holzheu & Turner, 2018). In Santa Cruz County, county agencies' lack of an effective disaster response plan before the CZU Fire led many fire victims to incur unnecessary expenses during the rebuilding process (Santa Cruz County Grand Jury, 2024). Notably, 3.5 years after the CZU Lightning Complex Fire, less than a third of all homes had been rebuilt. Tecovery obstacles continued to plague fire victims, the majority of whom were either underinsured or uninsured, while final insurance payouts were at times insufficient to cover the cost to rebuild.

The financial protection gap created by increasing flood and wildfire events can create a cascading effect on the Central Coast economy. Property damage and business interruptions can lead to decreased property values and reduced economic activity, which in turn diminishes the tax base for local governments. With lower tax revenues, municipalities often struggle to maintain and improve essential public services, including emergency response capabilities. Furthermore, the persistent threat of disasters can deter new investments and drive existing businesses to relocate, further eroding the economic fabric of Central Coast communities. Small businesses are particularly vulnerable to these disruptions and may face permanent closure following significant losses. Economic instability and diminished resources impede a community's ability to invest in necessary adaptation efforts.

5.2.4 Adaptations

Insurance in the Central Coast region is undergoing major shifts due to climate-driven wildfire and flood risks, with insurers raising premiums and restricting coverage, leaving many homeowners looking for alternatives. At the end of 2024, the California Department of Insurance passed regulations to increase access to insurance and allow insurance companies to use predictive climate modeling that may lead to higher premiums initially but greater long-term stability. The state's Sustainable Insurance Strategy is designed to stabilize the market by balancing rising premiums with increased coverage availability in high-risk zones (Trial by Fire 2018).

Protection Gap Entities help keep disaster risk insurable. Insurance is effective only when flood risks and losses fall within a manageable range of frequency and severity, and if there is adequate demand to spread losses (Kousky, 2022). Risk-layering combines different risk-financing tools (WFP, 2023) where small, frequent losses are managed with reserves to keep risk insurance affordable. More frequent and severe losses are managed with a contingent credit approach. Finally, losses that are infrequent but severe are managed with insurance. Reserving insurance for only those losses that exceed the immediate financial resources keeps insurance affordable. Other strategies like risk reduction, risk retention, or calculated risk-taking are also important. Providing access to innovative financial services that promote risk reduction and adaptation (Jarzabkowski et al., 2023; Schanz, 2018; WFP, 2023) encourages prudent risk-taking by assisting households and communities access credit and other forms of capital to finance adaptation, risk reduction, and risk transfer (see **Appendix A5.2.4**).

Developing a Protection Gap Entity can bring together different insurance, government, and intergovernmental stakeholders for a multi-faceted approach to financial resilience tailored to the region. Examples include the California Earthquake Authority, originally established to provide earthquake insurance and expanded in 2020 to administer the California Wildfire Fund. The Delta Region Geologic Hazard Abatement District was established to provide community flood insurance to the Sacramento–San Joaquin Delta. Protection Gap Entities can also catalyze innovative insurance and financial solutions to address climate-related risks: parametric insurance offers expedited payouts based on predefined environmental triggers; public-private partnerships can facilitate the development of novel financial instruments such as resilience bonds; and community-based insurance pools can more equitably distribute risk and enhance coverage accessibility for vulnerable populations.

In the Central Coast region, actions can involve a greater emphasis on disaster recovery planning beyond just insurance, such as establishing disaster recovery funds, implementing tax incentives for property owners who invest in resilience measures, as well as microfinance initiatives and low-interest loan programs that provide critical support for small businesses and low-income households who undertake protective retrofits. Updating land-use policies and building codes can discourage development in high-risk areas and promote resilient construction practices.

Under climate change, collaborative and innovative approaches, possibly centered around the establishment of dedicated Protection Gap Entities, have the potential to foster novel financial arrangements, promote risk reduction strategies, and ensure equitable access to resources. Other approaches include continuing to improve relevance of climate modeling to the insurance industry and the accuracy of insurance models, and continuing to track and mitigate insurance availability, adequacy, and affordability issues as equity issues for segments of the market including low-income consumers (Trial by Fire, 2018).

