

CALIFORNIA'S FIFTH
CLIMATE CHANGE
ASSESSMENT

Los Angeles 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 (**SSP 5–8.5**), 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
CLIMATE CHANGE
ASSESSMENT



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):

No AI tools were used in the preparation, review, or editing for this report.

Executive Summary

The Los Angeles (LA) region for California's Fifth Climate Change Assessment (Fifth Assessment) contains almost all of LA County, all of Orange County, and parts of San Bernardino, Riverside, and Ventura Counties, an area which is home to 43% of California's population. Since time immemorial, Indigenous Peoples have cared for and stewarded the region's lands and waters. These remain the homelands for diverse Tribal communities who continue to exercise sovereignty, maintain cultural relationships to place, and advance climate stewardship. The diverse topography from coastal plains to inland valleys to major mountain ranges creates a variety of microclimates that may respond differentially to climate change. Using high-resolution climate projections performed for the Fifth Assessment, we project a wide range of climate changes and impacts over the LA region:

- About 4°F (2°C) increase in average temperatures by mid-century (2041–2070), relative to present day. More warming is expected further inland, where temperatures are already the highest.
- A greater rate of increase in extreme temperatures, with the hottest day of the year projected to exceed 115°F (46°C) in inland areas by mid-century.
- Increased frequency of both wet and dry years, including more intense droughts.
- Intensification of the most extreme precipitation, translating into enhanced flood potential.
- Loss of about a third of the region's snowpack by mid-century. Together with increased precipitation variability, this will bring major challenges both for flooding and reservoir water capture.
- Water imports during dry years are expected to be reduced by 7% by mid-century.
- Due to warmer conditions and increased drought, annual burned area in the region is estimated to increase by 50% by mid-century, assuming no changes in land management.
- Potentially worse episodes of poor air quality, particularly related to wildfire smoke and ozone.
- Native vegetation, particularly chaparral, is likely to become increasingly stressed due to warming, drought, and wildfire, leading to increases in more fire-prone, invasive vegetation.
- Damage to vegetation is likely to cause continued habitat loss for wildlife, potentially leading to local extinction of a range of species.
- Increased vulnerability to sea level rise, with extreme coastal surges likely to cause extensive and damaging flooding, threatening billions of dollars worth of coastal infrastructure, including roads and housing.
- The vast majority of wetlands in the LA region are already lost. Many more are projected to be completely inundated with moderate sea level rise.
- Increased size and frequency of harmful algal blooms, coupled with increasing ocean acidification.

- Energy demand during extreme heat events (e.g., air-conditioning) is likely to put an unprecedented strain on energy systems.
- Home insurers are increasingly pulling out of fire-prone areas, making large parts of the region economically untenable for many people.
- More frequent, severe, and prolonged heat waves pose a serious threat to public health, particularly for the unhoused and Latino and Tribal communities living inland.
- One in five people is already energy-burdened.
- Extreme events have amplified pre-existing economic inequities due to lower-income people facing additional barriers to recover.
- Episodes of high wildfire smoke are likely to become more frequent and prolonged, disproportionately affecting outdoor workers, seniors, children, pregnant women, and otherwise vulnerable populations.
- Despite these challenges, the LA region already has many examples of successful climate resiliency and adaptation.

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Chapter 1.

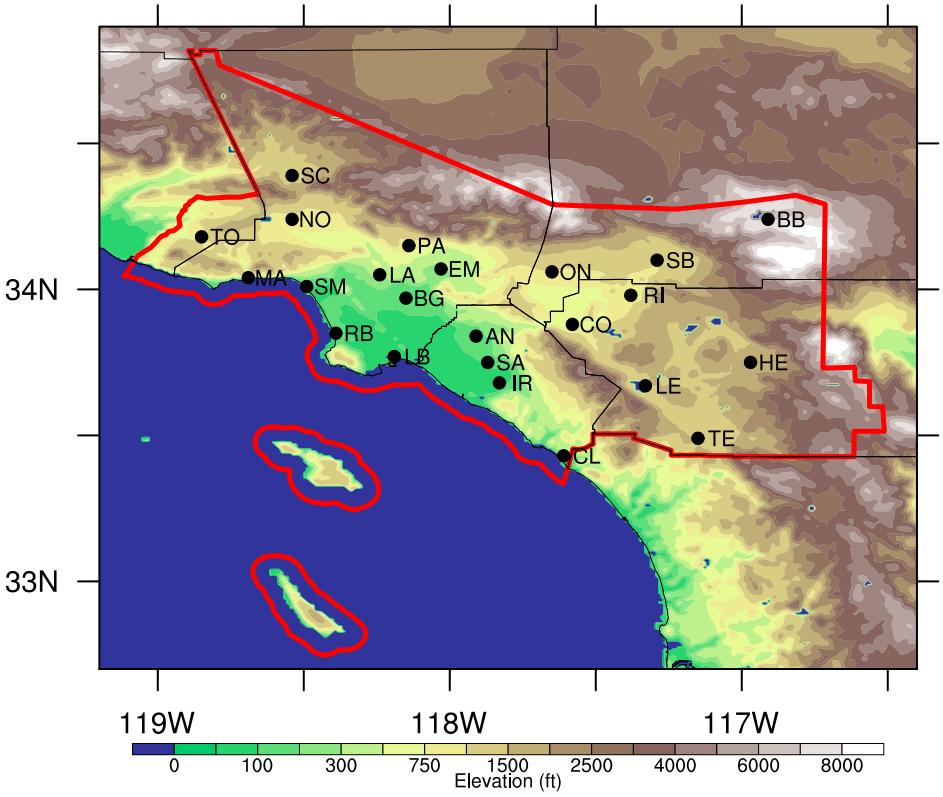
Introduction

The Los Angeles region encompasses almost all of LA County, all of Orange County, the mostly heavily urbanized parts of San Bernardino and Riverside counties, and a small but densely populated part of Ventura County (**Figure 1**). It is home to 16.6 million people (43% of California's population), making it the most populous of the nine regions within the Fifth Assessment. Since time immemorial, Indigenous Peoples have cared for and stewarded the region's lands and waters, and it remains the homelands for diverse Tribal communities. The LA region is a linchpin of California's economy, contributing nearly one-quarter of the state's total GDP through industries including entertainment, international trade through the Ports of LA and Long Beach, defense contracting, medicine, and technology.

The LA region is one of the most topographically and climatically diverse regions in the United States, ranging in elevation from sea level to over 10,000 ft (3,000 m), with coastal plains along the Pacific Ocean, the Santa Monica, San Gabriel, San Bernardino, Santa Ana, and San Jacinto Mountains, inland valleys, and two Channel Islands. Its natural landscapes include beach ecosystems and wetlands, chaparral, inland oak savannahs, and montane forests. The regional topography creates diverse microclimates, with coastal areas being known for their cool Mediterranean climate, inland valleys drier and prone to large temperature swings, and mountains experiencing colder climates and enhanced precipitation. The region faces a wide range of climate hazards, including extreme heat, drought, flooding, wildfire, hazardous air quality, mudslides, ocean acidification, and coastal surges.

The LA, San Gabriel, and Santa Ana Rivers and their tributaries historically meandered across the region before being channelized throughout the 20th century. Today, the region imports most of its water from the Owens Valley, the Sacramento–San Joaquin River Delta, and the Colorado River Basin via a vast network of aqueducts. However, some areas, such as Orange County and mountain communities, obtain a significant portion of their water from groundwater. To date, these sources have satisfied the region's huge residential, industrial, agricultural, and ecological freshwater demands.

The effects of climate change in the LA region have become increasingly evident, with a wide range of major weather and climate events causing devastating impacts and receiving national and international attention. These include countless record-breaking heat waves, two major droughts from 2012–2016 and 2021–2022, some of the wettest storms ever recorded, record flooding of coastal infrastructure, massive harmful algal blooms, and the most destructive wildfires (Palisades and Eaton) in the region's history.



California's Fifth Climate Change Assessment LA Region

Figure 1: *Includes the mainland and Santa Catalina and San Clemente Islands. Major cities/neighborhoods are annotated. SC: Santa Clarita; BB: Big Bear Lake; NO: Northridge; TO: Thousand Oaks; PA: Pasadena; SB: San Bernardino; MA: Malibu; SM: Santa Monica; LA: Downtown LA; EM: El Monte; ON: Ontario; BG: Bell Gardens; RI: Riverside; CO: Corona; RB: Redondo Beach; AN: Anaheim; LB: Long Beach; SA: Santa Ana; HE: Hemet; IR: Irvine; LE: Lake Elsinore; TE: Temecula; CL: San Clemente.*

The region has major affordability challenges and economic inequality, which leave millions of people with limited resources to adapt. Although the LA region is one of the most demographically diverse in the US, there is significant racial and ethnic segregation influencing the spatial patterns of exposures, vulnerabilities, and health risks. The region's legacy of discriminatory housing policies and wealth disparities leaves many low-income communities of color more vulnerable to impacts of extreme heat, for example, which occurs at far greater levels further inland. The region's housing crisis also has led to a high population of unhoused residents who are extremely vulnerable to climate change.

In this report, we present regional climate projections for temperature, precipitation, water resources, wildfire, and sea level rise/coastal surges, and discuss the potential of other climate-related hazards, such as air pollution (Chapter 2). We investigate climate-related impacts to regional ecosystems (Chapter 3), the built infrastructure and economy (Chapter 4), and the people (Chapter 5). Finally, we present examples of climate resiliency and adaptation, while highlighting gaps and opportunities for future adaptation (Chapter 6). This report was informed by an extensive community outreach campaign (**Box 2, Figure 2**). Overall, this report is intended to demonstrate that increasing the resiliency and sustainability of the LA region under a changing climate is a challenging, yet achievable task.

Box 1: *Indigenous Communities of the LA Region*

The LA region is the ancestral home to many Indigenous Peoples, including the Acjachemen (Juaneño), Cahuilla, Chumash, Payómkawichum (Luiseño), Serrano, Tataviam (Fernandeño), Tongva (Gabrieliño), and Kitanemuk & Kizh (Gabrieliño) Tribes. For thousands of years, Tribes maintained complex systems of stewardship, seasonal resource management, and governance that shaped the region's lands and waters.

This included cultural burning (distinct from prescribed fire), which reflects Indigenous fire stewardship practices rooted in place-based governance, cultural responsibility, and seasonal knowledges. While cultural burns can reduce dead vegetation and ladder fuels, their purposes extend far beyond fuel management and vary by ecosystem and Tribal community. In the LA region, fire practices historically differed across coastal plains, valleys, and mountain environments, shaped by local ecological conditions and community needs. Cultural fire has been used to cultivate food and materials, maintain habitat for traditional foods and medicines, support biodiversity, and sustain intergenerational knowledge systems.

Meanwhile, Indigenous Peoples actively stewarded rivers, streams, wetlands, and riparian areas, sustaining community water needs. Water systems were shaped through place-based management practices (including fire, cultivation of riparian plant materials, and fisheries management) that supported ecological health and cultural lifeways. Along the coastline and Channel Islands, Indigenous Peoples such as the Chumash and Tongva developed sophisticated maritime traditions, using tomols and ti'ats (plank canoes) to fish, trade, and sustain intertribal networks across kelp forests, estuaries, and nearshore waters.

Colonialism by waves of Spanish, Mexican, and American settlers has led to land seizure, disease, subjugation, slavery, relocation, broken promises, genocide, and multigenerational trauma for Native peoples, as was recently acknowledged by the City of LA. By the turn of the 20th century, the Indigenous population of California was one-tenth of what it was 50 years prior. With LA's history as the hub of Southern California's enslavement of Tribal Peoples, and the federal government's forced assimilation of Native Americans, many regional Tribes lack federal recognition and therefore face systemic barriers to land governance.

The forced assimilation of western land and water management practices has increased the region's vulnerability to climate change. For example, in 1850, cultural burning was banned, and Indigenous Californians who continued the practice were criminalized and, as recently as the 1930s, legally shot. The resulting disruption of Indigenous fire stewardship, combined with climate change, has led to a lack of healthy small fires, or "good fire", and an increase in major fires that cause forest die-off and an increase in invasive vegetation. The outlawing of cultural burning also constrains Indigenous ceremonial practices. Meanwhile, the region's waters were also made less sustainable, including establishing agriculture, ranch land, and later housing development within the floodplains of the LA, San Gabriel, and Santa Ana Rivers. A series of floods along these rivers led to sections being concretized in the mid-20th century to serve as storm drainage systems, rather than a natural resource. This move was aided by projects importing water from Central and Northern California and the Colorado River, rendering the region's natural water resources obsolete. Consequently, the LA region's infrastructure for capturing local water is limited, for example, accounting for just 9% of the LA Department of Power and Water (LADWP)'s water (LADWP, 2020).

Tribal connections to the lands and waters have endured through colonization and the imposition of western land management systems. Tribal communities continue to exercise their sovereignty, uphold their cultural responsibilities, and lead in climate adaptation and stewardship across the region. This is enabled by coordinated efforts by Tribal communities. For example, the Gabrieliño/Tongva San Gabriel Band of Mission Indians works directly with Native communities, local governments, and environmental organizations, using traditional ancestral knowledge to increase the resilience of ecosystems to the impacts of climate change. This includes the restoration of native habitats and ensuring sustainable land practices in Tongva lands. Similarly, the Yuhaaviatam of the San Manuel Nation conducts projects protecting Tribal lands and resources on the San Manuel Reservation. Here, they use their traditional knowledge with modern technologies to implement sustainable management practices. These include native species preservation, monitoring flow rates and water quality, and promoting renewable energy self-sufficiency. Meanwhile, the Canyon City Environmental Project is the first Tribal-led volunteer environmental advocacy and clean-up group established to protect and steward the San Gabriel Mountains. Increasingly, these efforts are enabled by Landback programs, in which Tribes re-establish ownership of some of their original lands in order to restore sustainable ancestral practices (*Section 6.4 Wilfire*).

Tribal organizations are also providing leadership in promoting sustainable water practices. Since its concretization, Indigenous organizations have led demands for the LA River to be returned to a functioning natural river ecosystem. Subsequently, LA County has released the LA River Master Plan, a series of projects to restore sections of the river to its natural state, thereby reducing flood risk, diversifying the ecosystem, improving local water resilience, and improving water quality. The Native connection to the region's waters was recently portrayed in the feature-length documentary, *Our Water Ways*, developed by The Sacred Places Institute for Indigenous Peoples (*Section 6.3 Water Resources*).

These examples demonstrate how Tribal organizations lead in addressing the region's dire need to return the landscape of Southern California to a state in which the impacts of climate change will be mitigated. Such an initiative is likely to have benefits regarding mitigation of wildfire, extreme heat, drought, flooding, and air quality. Further discussion is provided throughout this report of how climate change is expected to impact Tribal lands and Peoples, including examples of where cooperation between Tribes and non-Indigenous partners is paramount to ensuring climate resiliency in the LA region. In addition, the Fifth Assessment's "Tribal and Indigenous Communities Statewide Topical Report" provides more details on Tribal experiences of climate change throughout California, as well as the actions being taken by Indigenous communities to adapt and become resilient to climate change.

Box 2: *TreePeople Community Engagement Campaign*

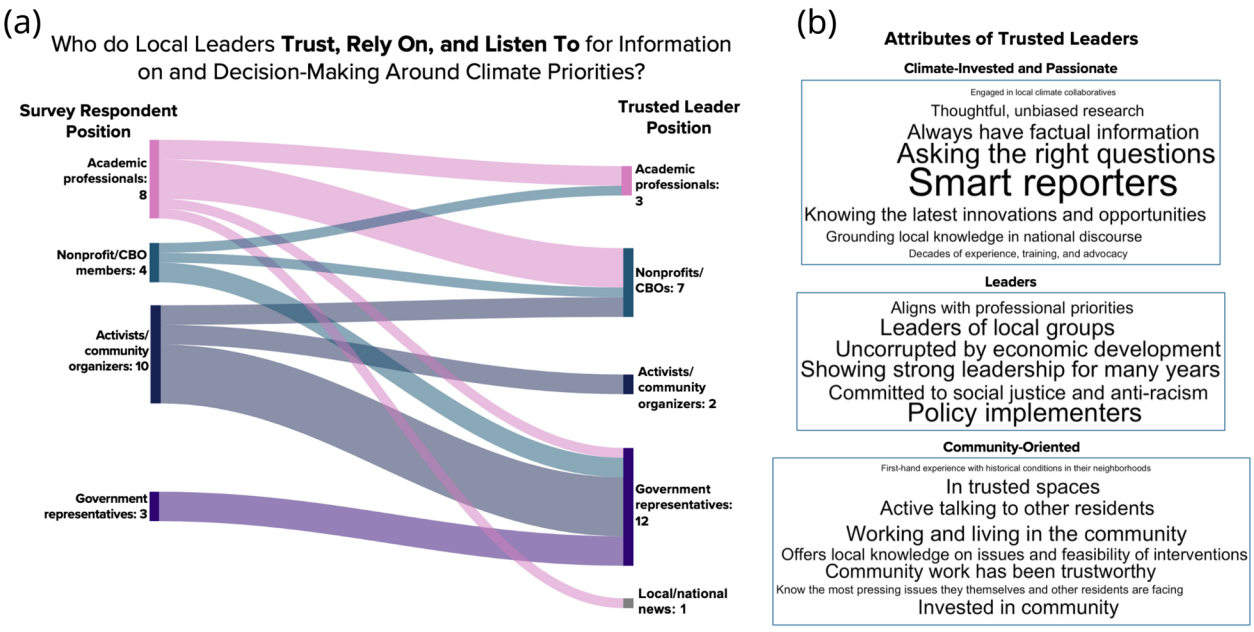
In an effort to identify the climate issues of greatest concern to the community, a community outreach campaign was conducted for this report. This was led by TreePeople, an LA-based community organization that researches and implements sustainable solutions to protect and restore natural resources, and educates communities to take steps to address climate change, explore green careers, and promote environmental equity. As a local leader in climate resiliency with deep community ties, TreePeople is ideally positioned to engage with communities to establish local priorities. In the year leading up to the submission of the LA Regional Report, TreePeople led a two-pronged community outreach campaign.

The first component was a *Listening to Leaders Survey* to determine who the public trusts for decision-making around climate and what attributes make someone a trusted figure in climate leadership (**Appendix, Text A1**). This survey revealed that government representatives are considered the most trusted leaders for information on and decision-making around climate priorities, followed by nonprofits/community-based organizations (CBOs) (**Figure 2a**). Responses indicate that survey respondents tend to trust those who have a proven track record of active work within the climate space, prioritizing years of experience, specifically in:

1. Serving as a leader within a given space ("Leaders")
2. Championing community concerns ("Community-Oriented")
3. Degree of passion and investment in climate issues ("Climate-Invested and Passionate")

In the second component, TreePeople solicited "Climate Stories," detailing personalized experiences of the impacts of climate change in the LA region. This approach is intended to convey the community perspective on climate hazards, illustrating how climate change amplifies existing inequities, while highlighting community-based solutions to enhance local climate resilience. The Climate Stories are presented throughout this report.

In addition to the above community surveys, TreePeople created a database of climate organizations and resources in the LA region. This is intended to support communities facing climate impacts and improve climate resilience.

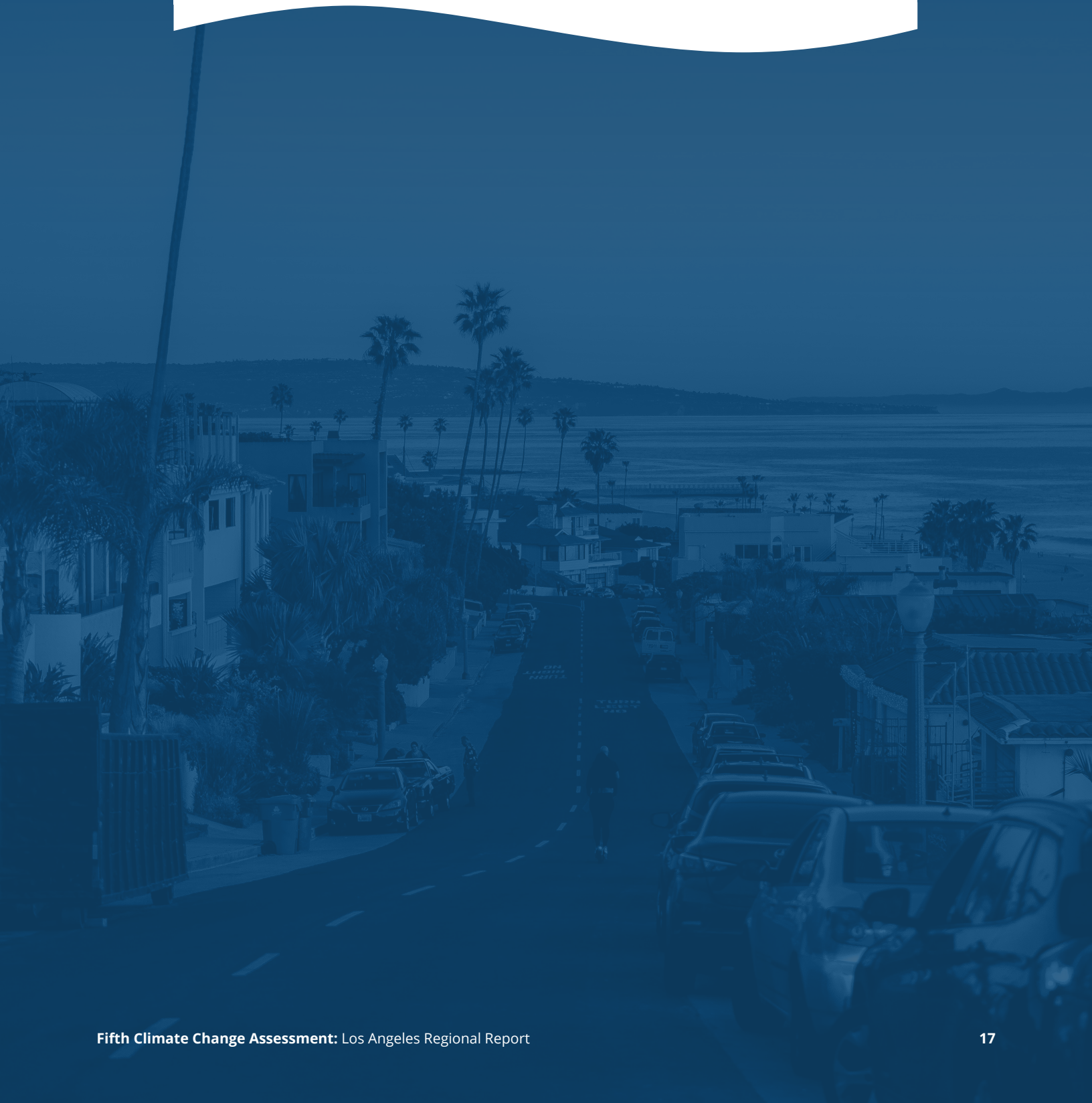


Survey Results of Perceived Climate Leaders in the LA Region

Figure 2: *(a) Sankey Chart representing positions of survey respondents (left) and positions of the leaders they trust (right). The numbers on the left indicate how many respondents fall under each category, and the numbers on the right indicate how frequently the given leader category was identified across respondents. The width of lines indicates the frequency of the given combination of respondent category and identified leader category. (b) Word clouds of survey responses detailing attributes of perceived climate leaders. The size of the font reflects how prevalent the given issue was among respondents. Issues were divided among three categories in an effort to establish clear attributes for trusted leaders and assigned to a category based on their connection to each attribute.*

Chapter 2.