5.3 Economics of Climate Adaptation

Synthesis Author: *Galina Hale*

5.3.1 Introduction

Key impacts of climate change, such as natural disasters like floods and wildfires, are threatening people, property, and nature in California. Investment in climate adaptation with careful cost and benefit analysis is key. Multiple stakeholders should be included in designing and funding adaptation projects to ensure social justice, minimal unintended consequences, and fair distribution of costs. Investments in natural infrastructure, such as wetland restoration and green stormwater systems, can mitigate flood risk while providing substantial ecological advantages. Quantifying the value of these nature-based solutions enables stakeholders, such as insurance providers, to justify financial support for such critical investments.

5.3.2 Quantification Approaches

Quantifying the potential damage reduction value of adaptation projects is not straightforward. Traditional approaches that add up physical structure damages in various scenarios and return

periods likely underestimate both damages and the impact of adaptation projects on reducing the damages. For example, when residential properties are affected by a disaster, the costs include not only structure repairs, but also temporary relocation, rental expenses for home occupants, lost rental income for homeowners, and possibly lost work income. In flood-prone areas of Half Moon Bay, Santa Cruz, and Ventura, these additional costs increase the benefits of adaptation by 20–40% compared to structural damage-only calculations (Reguero et al., 2026). For damaged commercial properties, the indirect costs include lost business income, potentially lost jobs, and possible effects up and down the supply chains. These additional costs can make adaptation benefits 3–5 times higher than if only physical damages were considered (Reguero et al., 2026). Such calculations also allow for the quantification of individual stakeholders' benefits from the adaptation project to facilitate public-private partnerships. In addition to reducing expected damages from disasters, adaptation projects reduce uncertainty about potential losses. Financial institutions factor uncertainties into their decision-making, as do individuals. Evaluating uncertainty reduction is therefore crucial to encouraging private sector participation in adaptation funding.

5.3.3 Adaptation Costs

Due to the increasing frequency and severity of climate-related disasters, such as flooding and wildfires, large sums of public and private funds are spent on rebuilding in their aftermath. In the process of restoring their real estate, financially vulnerable households and small businesses might not have the ability to rebuild in a way that is consistent with climate mitigation and adaptation needs. State and local governments can assist in the provision of adaptation and mitigation investments and incentives to reduce these vulnerabilities. These policies need to be designed in a way that leads to closing, not widening, of the climate justice gap. Statistical analysis by Hale et al. (2025) uncovered positive spillover effects of county-level climate policies on household adaptation activities, but only for middle-income households. High-income households are not generally sensitive to incentives, while low-income households are not able to take advantage of them, as they frequently take the form of tax rebates. Many adaptation projects involve local public goods; therefore, if high-income households can be incentivized to participate in funding such projects, this would reserve precious public funds for adaptation projects in lower-income neighborhoods.

Interviews with community organizations in areas affected by floods and wildfires in recent years reveal that disaster response measures in frontline communities need to prioritize emergency communications and evacuation plans, permanent storage of emergency supplies (such as sandbags in flood-prone areas), inclusive access to financial aid (especially for immigrants and the elderly), and more rapid deployment of rescue funds—potentially with the help of local community organizations and plans for extended financial, physical, and mental health support for families affected by housing or job loss. The costs associated with adaptation projects and preparation and administration of disaster response need to be compared with the costs of not investing in these projects, which manifests in higher post-disaster impacts. Post-disaster impacts tend to be higher in lower-income communities and are therefore inversely related to the market value of properties at risk, though many published studies focus on market values of properties to measure adaptation benefits (e.g., Kelly & Molina, 2023).

5.4 Climate Justice

Synthesis Authors: *Sidney Madsen and Eloy Ortiz*

5.4.1 Introduction

In California, environmental justice is embodied in Cal. Gov. Code, § 65040.12. where it is defined as "the fair treatment and meaningful involvement of people of all races, cultures, incomes, and national origins, with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies." In keeping with that goal, climate justice is the concept that no community or group of people should bear a disproportionate burden of climate change impacts or the costs of climate mitigation and adaptation. Climate justice underlines that for historically marginalized and vulnerable populations, climate change can exacerbate already existing issues including environmental hazards, socio-economic challenges, and public health challenges.