Climate Science: Historical & Projected Trends



Key Messages

- Approximately 4°F (2°C) of warming has occurred over the LA region since the beginning of the 20th century.
- A further 4°F (2°C) increase of average temperatures is expected by mid-century (2041–2070) relative to present day; more warming is expected further inland, where temperatures are already the highest.
- Extreme temperatures are likely to increase at a greater rate, with the average hottest day of the year projected to exceed 115°F (46°C) in inland areas by mid-century.
- Annual average precipitation is not expected to change, but both wet and dry years are expected to become more frequent, and droughts are expected to last longer.
- Extreme precipitation will intensify across the region, with particularly large increases for hourly extremes.
- About a third of the region's snowpack may be lost by mid-century.
- Annual burned area from wildfires may increase by 50% by mid-century, assuming no changes in land management.
- The region's coastline is vulnerable to sea level rise.
- Climate change has the potential to worsen poor air quality episodes, particularly related to wildfire smoke, but also related to ozone.
- In this section, we present future climate projections for the LA region from models in the Coupled Model Intercomparison Project Phase 6 (CMIP6).

As detailed above, these projections were made under the SSP 2–4.5, SSP 3–7.0, and SSP 5–8.5 scenarios. Of these scenarios, SSP3–7.0, commonly used for impact studies (Riahi et al., 2017; IPCC, 2021), is in line with current projected emissions and is the most likely scenario unless strong interventions are made in the coming decades. Thus, we focus on this scenario for most of the climate projections we present.

The Fifth Assessment uses climate models that have been "downscaled" over California to a 3-km grid to improve regional spatial resolution of the complex terrain and associated microclimates of Southern California. See Cal-Adapt and the Climate Data and Analysis Working Group (C-DAWG) for more details.

For each emissions scenario, there is a range of projections across different climate models. In most cases, we report the average over all models for a given scenario. This is our best possible prediction of a given metric of climate change, but should not be taken as a confident assertion that the given metric will change by that specific amount. To express the variability in predictions, in some situations, we report the full range of projections or the standard deviation across models. This approach is intended to communicate the inherent uncertainty of making specific climate change projections, but also to demonstrate cases where models agree on the direction of a given change even if the magnitude of these changes is uncertain.

Values for climate variables are presented in **Historical** (1981–2010), **Mid-Century** (MC; 2041–2070), and **End-of-Century** (EC; 2071–2100) climates. The historical period, as defined, is intended to be a relatable frame of reference against which future comparisons are made. However, it is important to note that substantial warming had already occurred up to this point since the beginning of the 20th century (*Section 2.1 Warming*).

The LA region includes both Santa Catalina and San Clemente Islands (**Figure 1**). While Santa Catalina Island is naturally included in a map of the LA region, San Clemente Island is not; expanding the map to include San Clemente Island prevents detail in the LA regional geography from being captured, and thus it is not shown in subsequent maps. However, we quote projected climate change statistics for both islands.

2.1 Warming

While some climate hazards show uncertainty across climate models in the direction of changes, increased temperatures are universally projected by climate models (Sun et al., 2015; Hall et al., 2024). According to global climate models, warming over the LA region is expected to occur at about a 50% greater rate than for the global average (Tebaldi et al., 2021). This will affect average and extreme temperatures, and metrics including relative humidity, such as heat index.

2.1.1 Regional Average Warming

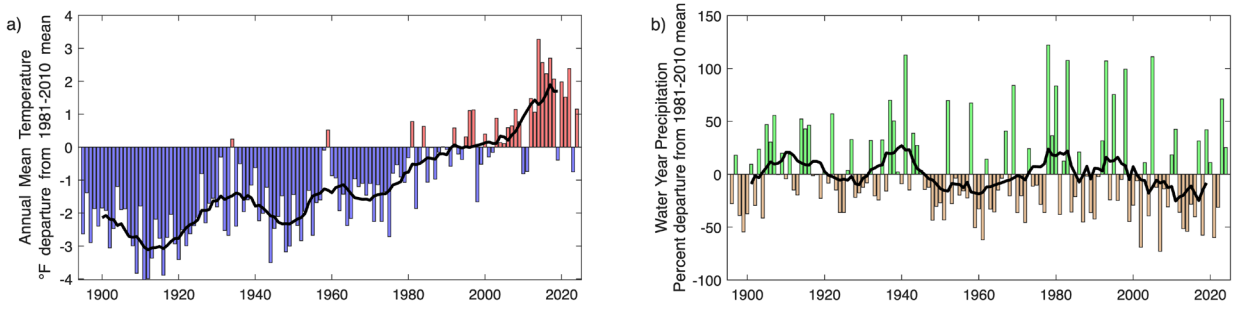
The LA region has experienced consistent warming since the early 20th century (**Figure 3a**). Average temperatures over the last decade are about 4°F (~2°C) higher than at the beginning of the 20th century. Importantly, the 10 warmest years on record were in the last 13 years. The models closely capture the observed warming since 1950 (**Figure 4a**), where the gray shading and gray curve denote the range and average, respectively, of climate models run over the historical period. Direct comparison should only be made between the models and observations in long-term warming, given year-to-year and decade-to-decade variability in the observations.

Box 3: *The Importance of Average Warming*

Although year-to-year fluctuations in temperature are natural, long-term changes in average temperatures represent the state of the Earth's energy balance. Long-term warming means that the Earth is absorbing more energy than it is releasing back to space. Every degree of average warming brings increased risk of extreme events, including heat waves, heavy rainfall, drought, wildfires, and coastal surges. Each degree also results in less precipitation in the mountains falling as snow, which both increases flood risk during large precipitation events and makes it more challenging to capture water in reservoirs.

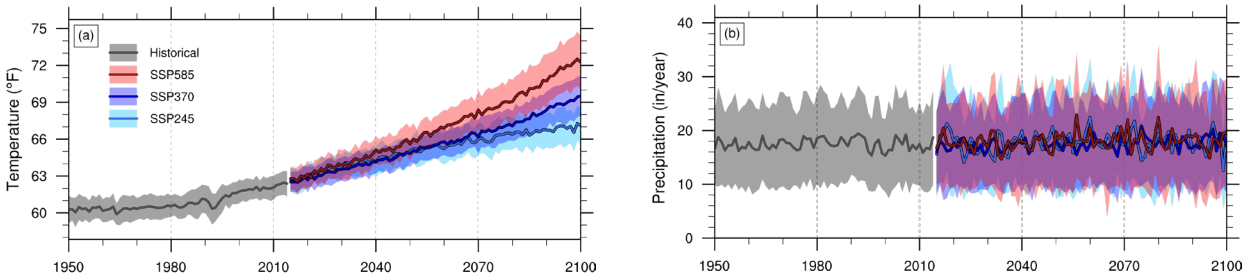
Under all emissions scenarios and in all downscaled climate models, warming in the LA region is projected to continue, particularly under scenarios in which more fossil fuels are burned (**Figure 4a**). In the first half of the 21st century, warming is expected to continue at approximately the same rate as in recent decades, with relatively little disagreement in the rate of warming across SSPs. Averaged over the MC period and across models, there is about a 3°F (~1.5°C) warming relative to present day in SSP2–4.5 and SSP3–7.0, and about 4°F (~2°C) in SSP5–8.5. But by the

end of the century, there is a large range of projections across SSPs. Averaged over the EC period and across models, there is about 4°F (~2°C), 5°F (~2.5°C), and 7°F (~3.5°C) warming in the three SSPs, respectively, relative to present day. The only SSP in which the rate of warming decreases is SSP2–4.5 (beginning about 2070), given that emissions begin to fall around 2050 in that scenario. There is also uncertainty across models, albeit lower than the uncertainty across SSPs. Over the MC period, there is a model range of about 2°F (~1°C) in all SSPs (in other words, 1°F (~0.5°C) either side of the model average). Over the EC period, there is a model range of about 2°F (~1°C), 3°F (~1.5°C), and 4°F (~2°C) in the three SSPs, respectively.



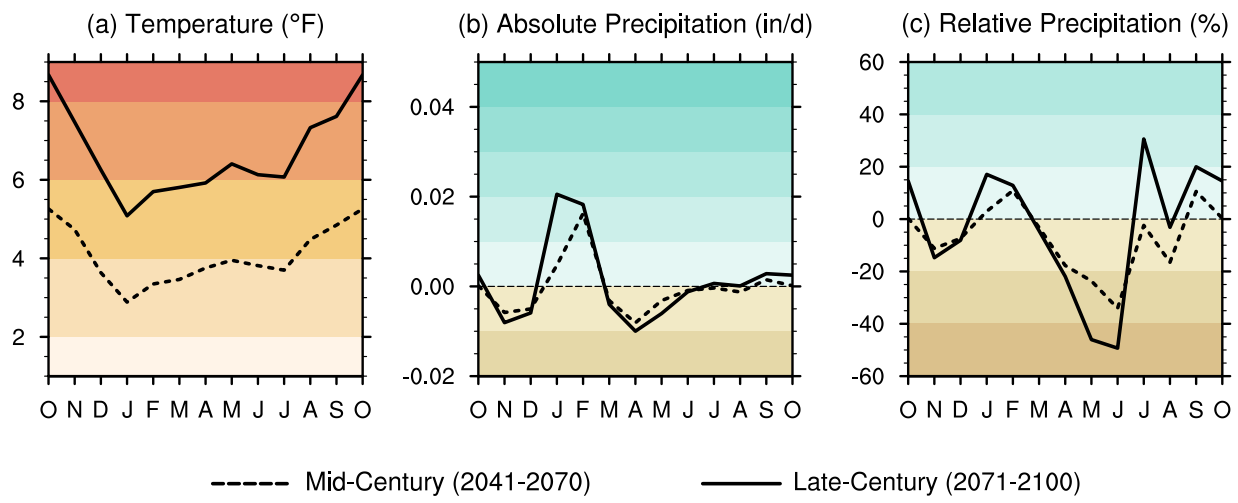
Observed Temperature and Precipitation Trends Averaged Over the LA Region

Figure 3: *(a) Mean annual (Jan–Dec) temperature; (b) water year (Oct–Sep) precipitation. Reported as anomalies from the historical period (1981–2010). The black line shows the 11-year centered moving average. Data from nClimgrid. Provided by John Abatzoglou, UC Merced.*



21st-Century Temperature and Precipitation Projections Averaged Over the LA Region

Figure 4: *(a) Mean annual temperature and (b) precipitation, estimated by 15 LOCA2-Hybrid downscaled climate models over the historical period (1950–2014; gray) and future periods (2015–2100) under three climate scenarios (cyan/blue/red). For each time period/scenario, the line denotes the average across models, and the shading denotes the plus/minus one standard deviation range across models. Note that not all models have data for all scenarios (**Appendix, Table A1**), meaning there are small discrepancies in the set of models used across scenarios. Provided by Paul Ullrich, UC Davis.*



Seasonal Temperature and Precipitation Projections Averaged Over the LA Region

Figure 5: *Change in monthly-mean variables from historical (1981–2010) to future (2041–2070 and 2071–2100, under SSP3–7.0 scenario). (a) temperature (°F), (b) precipitation (in/day), and (c) precipitation (% of 1981–2010). Averaged over 14 LOCA2-Hybrid downscaled climate models. Provided by Paul Ullrich, UC Davis.*

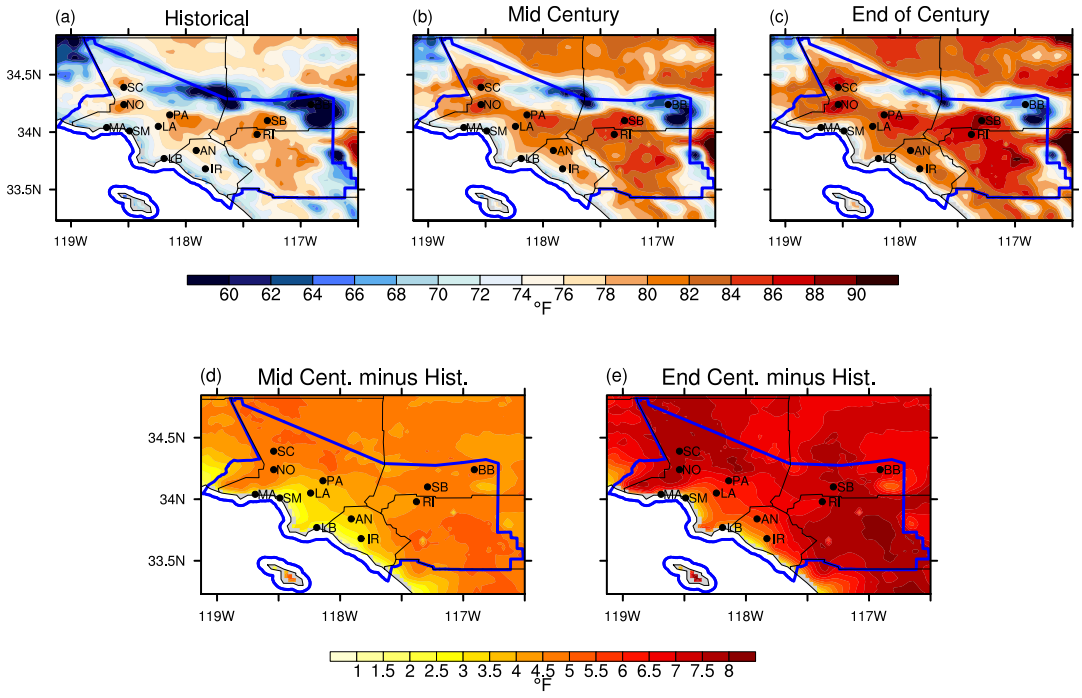
Projected warming is non-uniform across the annual cycle (**Figure 5a**). Here, results are shown for SSP3–7.0 only, but are qualitatively very similar in all SSPs. Warming is expected to be maximized in October (5.2°F/2.9°C warming by MC) and minimized in January (3.0°F/1.7°C). In general, warming is greatest in the summer and fall. We show just the changes averaged across climate models, but note that uncertainty in the changes in individual calendar months is highly similar to that of annual-mean warming (**Figure 4a**).

2.1.2 Geographical Warming Patterns

To analyze the geographical patterns of expected warming, we focus on the SSP3–7.0 scenario and show only the average across models. For other SSPs, the results at individual locations are approximately shifted by the inter-SSP differences in **Figure 4a**. Across models, the uncertainty at individual locations is similar to that in the regional average in **Figure 4a**. Thus, at individual locations, there is uncertainty in the amount of warming, but all models predict that warming will occur.

Annual daily-maximum temperature over the region averages 73°F (23°C), with the well-known pattern of cooler coastal temperatures, warmer inland temperatures, and the lowest temperatures over the mountains (**Figure 6**). We annotate cities to highlight valleys with relatively high temperatures (see **Figure 1** for translation of shorthands). Meanwhile, the warming statistics for each city are given in **Appendix, Table A2**.

By MC, average daytime temperature increases to 77°F (25°C), an average warming of 4.4°F (2.4°C) over the region; and by EC, it increases to 80°F (27°C), a warming of 6.9°F (3.8°C). The warming is lowest near the coast and progressively increases further inland. For example, Santa Monica and San Bernardino, respectively, warm 1.6°F (0.9°C) and 4.6°F (2.6°C) by MC. Daily-minimum (i.e., nighttime) temperatures are expected to show similar patterns (**Appendix, Figure A1**).

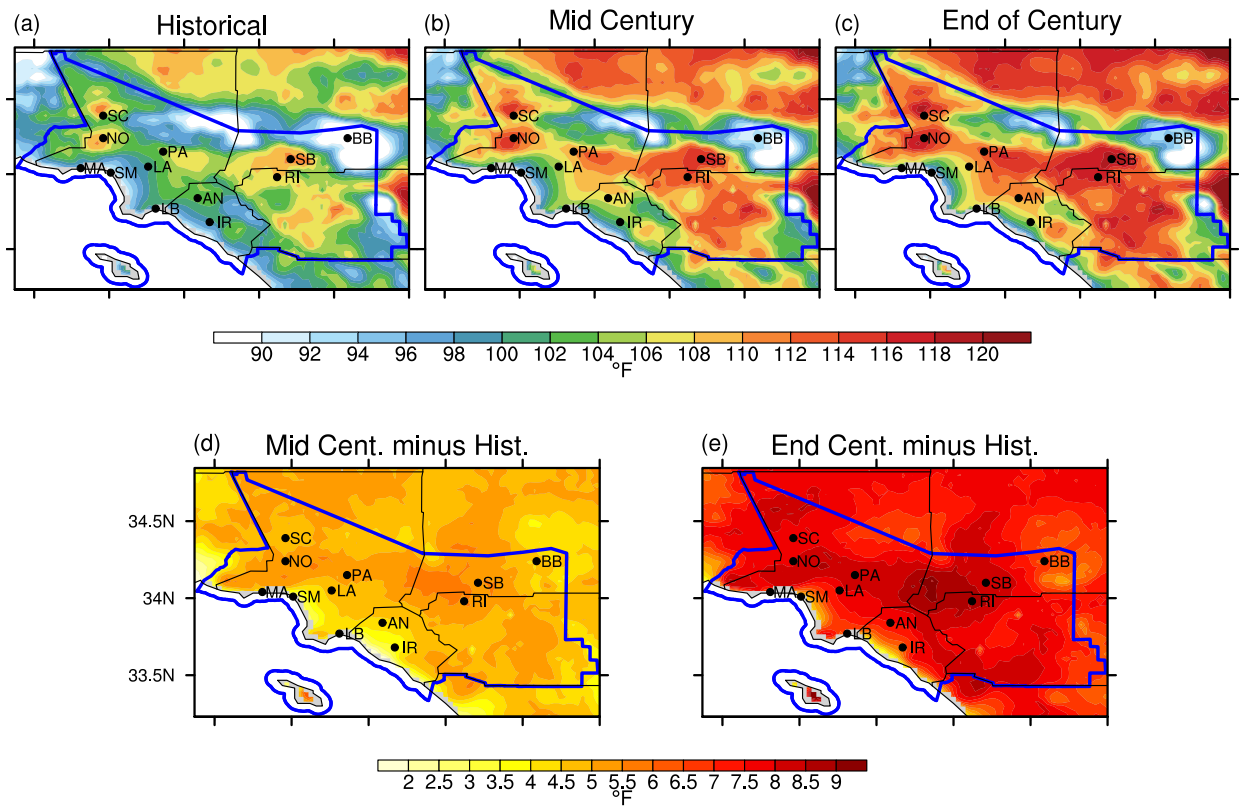


Daily-Maximum Temperature Across the LA Region During Historical and Future Periods

Figure 6: *Top row: Daily-maximum temperature, averaged over the (a) historical (1981–2010), (b) mid-century (2041–2070), and (c) end-of-century (2071–2100) periods. Bottom row: Increase of the same metric in (d) mid-century and (e) end-of-century periods, relative to historical. All data are averaged over 14 LOCA2-Hybrid downscaled climate models under the SSP3–7.0 scenario. Cities are annotated as detailed in* ***Figure 1****.*

2.1.3 Extreme Heat

We expect extreme heat to increase more than average temperatures. We use several metrics to convey this, beginning with annual-maximum daytime temperature (**Figure 7**). Historically, this metric averages 101°F (38°C) over the region, increasing inland from 88°F (31°C) in Santa Monica to 110°F (43°C) in San Bernardino. Under the SSP3–7.0 scenario, averaged over the region, the hottest day warms by 4.8°F (2.7°C) and 7.6°F (4.2°C) by MC and EC, respectively, reaching 105°F (41°C) and 108°F (42°C). The rate of increase is greater further inland, with Santa Monica and San Bernardino respectively warming 2.7°F (1.5°C) and 5.4°F (3.0°C) by MC, reaching 91°F (33°C) and 116°F (47°C).



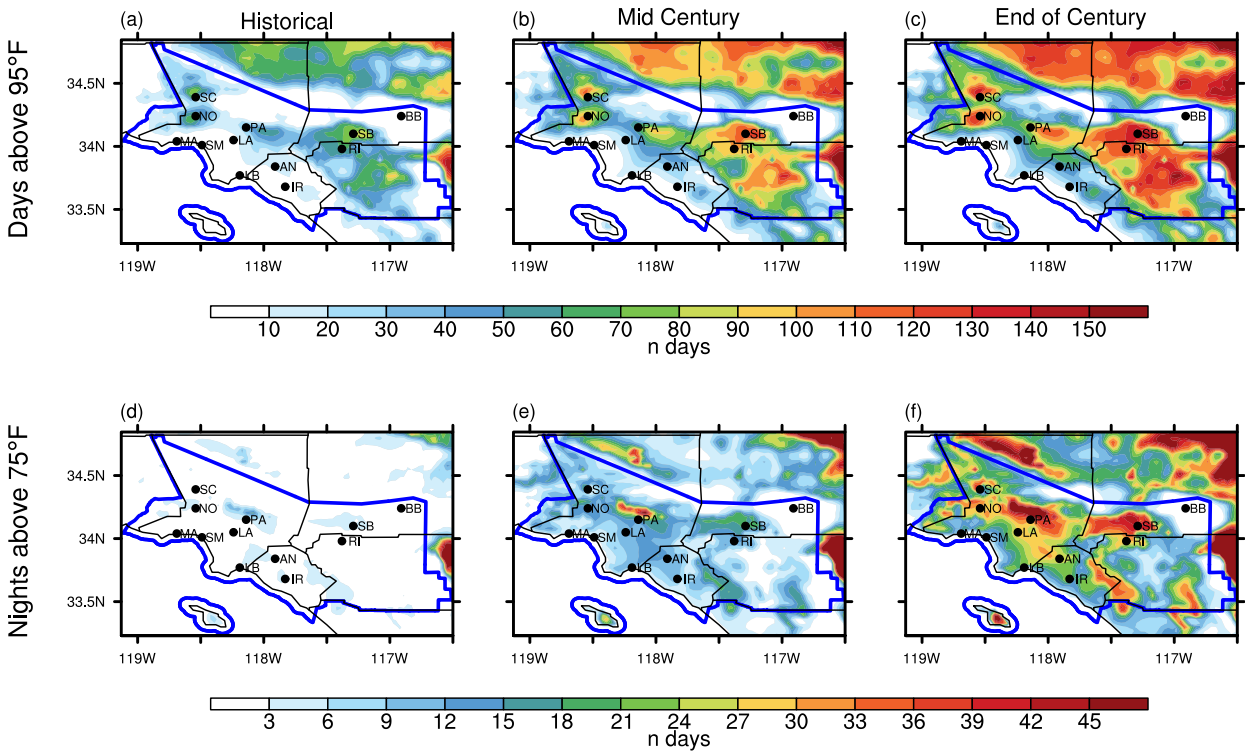
Extreme Heat Magnitude Across the LA Region During Historical and Future Periods

Figure 7: *Top row: Annual-maximum daytime temperature, averaged over the (a) historical (1981–2010), (b) mid-century (2041–2070), and (c) end-of-century (2071–2100) periods. Bottom row: Increase of the same metric in (d) mid-century and (e) end-of-century periods, relative to historical. All data are averaged over 14 LOCA2-Hybrid downscaled climate models under the SSP3–7.0 scenario. Cities are annotated as detailed in* ***Figure 1****.*

We also project extreme heat frequency, defined as the number of days per year exceeding 95°F (35°C) (**Figure 8**, top row). This is a temperature above which there is a danger to human health if spending significant time outdoors (e.g., outdoor manual laborers and unhoused populations). The historical regional average is 19 days, but only inland areas experience more than 10 such days per year. In the future, the regional average is projected to increase to 39 and 54 days by MC and EC, respectively. Inland areas are expected to exceed 95°F for a significant portion of the year

(120 days in San Bernardino by MC, compared to 81 historically). Even the historically temperate Channel Islands are expected to experience a significant number in the future (15 and 11 days for central Santa Catalina and San Clemente Islands by MC, compared to 3 for both islands, historically). More frequent extreme heat means that heat waves become longer (about 50% longer by MC and more than twice as long by EC; **Appendix, Figure A2**).