Multiple definitions of vulnerable communities are used in California. California defines Disadvantaged Communities (DACs) based on a combination of socio-economic factors and pollution burdens (SB535, 2012). In the Central Coast, there are 20 census tracts with vulnerable populations designated as DACs (Cal EPA) due to high pollution burdens, including pesticides (11 at or above 97th percentile), waterbodies or groundwater threats (10 at or above 95th percentile), lead exposure (4 at or above 95th percentile), and proximity to toxic or hazardous waste sites (2 at or above 90th percentile). These tracts also rank high in terms of socio-economic barriers including high linguistic isolation, limited education, and poverty (OEHHA, 2022). The total population of these tracts is 105,100, with 57,800 in Ventura, 18,500 in Monterey, 15,400 in Santa Cruz, and 13,300 in Santa Barbara. Santa Barbara is the only county with a DAC meeting the criteria of land controlled by a federally recognized Tribe—the Santa Ynez Band of Chumash Indians. The majority of DACs within all four counties are located in heavily agricultural areas, such as the Pajaro Valley (Santa Cruz), Salinas Valley (Monterey), Oxnard area (Ventura), and Guadalupe (Santa Barbara). Populations are predominantly Hispanic, and many rely on agricultural work for their living, an occupation that exposes them to the health and economic impacts and risks of climate change (El Khayat et al., 2022; Census Bureau Data, 2020). No census tracts within San Benito and San Luis Obispo were designated as DACs.

5.4.2 Overview of Climate Justice Organizations

A review of projects and initiatives to address climate justice in the region identified 33 relevant organizations or initiatives. For most, climate justice was an important aspect of their work: four stated that it was their central mission (e.g., "climate justice" was in the organization's name) and 17 indicated that climate justice was a major component of their work. Climate justice was a minor aspect of the work of 12 organizations or projects, most of whose work was dedicated to other types of climate action or social justice. Initiatives were defined as climate justice when they targeted the disproportionate impact of climate change on (1) those most vulnerable to climate change impacts (e.g., low-income, Latino, undocumented households) or (2) addressed those most impacted by climate change through strategies such as power sharing, representation of vulnerable or impacted populations within decision-making and advocacy work, or targeted resources and service provision and programs.

Projects and initiatives varied in the type of climate problem or solution they sought to address. The most common issues were (1) community resilience and disaster response and recovery and (2) community health. Other issues, often offered as co-benefits of GHG emission reduction were: hazard mitigation, public transportation and mobility, housing improvements, community gardens and green space, and workforce development. The most common strategies for action were public outreach and education, community organizing, and coalition building/stakeholder collaboration. Less common strategies that were still practiced by at least one-quarter of initiatives were: resources and service provision, planning, and data collection/research.

5.4.3 Summary of Organizations, Initiatives, and Programs

Some of the organizations, initiatives, and programs with adaptation strategies are highlighted below with summaries paraphrased by the organizations or quoted directly from submissions to the Central Coast Regional Report website. Complete summaries can be found in **Appendix 5.4.3**.

Hazard Mitigation was the focus of 11 initiatives/programs that addressed reducing exposure to environmental hazards linked to direct and indirect climate change impacts, such as air pollution from industrial facilities and wildfire smoke, drinking water pollution, pesticides, and heat waves. It was a primary concern in farmworker and low-income communities.

Community Action Board of Santa Cruz County (CAB) projects include creating and disseminating training resources to prepare for and respond to floods, including sandbag structures, evacuation assistance, and distribution of food, blankets, and other basics to displaced families. In Pajaro, CAB helped residents access critical resources for recovery, such as direct state economic assistance, rental assistance, and food aid. CAB is also leading the Pajaro Long-Term Recovery Alliance, composed of over 20 CBOs, organizing monthly meetings with county, state, and federal agencies, business owners, and CBOs to facilitate a coordinated and inclusive recovery. It co-hosts weekly meetings with Casa de la Cultura to build community connectedness and leadership capacity. Successes include directing $10 million of state economic relief to Pajaro residents and informing improvements in the Army Corp of Engineers' emergency communication protocol. CAB also contributes to several research initiatives to document the impacts of climate change to inform programming for disaster preparedness.