Meanwhile, extreme nighttime temperatures that are historically rare will become more frequent. This is defined as the number of days per year where the temperature does not go below 75°F (24°C) overnight (**Figure 8**, bottom row). If temperatures do not drop down to comfortable levels at night, houses without air conditioning or significant heat reflectivity will progressively heat up more each day during a heat wave, threatening human health. The regional, historical average of nights exceeding 75°F per year is one, but only inland valleys experience more than one or two. This increases to 7 and 17 by MC and EC, respectively. As with other metrics, inland areas suffer the most (19 in San Bernardino by MC, compared to 4 historically).



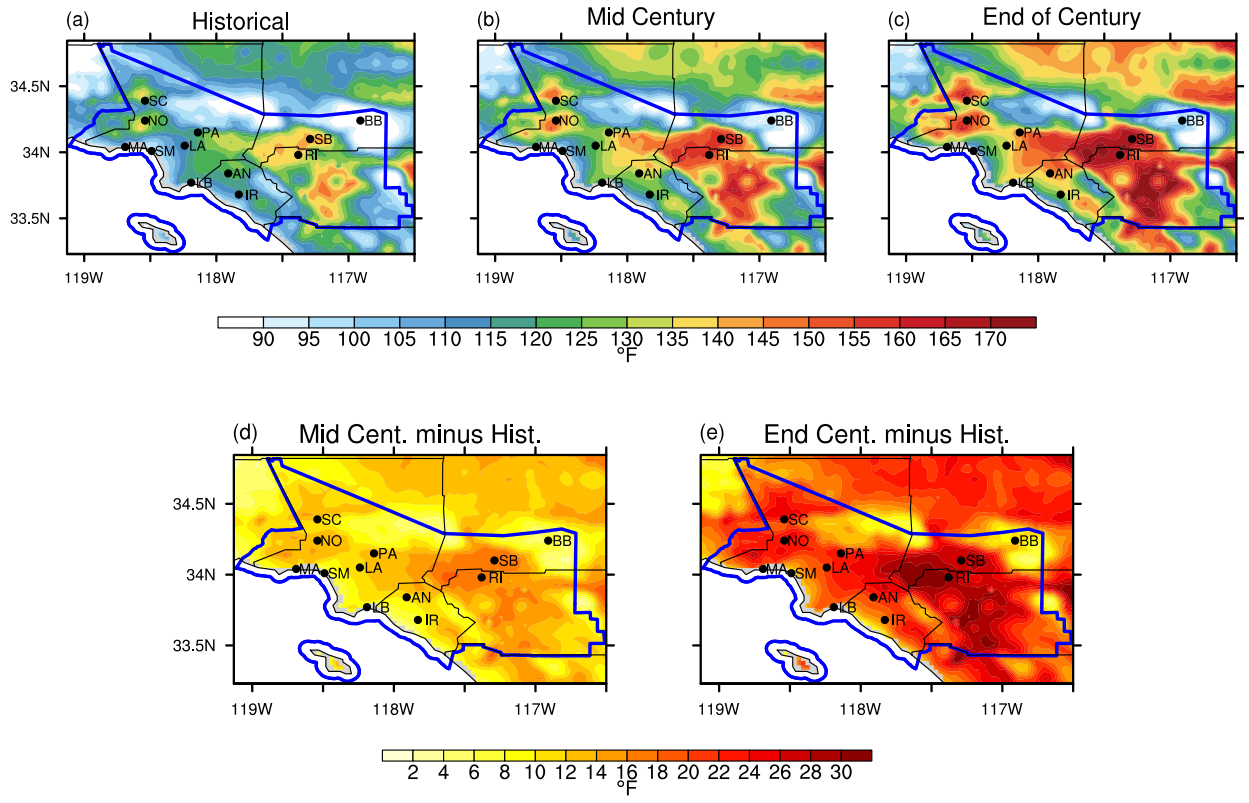
Extreme Heat Frequency Across the LA Region During Historical and Future Periods

Figure 8: *Top row: The number of days per year with daily-maximum temperature exceeding 95°F (35°C), averaged over the (a) historical (1981–2010), (b) mid-century (2041–2070), and (c) end-of-century (2071–2100) periods. Bottom row: Increase of the same metric, but for daily-minimum temperature exceeding 75°F (24°C), averaged over the (d) historical, (e) mid-century, and (f) end-of-century periods. All data are averaged over 14 LOCA2-Hybrid downscaled climate models under the SSP3–7.0 scenario. Cities are annotated as detailed in* ***Figure 1****.*

2.1.4 Heat Index

Heat metrics that include relative humidity may be more relevant than temperature alone for capturing the health impacts of elevated heat exposure. The National Weather Service's Heat Index considers both temperature and relative humidity and is thought to capture what the temperature "feels like," relative to how well the body can cool itself through perspiration in the shade (Black, 2010).

Historically, the annual-maximum heat index averages 114°F (46°C) across the LA region, increasing from 90°F (32°C) in Santa Monica to 141°F (61°C) in San Bernardino (**Figure 9**). By MC, the regional average is projected to be 125°F (52°C), with, for example, 157°F (69°C) in San Bernardino. By EC, the average annual-maximum "feels like" temperature across the region is projected to be 135°F (57°C), with 168°F (76°C) in San Bernardino. For reference, a Heat Index of 125°F (52°C) or higher is classified as *Extreme Danger*, with heat stroke highly likely with prolonged exposure. Thus, although the LA region typically experiences dry heat, compounding humidity will make the hottest day of the year extremely hazardous in inland areas. Extreme wet-bulb temperature, which also includes relative humidity, is also expected to experience major increases (**Appendix, Figure A3**).



Annual-Maximum Heat Index Across the LA Region During Historical and Future Periods

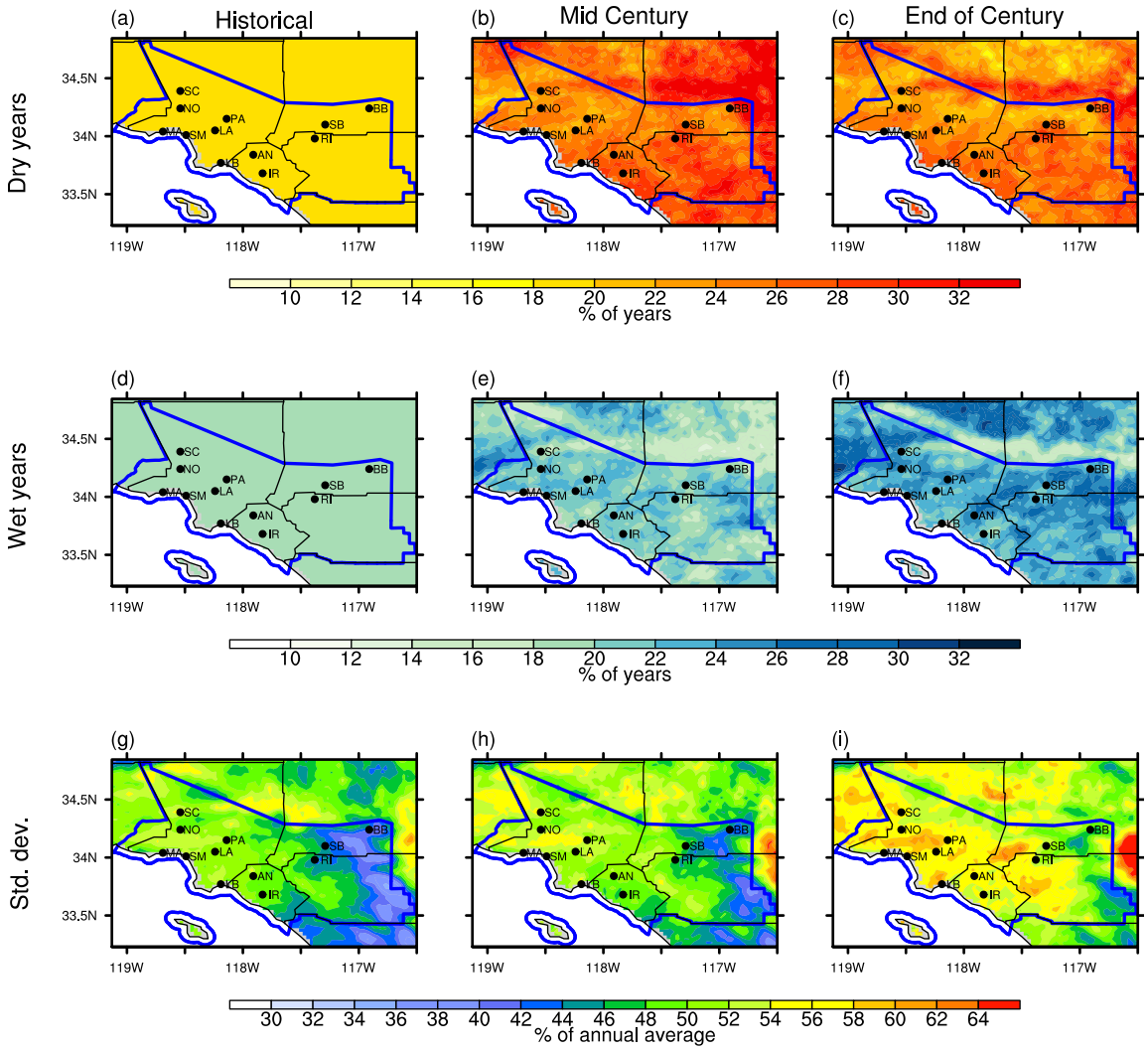
Figure 9: *Top row: Annual-maximum daily-maximum heat index, as defined by the National Weather Service, averaged over the (a) historical (1981–2010), (b) mid-century (2041–2070), and (c) end-of-century (2071–2100) periods. Bottom row: Increase of the same metric in (d) mid-century and (e) end-of-century periods, relative to historical. All data are averaged over 12 LOCA2-Hybrid downscaled climate models (fewer than other figures because of relative humidity being unavailable for some) under the SSP3–7.0 scenario. Cities are annotated as detailed in* ***Figure 1****.*

2.2 Precipitation

Climate change is expected to produce significant changes to precipitation patterns (Swain et al., 2025). In the LA region, precipitation typically occurs in the winter, associated with a handful of atmospheric rivers each year that transport moisture across the Pacific Ocean (Dettinger et al. 2011; Harris & Carvalho, 2018; Cannon et al., 2018). When an atmospheric river makes landfall over Southern California, it interacts with the region's complex geography, leading to extreme precipitation. It falls predominantly as rain, but also as snow at high elevations in the San Gabriel, San Bernardino, and San Jacinto Mountains. The resulting precipitation is critical for filling reservoirs, supporting ecosystems, and alleviating fire risk, but too much falling over a short period can lead to flash flooding and mudslides. Precipitation around the world is expected to become more extreme (O'Gorman, 2015; Pfahl et al., 2017). The LA region, together with the remote regions from which water is imported, is no exception (Hall et al., 2024; Rahimi et al., 2024). Considering its complex topography and the resulting precipitation variations across the region, the Fifth Assessment's high-resolution climate change experiments are uniquely suited to investigate projected changes.

2.2.1 Annual Precipitation

There has been no trend in annual precipitation averaged over the LA region, but precipitation has undergone an increase in year-to-year variability (**Figure 3b**). For example, since the beginning of the 20th century, 10 out of the 24 most extreme years (extremely wet or dry years where the annual total precipitation is more than 50% above or below the long-term mean) have occurred since 1990.



Frequency of Wet and Dry Years Across the LA Region During Historical and Future Periods

Figure 10: *Top row: The frequency of years below the 20th percentile of historical annual precipitation, shown for (a) historical (1981–2010), (b) mid-century (2041–2070), and (c) end-of-century (2071–2100) periods (historical frequency is 20% by definition). Middle row: Increase in the same metric, but for years above the 80th percentile, shown for (d) historical, (e) mid-century, and (f) end-of-century periods.. Bottom row: The standard deviation of annual precipitation in the same periods, divided by the historical annual mean precipitation at the same pixel, shown for (g) historical, (h) mid-century, and (i) end-of-century periods. All data are averaged over 14 LOCA2-Hybrid downscaled climate models under the SSP3–7.0 scenario. Cities are annotated as detailed in* ***Figure 1****.*

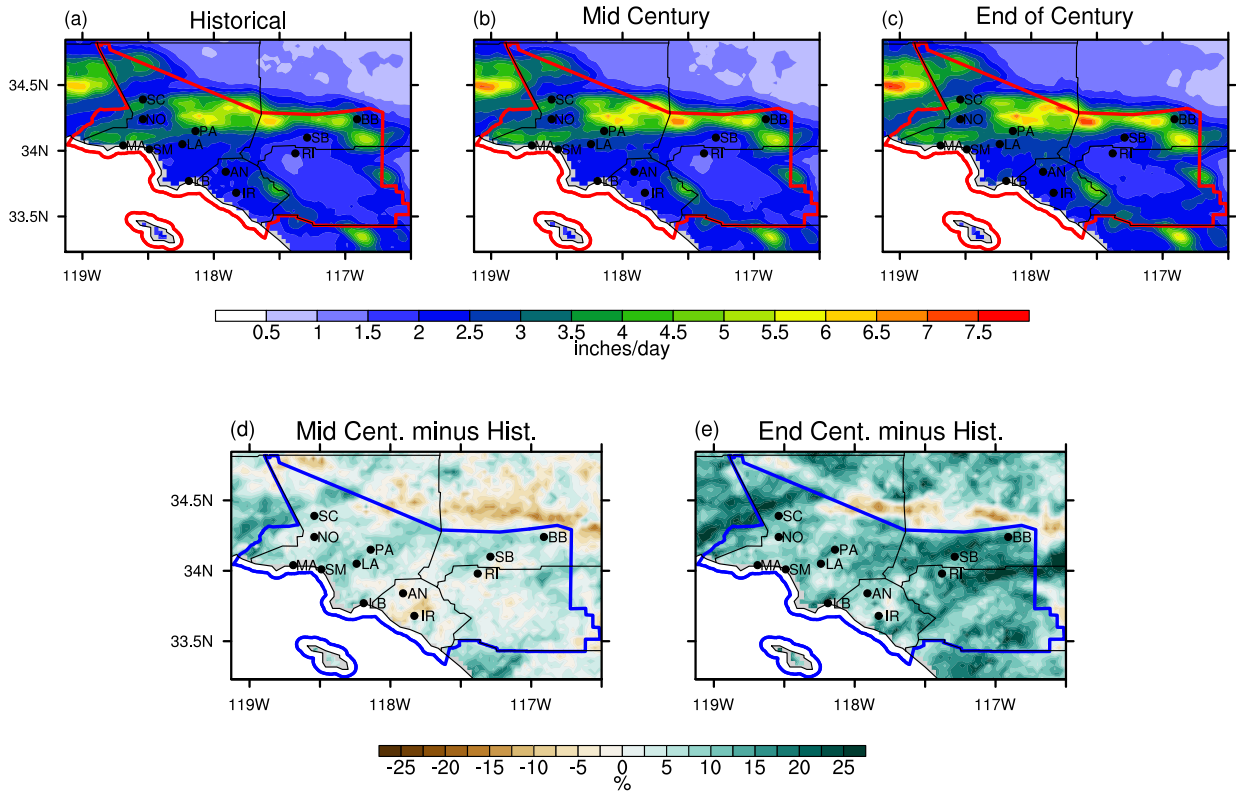
This pattern of unchanged average precipitation, but increased year-to-year variability, is expected to continue throughout the 21st century (**Figure 4b**). The large uncertainty across models, indicated by shading (**Figure 4b**), indicates that some models project wetter conditions and some drier conditions, and thus it is not possible to confidently predict average change. However, under all scenarios, year-to-year variability increases. For example, averaged over models, the standard deviation of annual precipitation is 8.2 inches (208 mm) in the historical climate and, under SSP3–7.0, 8.4 inches (213 mm) and 9.2 inches (234 mm) by MC and EC, respectively. The geographical patterns of these projections are shown for average precipitation (**Appendix, Figure A4**) and for year-to-year variability (**Figure 10**), illustrating that the regional-average projections generally apply throughout the region.

The increased year-to-year variability implies an increased occurrence of both wet and dry years, defined as the historical 80th and 20th percentiles, respectively (**Figure 10**). Thus, so-called hydroclimate whiplash (year-to-year swings between wet and dry conditions) is expected to intensify, as has been predicted more broadly for California and the western US (Swain et al., 2018; Chen et al., 2022a; Swain et al., 2025). This could present significant water management challenges, requiring infrastructure that can be resilient to prolonged extreme dry *and* wet conditions. Furthermore, dry periods are expected to be longer (**Appendix, Figure A5**). Here we refer to meteorological drought (a deficit in precipitation), distinct from hydrological drought (a deficit in runoff; *Section 2.3 Water Resources*) and agricultural drought (a deficit in soil moisture; *Section 2.4 Wildfire*), both of which also depend on temperature.

In addition, changes are expected in the annual cycle of precipitation (**Figure 5b, c**). By MC, precipitation is projected to increase by about 0.02 inches (0.5 mm) per day (roughly a 20% increase) in January and February but decrease by about 0.01 inches (0.25 mm) per day (roughly a 10% decrease) in November, December, March, and April. About 30% of late spring precipitation and some summer precipitation are projected to be lost, which constitute a minute fraction of annual precipitation, but small amounts during this time can alleviate fire risk during the extended summer dry period. Therefore, the year's precipitation is expected to fall in a shorter period than historically, meaning more of a tendency for rain to fall on already saturated ground, likely causing acute flooding. Meanwhile, there is a potential for chronic water shortages due to the challenges of capturing more precipitation in shorter spurts (*Section 4.2 Water Resources*).

2.2.2 Extreme Precipitation

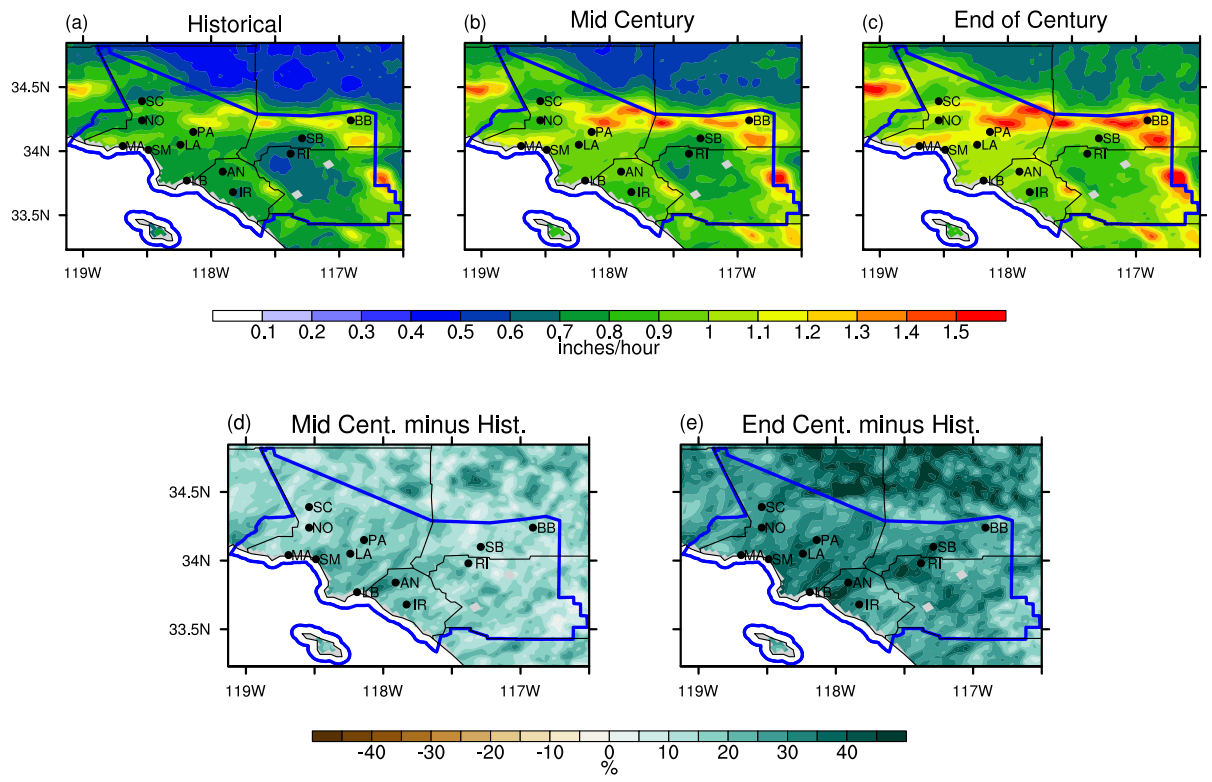
Extreme precipitation over short intervals is more predictive of flooding than annual totals (see *Section 2.3 Water Resources* for more specific flooding projections). We see this by looking at daily precipitation on the wettest day of the year (termed Rx1day) in **Figure 11**. Unlike average precipitation, this metric shows robust increases throughout the region, averaging 2.7 inches (69 mm) per day historically, and increasing to 2.8 inches (71 mm) and 3.0 inches (76 mm) per day by MC and EC, respectively. At MC, the changes are somewhat noisy and include small areas where Rx1day decreases. But, by EC, the projected increases are more uniformly positive. These changes are similar to those projected in other Fifth Assessment regional reports.



Extreme Daily Precipitation Magnitude Across the LA Region During Historical and Future Periods

Figure 11: *Top row: Annual-maximum daily precipitation (termed Rx1day), averaged over the (a) historical (1981–2010), (b) mid-century (2041–2070), and (c) end-of-century (2071–2100) periods. Bottom row: Percentage increase of the same metric in the (d) mid-century and (e) end-of-century periods, relative to historical. All data are averaged over 14 LOCA2-Hybrid downscaled climate models under the SSP3–7.0 scenario. Cities are annotated as detailed in* ***Figure 1****.*

Extreme hourly precipitation (defined as the wettest hour of the year, Rx1hour) increases at even greater rates (**Figure 12**). This metric represents the most intense burst of precipitation experienced in a year and is closely related to flash flooding and debris flows (see *Section 2.7 Compound Extremes*). Averaged over the region, extreme hourly precipitation increases from 0.82 inches (21 mm) historically, to 0.95 inches (24 mm) by MC and 1.04 inches (26 mm) by EC. This amounts to 17% and 29% increases, compared to 4% and 13% increases of Rx1day. Unlike Rx1day, the Rx1hour changes by MC are universally positive, and the increases by EC are even more uniform over the region than for Rx1day. For example, Malibu, Santa Clarita, and Big Bear Lake, which span a wide range of historical values and experience strongly contrasting microclimates, are projected to experience 31%, 33%, and 33% increases by EC, respectively. This reflects that extreme hourly precipitation more closely follows the Clausius–Clapeyron relationship: that the moisture-holding capacity of the atmosphere increases by about 7% per degree Celsius of warming, regardless of location (Allen & Ingram, 2002; O'Gorman & Schneider, 2009).