The City of Watsonville is implementing its Climate Action and Adaptation Plan and Local Hazard Mitigation Plan. Prioritized projects include Struve Slough ecological restoration, transportation electrification, city building decarbonization, micromobility and bikeshare, green infrastructure, and climate justice initiatives. Many projects are in partnership with local community-based organizations, such as the multi-jurisdictional Regional Climate Project Working Group which encompasses the tri-county Monterey Bay area. Community outreach efforts focus on initiatives like Extreme Heat and Save Our Water. The city also distributes educational flyers on heat safety and assists residents in developing extreme heat plans and locating cooling stations, particularly low-income and marginalized groups who are most vulnerable.

The City of Santa Cruz addresses coastal climate hazards and riverine flooding with nature-based projects, prioritizing the needs of Tribal groups and frontline neighborhoods. They use multilingual outreach and other strategies to ensure participation.

Resilience, Disaster Response, and Recovery was supported by nearly half of the initiatives and projects in DACs, highlighted below. This work involved providing resources such as disaster aid, safety protection, and language access to emergency information.

Mujeres en Acción, a Monterey County NGO is supporting Spanish-speaking and Mixteco communities affected by flooding in Pajaro and Prunedale, providing essential resources like mattresses, furniture, food, clothing, blankets and appliances, along with FEMA application assistance and delivering financial aid, food, clothes, and blankets.

Community Foundation Santa Cruz County supports Spanish-speaking and Mixteco communities affected by flooding in Pajaro and Prunedale. In collaboration with ALL-IN Monterey County, they provide preparedness workshops, essential home resources, FEMA application assistance, and financial assistance. Outreach includes phone calls, shelter visits to distribute flyers, and door-to-door canvassing, particularly targeting elders and hard-to-reach populations. They collaborate with schools, migrant programs, and churches to spread awareness. They also fund the work of community partners like Regeneration Pajaro Valley Climate Action, O'Neill Sea Odyssey, Save Our Shores, Coastal Watershed Council, and Elkhorn Slough Foundation.

Community Foundation of Monterey County's new initiative, the Monterey County COAD [Community Organizations Active in Disaster], is a consortium of NGOs that provide service to those imperiled, impaired, or impacted by disaster, and to eliminate unnecessary duplication of resources in disaster/emergency management by ensuring communication and collaboration across all sectors.

Undocufund, a Santa Barbara and Ventura County NGO, works to ensure more equitable disaster relief, with more than 80% of support going to farmworker and immigrant households—which experience disproportionate impacts from climate events and systemic exclusion from federal relief.

Coalition Building, Community Organizing and Capacity Building

The Monterey Bay Climate Adaptation Network, a project of the California Marine Sanctuary Foundation, provides "broad and inclusive participation of local and regional government agencies, researchers, non-government organizations, and other stakeholders, with meaningful engagement of disadvantaged communities and of Tribes."

Central Coast Climate Justice Network connects social justice and environmental organizations and leaders in Ventura and Santa Barbara Counties, focusing on a just transition away from fossil fuels and centered on communities bearing a significant burden of climate impacts.

Central Coast Climate Collaborative (4C) serves as an information hub and capacity builder, bringing together local governments, communities, nonprofits, businesses, academia, and Tribes to promote equitable access to climate solutions.

Climate First: Replacing Oil and Gas (CFROG) works with community members and local coalitions to promote clean energy generation, emission reductions, and systematic moves away from fossil fuel demand infrastructure. They train local community members across generations to be part of advocacy campaign design, implementation, and leadership.

The Central Coast Alliance for a Sustainable Economy (CAUSE) combines community organizing, leadership development, policy research, and advocacy to address the inequitable health impacts

of climate change. Universities and Tribal groups were also involved in documenting the impacts of climate change on vulnerable communities' health and housing and disseminating their findings to affected communities (e.g., UCSC, Northern Chumash Tribe).

Data Collection was a focus of some organizations to document health risks and effects.

Climate First: Replacing Oil and Gas deploys air quality monitoring devices in highly impacted communities to galvanize impacted communities to push collectively for local pollution reduction solutions with evidence from local air monitoring and their lived experiences.

Public Outreach and Education is a key strategy for many of the organizations and initiatives.

Community Environmental Council (Santa Barbara, San Luis Obispo) collected and analyzed local air quality data and created bilingual resources and opportunities for community discourse on air pollution, pesticide exposure, and health.

Regeneración - Pajaro Valley Climate Action, an NGO in Santa Cruz and Monterey counties, focuses on developing new environmental justice champions, providing a platform to amplify their voices and actions, and expanding leadership in underrepresented communities to inform local strategies. They build relationships and a shared sense of urgency in community leaders, grassroots groups, NGOs, researchers, and public agencies to collectively "take action to adapt to and halt the damaging effects of a changing climate." They share local stories in exhibits created by youth residents who were affected by the Pajaro flood. Other outreach efforts focus on individual behavior change that can improve community resilience to climate change, for example, by conserving water (Mujeres en Accion).

The Monterey Bay Area Climate Justice Collaborative is housed within Regeneracion and serves as a pivotal piece in envisioning and promoting climate justice in the region. The Collaborative brings together members from different sectors and regions of the Monterey Bay area to increase the region's competitiveness for grant funding by co-creating equitable climate projects and proposals and ensuring community representation on decision-making bodies.

Community Bridges/Puentes de la Comunidad focuses efforts in underserved and over-impacted communities facing climate change impacts using education, resource allocation and public information to enhance climate resiliency.

Workforce Development was an important approach, including the creation of training programs to prepare members of disadvantaged communities for jobs in the carbon-neutral, clean energy economy (e.g., Uplift Central Coast and the Monterey Bay Climate Action Adaptation Network [MBCAAN]) or disaster risk reduction and adaptation.

The Cultural Fire Stewardship Program is a partnership between the Tamien Nation and the Central Coast Rx Fire Council "to train Tamien Tribal citizens and other California Indian community members to become certified qualified Type 2 Wildland Firefighters," "mentoring trainees for their ultimate qualification to lead cultural prescribed burn projects."

Reducing GHG Emissions was addressed by about half of initiatives, including the co-benefits of GHG emission reductions such as public transportation and mobility, housing improvements, community gardens and green space, and workforce development. Transformative Climate Communities planning grants supported some of these initiatives.

5.4.4 Case Study: Impact of the Pajaro River Levee Breach and Flood

Synthesis Author: *Eloy Ortiz*

In March 2023, a powerful atmospheric river hit Monterey County. The town of Pajaro in Northern Monterey County flooded due to a levee breach on the night of March 11, 2023. The flood came almost 28 years to the day after an earlier flood in March 1995. In April of 2022, the federal government designated funds for the reconstruction of the Pajaro levee (Hagemann, 2022). For years, the Army Corps decided project locations based on the value of homes and other structures in a given area. Pajaro, a primarily low-income and working-class community, had only 700 home structures, and for years, the Army Corps' formulas for investment in the levee did not make financial sense.

When the levee breached, residents were evacuated from Pajaro in the middle of the night and sent to nearby shelters at the Santa Cruz County Fairgrounds or other places further south of Monterey County. Some residents slept in their cars in Watsonville because they didn't know where to go or did not want to be at the shelters with COVID-19 still a consideration for immuno-compromised family members. Residents were blocked from entering Pajaro for 10 days. After they returned, they faced a contaminated water system, ruined possessions, odors from the mix of water and mud, mold, financial expenses, anxiety, and depression (**Figure 35**).



Figure 35: *Aftermath of the Pajaro Levee Breach. Photos by Eloy Ortiz.*

The Pajaro recovery was—and still is—a struggle for residents, who are largely Spanish speakers with a significant number of indigenous language speakers from southwestern Mexico. Homes are largely rentals. FEMA provided aid for residents who could show proof of legal status, something that many residents could not or would not do. FEMA also required documentation for paying out damaged cars, appliances, and other goods. Most residents did not have documentation for which kinds of appliances were damaged or other innumerable losses.