Extreme Hourly Precipitation Magnitude Across the LA Region During Historical and Future Periods

Figure 12: *Top row: Annual-maximum hourly precipitation (termed Rx1hour), averaged over the (a) historical (1981–2010), (b) mid-century (2041–2070), and (c) end-of-century (2071–2100) periods. Bottom row: Percentage increase of the same metric in the (d) mid-century and (e) end-of-century periods, relative to historical. All data are averaged over 4 WRF downscaled climate models under the SSP3–7.0 scenario. Cities are annotated as detailed in* ***Figure 1****.*

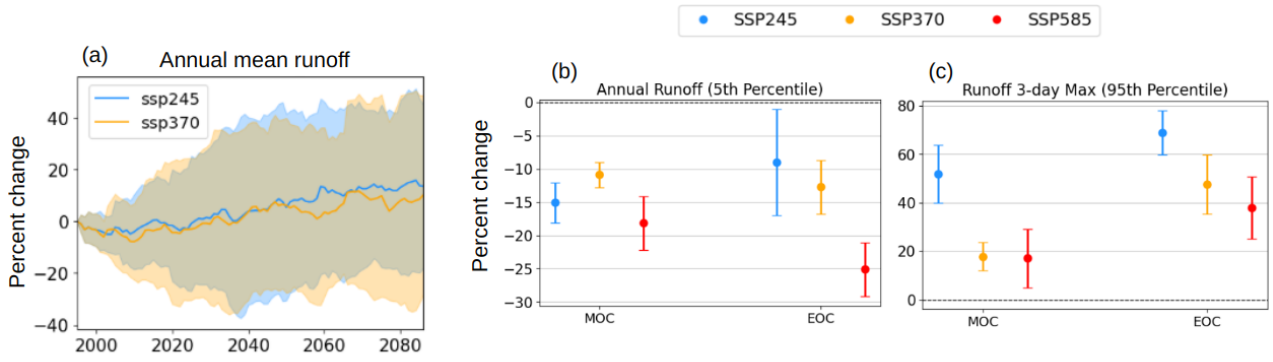
2.3 Water Resources

The changes in precipitation and temperature in *Section 2.1 Warming* and *Section 2.2 Precipitation* have combined consequences for runoff and water resources. Given that wet and dry precipitation extremes are both expected to intensify, we would expect the same for runoff. But the impact of warming and thus greater evaporation is likely to complicate the relationship between precipitation and runoff. We perform a deeper investigation into this complicated system using simulations of water on the land surface. These simulations use historical and future temperature and precipitation patterns previously reported as input to the model. In these simulations, land cover data is kept constant at historical values, and potential human disturbances like changes in impervious cover are not accounted for. This approach allows for a focus on the influence of climate change on water resources, rather than any infrastructure or agricultural changes. In turn, these changes to water resources have implications for wildfire (*Section 2.4 Wildfire*) and compounding hazards (*Section 2.7 Compound Extremes*). We present results under various emissions scenarios so that they can be linked to the scenario-dependent temperature and precipitation projections in **Figure 4**.

2.3.1 Runoff

Average runoff (flow of water across the earth) is not expected to change (**Figure 13a**). The trend exhibits large uncertainty across models, where the mean projection across models is dwarfed by the standard deviation (4.3±33% (mean plus or minus standard deviation across models) by MC for SSP3–7.0). This means that it is not possible to confidently predict either an increase or decrease in the average. Similarly, individual seasons also show no robust changes (not shown).

However, runoff is more likely to change under extreme dry and extreme wet conditions. In **Figure 13b**, projected changes of total runoff during the driest 5% of years are shown, corresponding to a 20-year event. Projections indicate an increasing intensity drought associated with the 5th percentile event. For example, by MC and under the SSP3–7.0 scenario, 5th percentile years are expected to be roughly 11±2% drier for runoff, meaning that 11% less water is expected to flow in the LA region than in the equivalent historical droughts. As expected, higher emission scenarios and EC conditions further intensify the drought projections.



Predicted Local Water Availability in the LA Region Through the 21st Century, Including Drought and Flood Potential

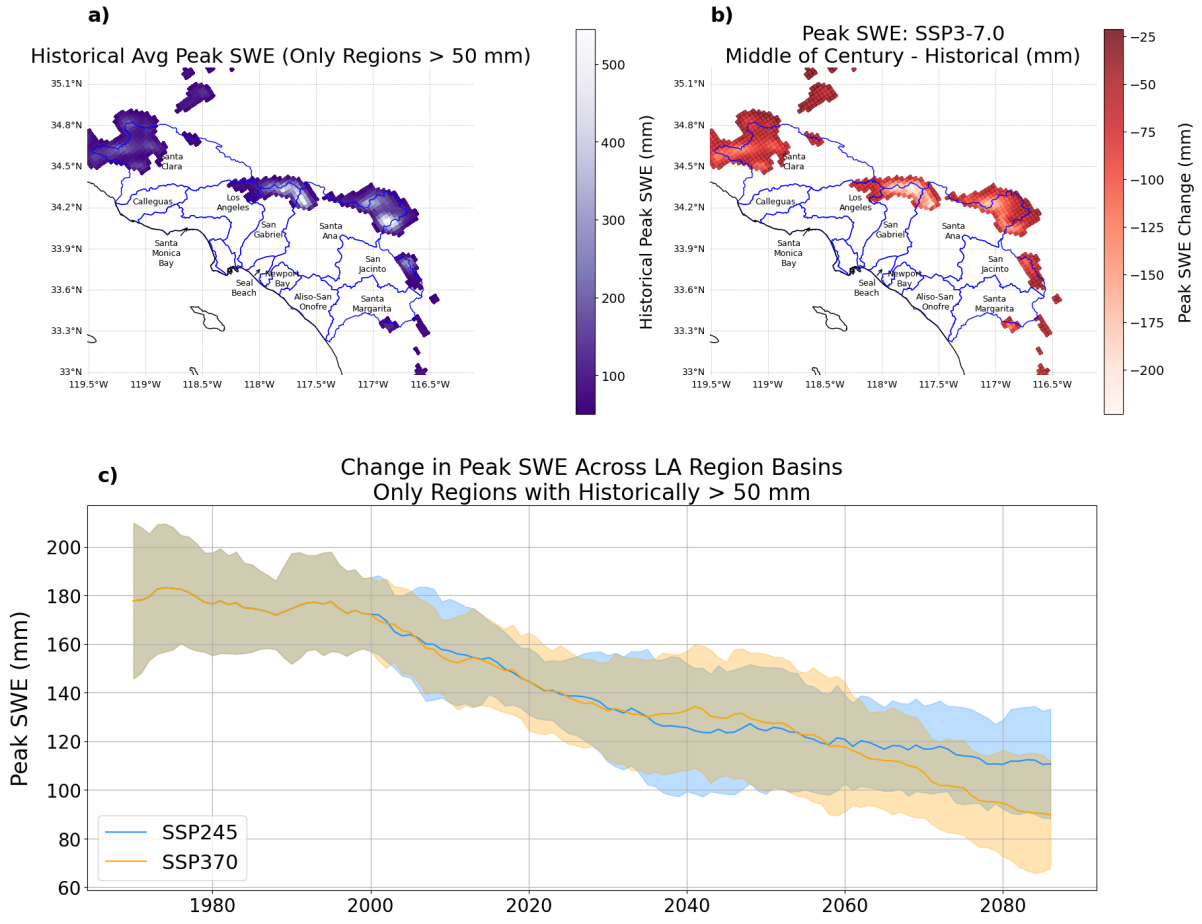
Figure 13: *(a) Average annual runoff under SSP2–4.5 and SSP3–7.0. (b) Intensification of the once-in-20-year drought, defined as the 5th percentile of annual runoff averaged across the LA region. (c) Intensification of the once-in-20-year flood, defined as the 95th percentile of 3-day annual maximum runoff. In (b) and (c), changes are evaluated at mid-century (MC, 2041–2070) and end-of-century (EC, 2071–2100), and shown for SSP2–4.5, SSP3–7.0, and SSP5–8.5. In all panels, runoff is averaged across the LA region, based on a 30-year rolling average of the relevant metric, and the changes are shown relative to the historical period (1981–2010). Runoff is taken from simulations of the Noah-MultiParameterization land-surface model, driven by daily temperature and precipitation from 11 LOCA2-Hybrid downscaled climate models in 11 separate simulations. In each panel, the mean and standard deviation of these simulations are shown (lines and shading in a; dots and whiskers in b, c).*

Extreme wet events are also likely to intensify (**Figure 13c**), as previously shown for precipitation. Unlike drought conditions, for which annual runoff is used, flooding potential is best represented by shorter timescales. Thus, we show the 95th percentile of annual-maximum 3-day runoff, corresponding to the 20-year wet extreme, which shows robust increases. For example, under SSP3–7.0 by MC, this extreme wet metric is projected to increase by 18±5.7%, meaning that 18% more water is predicted to flow under the most extreme flooding conditions compared to historical (1981–2010) extremes. While higher emission scenarios lead to more severe droughts, higher emissions actually lead to reductions in extreme wet runoff conditions. For example, SSP2–4.5 leads to wet runoff extremes reaching as high as 52±12% by MC, while SSP5–8.5 projections are similar to SSP3–7.0. This reflects that in higher-emissions scenarios with greater warming, soil

moisture tends to decrease due to increased evaporation, relative to lower-emissions scenarios. This lower soil moisture can then dampen runoff generation during heavy rainfall. Thus, although robustly increasing, wet runoff extremes are not likely to increase linearly with warming.

2.3.2 Snowpack

We project changes in snowpack across the LA region and its headwater basins in **Figure 14**. **Figure 14a** shows the areas with a historical snowpack greater than 50 mm (2.0 in), which generally corresponds to the headwater regions. We evaluate a common metric for representing snowpack—the annual-maximum snow water equivalent (peak SWE). From the SSP3–7.0 projections, there is roughly a 31±14% decrease in average peak SWE by MC (180 mm under historical conditions reduced to 125±25 mm; **Figure 14b**). As expected, further decreases occur further into the 21st century (**Figure 14c**).



21st-Century Snowpack Projections in the LA Region

Figure 14: *(a) Historical (1981–2010) average peak SWE, just showing areas with at least 50 mm (2.0 in). Blue polygons represent Hydrologic Unit 8 (HUC8) watersheds within the LA region. (b) Changes in peak SWE by mid-century (2041–2070) under SSP3–7.0 scenario. (c) Time series of the 30-year centered rolling average of peak SWE. Lines and shading represent mean and plus/minus one standard deviation, respectively, across models, shown for SSP2–4.5 and SSP3–7.0. Based on daily temperature and precipitation from 11 LOCA2-Hybrid downscaled climate models that were subsequently used to drive the Noah-MultiParameterization land-surface model.*

2.4 Wildfire

Wildfire presents increasing threats both in rural and urban areas of the LA region. Fire is a natural part of the Southern Californian ecosystem and provides a wide range of benefits, including removing dead vegetation, allowing soil to regenerate, enhancing biodiversity, improving tree health, and slowing the spread of pests and disease. However, the natural fire cycle is in strong contrast to the major uncontrolled fires that have been experienced recently. This phenomenon was exemplified by the Palisades and Eaton Fires in January 2025, destroying 6,837 and 9,414 structures and directly claiming 12 and 19 lives (CAL FIRE, 2025a; CAL FIRE, 2025b). Although wildfires have also been impacted by unsustainable land management (*Section 3.1 Chaparral and Coastal Sage Scrub* and *Section 3.2 Conifers*), these recent fires are illustrative of a general intensification under climate change.

Box 4: *The Wildland–Urban Interface*

The Wildland–Urban Interface (WUI) describes the transition zone between an urban area and the natural lands beyond. Here, housing and other human development lie in close proximity to wildlife and native vegetation. The WUI was the fastest-growing land-use type in the United States in recent decades, reflecting the great need for new housing (Radeloff et al., 2018). The LA region contains a unique amount of WUI, given the intermingling of dense urban areas with protected wilderness. In the WUI, housing is typically more spread out than in fully urbanized areas. But there are ecological downsides of development in the WUI, including threats to wildlife that would not otherwise live near humans, introduction of invasive vegetation, and forest fragmentation (Radeloff et al. 2018; Carlson et al. 2022).

The WUI is particularly associated with increased fire hazards. This relationship is two-fold: first, there is more potential for human ignitions near flammable materials (Syphard et al., 2007); and second, housing is especially vulnerable to fast-spreading fires that would be unable to penetrate fully urban areas (Calkin et al., 2014). Both of these dangers were realized in the devastating 2025 LA County fires. Development in the WUI makes fire management extremely challenging. Small fires that would otherwise burn out are not allowed to run their natural course due to the threat to property and human life (Radeloff et al., 2018). See *Section 6.4* for initiatives that are underway to prepare for and mitigate the impacts of future fires.