The Pajaro flood also had a lasting impact on agricultural laborers, including those who lived outside of the flooded area. Pajaro is surrounded by farms, which employ a large proportion of its population. The flooding closed many farms and delayed planting through May 2023 as heavy rains continued in the area. The lack of agricultural work meant they had to make difficult

decisions to move out of the area, ask for loans from friends and family, use the little savings they had, or find work in other fields or locales.

There have been some limited benefits and expanded services for the residents of Pajaro as they continue their recovery, including funds for flood recovery, establishment of community centers, and efforts to secure further support (See **Appendix 5.4.4**):

Small agricultural towns with large Latino populations, like Pajaro, are the backbone of the $60 billion-per-year California agricultural economy. These communities feed the state and the nation and are largely feeling the brunt of climate change disasters, often without resources to be resilient and recover economically, emotionally, or in a healthy, safe manner.

Chapter 6.

Conclusion



The Central Coast region will experience major climate changes in the future. Projections include rising temperatures combined with increased precipitation variability and more extreme droughts alternating with major storms.

Water supplies will be increasingly challenged in a region dependent primarily on local surface and groundwater, as storage is reduced and some local wells go dry. Saltwater intrusion, already a major concern, will be exacerbated further, reducing available water supplies. Agriculture will see significant impacts including reduced water for irrigation, shifts in crop production, increases in plant disease and pest pressures, and the acceleration of soil organic matter loss with the reduction of soil carbon reserves. Severe wildfires and post-fire sediment-laden floods that have already devastated the region will worsen, impacting air and water quality. Terrestrial and coastal ecosystems that dominate the Central Coast's landscape will be stressed by heat, drought, loss of fog, and sea level rise, placing many endemic plant communities and endangered species at risk. Ocean ecosystems will see rocky coasts, tidal marshes, and beaches likely lost, imperiling recovery of endangered shorebirds. The largest marine heat wave ever recorded in 2014–2016 caused die-offs of kelp forests and range shifts of species, and at least one regional fishery collapsed.

Communities, especially lower- and middle-income households, will face multiple climate-related challenges. They will see a rise in heat-related deaths, reduced air and water quality, challenges to food and water supplies, and an increasing prevalence of diseases. At the same time, the closure of rural hospitals will reduce care for more vulnerable populations. There will be an increase in already high energy-cost burdens, and economic losses from extreme events will rise.

Adaptation efforts in the region have significantly increased in the last decade. Nature-based strategies to combat beach loss include oyster reefs; dune, wetland, and seagrass restoration; and beach nourishment and sand retention. To address water availability, agencies are building drought resilience through the enhancement of storage, the reduction of demand, and an increase in groundwater recharge. Agriculture is developing heat mitigation strategies, water-limited farming, and increased compost applications and cover cropping to increase soil organic matter, along with improving on-farm groundwater recharge practices. A robust set of tools for managing wildfire are emerging, including cultural burning by Native American Tribes and home hardening. Significant region-wide conservation efforts are underway, many led by or being done in coordination with the Native American Tribes in the region, including efforts to restore tidal marshes. New models are improving assessments of sustainable fish harvest under climate change. Heat action plans and flood emergency plans are being developed along with the restoration and protection of natural habitats to build the resiliency of transportation infrastructure.

There are significant disparities between wealthier coastal tourism-based communities and more economically disadvantaged communities with limited resources to respond to climate hazards. To address this, multiple climate justice organizations, cities, and counties are focusing on public outreach and education; community organizing, coalition building, and collaboration; and resources and service provision, planning, research, and data collection.

Small agricultural towns are the backbone of the region's agricultural economy. These towns are experiencing major climate change disasters, but they do not have the resources to build resilience and recover in an economically, emotionally, or healthy and safe manner. Along the Pajaro River, where floods devastated the area in 2023, local organizations are stepping in with advocacy work and are developing partnerships with external partners to bring resources to Pajaro residents. These approaches are representative of flood planning strategies in the entire region and reflect the commitment of the region to addressing the multiplicity of future climate impacts.

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