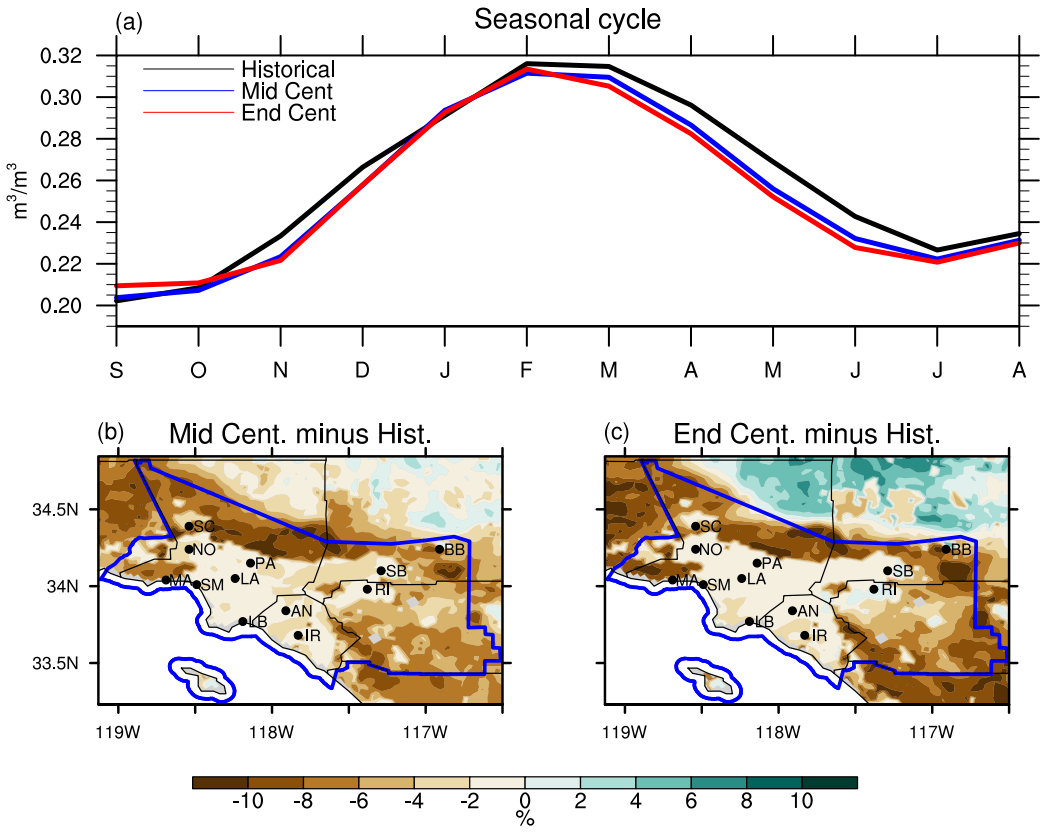
2.4.1 Fire Weather

The clearest mechanism by which climate change intensifies wildfires is by warming, which increases evaporation, drying out the vegetation. Many studies have attributed increases in fire activity in California to increased fuel aridity resulting from warming (Dong et al., 2022; Goss et al., 2020; Westerling, 2016; Williams et al., 2019). The expected continuation of warming in the region (*Section 2.1 Warming*) is likely to perpetuate this trend.

The disruption to precipitation patterns (*Section 2.2 Precipitation*) will also be a factor, illustrated by the expected increase in both wet and dry years (**Figure 4** and **Figure 10**). If wet years do get wetter, then this will likely lead to an abundance of vegetation following the wet season, which will be more likely to desiccate under the warmer conditions expected throughout the year (**Figure 5a**). An increase in the frequency of dry years (**Figure 10**) would then further exacerbate the risk when the wet season fails to materialize, drying out already abundant fuel. Precipitation volatility contributed to the severity of the 2025 fires (Madakumbura et al., 2025a) (i.e., the extremely wet winters of 2022/23 and 2023/34, and the extremely late start to the 2024/25 wet season). The projected concentration of the wet season, meaning that the January/February peak becomes

wetter, while the earlier and later months of the wet season become drier (**Figure 5b**), is also relevant for fire risk. This trend may have been in effect for the January 2025 fires, with almost zero precipitation over the LA region in the early part of the wet season. Thus, we may expect the anomalous precipitation patterns that made the landscape so flammable prior to the 2025 wildfires to become more frequent in the future.

Given the projected changes in temperature and precipitation, soil moisture in the LA region is also expected to undergo changes (**Figure 15a**), which we use as a proxy for the moisture in the fuels. Although soil moisture in the heart of the wet season is not expected to change, soil moisture on either side of the wet season notably decreases. The decreases in soil moisture are particularly pronounced in late spring and early summer, which are the result of both an earlier end to the wet season and warmer conditions. The drier soil (and vegetation) in the fall implies an increasing likelihood of fires prior to the onset of the wet season, such as in 2025. Meanwhile, the drier soil in the spring/summer implies an earlier onset of the summer fire season, as has already occurred over recent decades (Madakumbura et al., 2025b). Notably, the greatest projected decreases across the region are in the mountains, with about a 10% decrease in average warm-season soil moisture (**Figure 15b, c**). This includes the Santa Monica, San Gabriel, and San Bernardino ranges, where almost all fires in the LA region start.



The Projected 21st-Century Change to Soil Moisture

Figure 15: *(a) Monthly climatology of surface soil moisture, averaged over the LA region, shown for historical (1981–2010), mid-century (2041–2070), and end-of-century (2071–2100) climates. (b, c) The change in average warm-season (May–Oct) soil moisture, relative to historical (1981–2010): (b) mid-century (2041–2070); (c) end-of-century (2071–2100). Taken from the average of 4 WRF downscaled climate models under SSP3–7.0. Cities are annotated as detailed in* ***Figure 1****.*

On a more optimistic note, Santa Ana winds, which drove the Woolsey and January 2025 fires, and in general drive the most destructive fires in the region, are projected to experience small decreases (**Appendix, Figure A6**), consistent with previous studies (e.g., You & Delworth, 2025). This manifests as both a decrease in frequency of Santa Ana days and in peak wind speeds on those days. It is important to note two caveats. First, this is unlikely to have any impact on fire activity in the summertime, when most fires historically occur, typically with no association to Santa Ana winds. Second, this does not preclude the occurrence of major Santa Ana wind events (such as in January 2025) from remaining as high as historically, or even becoming more frequent, which is a subject of ongoing investigation in the climate-science community.

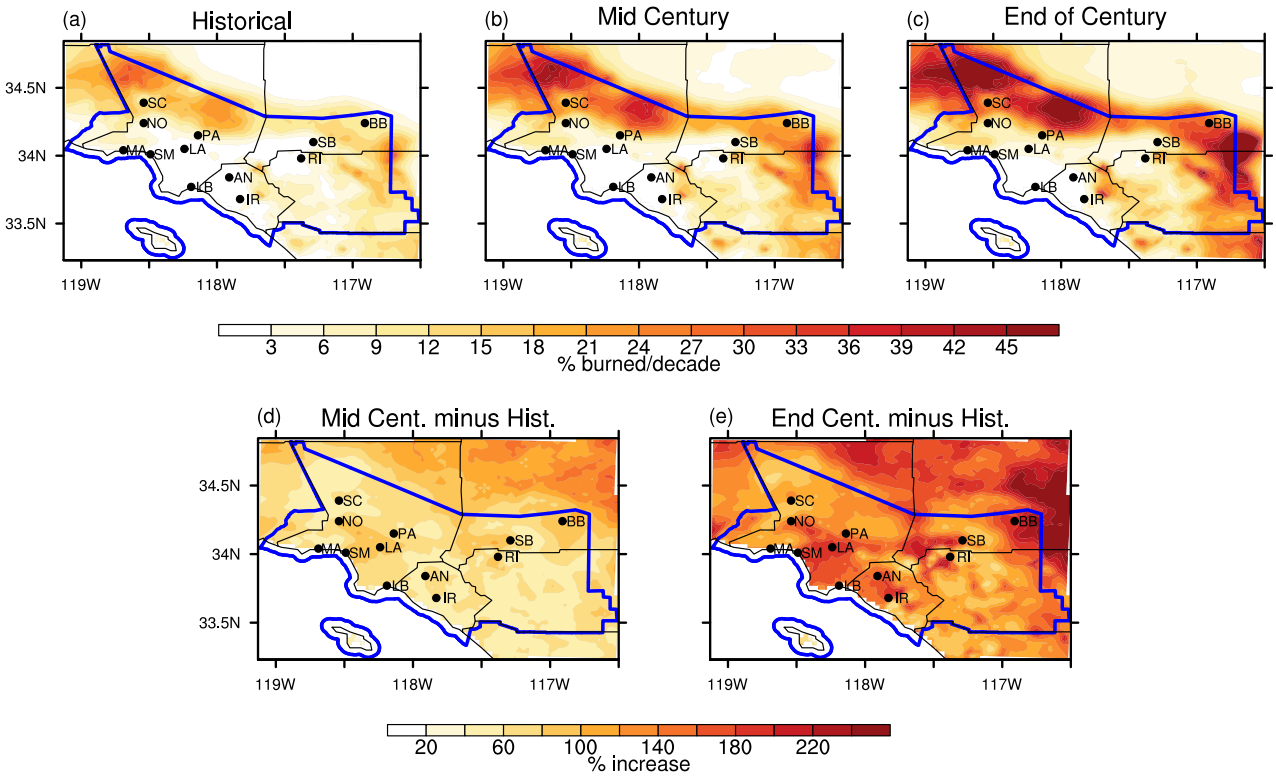
Box 5: *Santa Ana Winds*

Santa Ana winds are offshore winds over Southern California, typically occurring in fall and winter. They arise from cold air over the Great Basin in the cool season, which periodically establishes a strong high-pressure system, pushing air toward the coast. Because Santa Ana winds originate from the desert, they are of low humidity. As they descend from mountain passes toward the coast, they experience further drying and accelerate. The resulting strong and dry winds are notorious for fanning the flames of wildfires. Under climate change, warming is expected to be greater further inland. Thus, the cold air mass over the Great Basin in the cool season may become less prominent, which could reduce the frequency and intensity of Santa Ana winds (**Appendix, Figure A6**).

2.4.2 Fire Projections

Altogether, the above influences on fire risk can be summarized by the projections from the Westerling Fire Model through the 21st century (**Figure 16**). This fire model predicts the presence or absence of a fire at high resolution (30-m) based on temperature, precipitation, wind, and relative humidity patterns from the climate models.

Based on these projections, we present the decadal burn frequency throughout the LA region. The fire model accurately depicts fire activity being maximized in the mountains (10–30% burned per decade), with minimal activity throughout the LA Basin (less than 3% burned per decade). The historical regional average is 8% burned per decade, which increases to 12% and 17% by MC and EC, respectively. Of note, the greatest fractional increases are in the historically less burned parts of the region (about a 100% and 200% increase throughout the City of LA by MC and EC, respectively). In the heavily urbanized areas, this is perhaps of lower consequence (i.e., a 200% increase of an infinitesimal historical amount). But near the WUI, such as Altadena and Pacific Palisades, where fires are rare but potentially devastating, a threefold increase in fire activity would be extremely impactful.



21st-Century Projections of Burned Area Across the LA Region

Figure 16: *(Top row) Projections of burned area from the Westerling Fire Model under (a) historical (1981–2010), (b) mid-century (2041–2070), and (c) end-of-century (2071–2100) climates, as well as (bottom row) fractional increases in future climates relative to historical: (d) mid-century (2041–2070); (e) end-of-century (2071–2100). The fire model predicts presence or absence of fire on a given day in each 30-meter pixel. These results are aggregated spatially and temporally to give the percentage of each 3-km grid cell that burns per decade. The fire model is driven by each of four WRF downscaled climate models under SSP3–7.0, and the average of these four is plotted. Cities are annotated as detailed in* ***Figure 1****.*

We note that these fire projections assume no changes to vegetation management, which could impact projected fire risk. For instance, Tribal communities and organizations have long campaigned and advocated for the return of cultural burning and removal of non-native vegetation, which is gaining support (*Section 6.4.2 Reducing the Spread of Fires*, **Box 15**). Furthermore, the State is undergoing rulemaking that could greatly impact the presence of vegetation within the defensible space surrounding structures in higher risk areas, such as the WUI.

These projections also assume no change in human-related ignitions, which is a highly complex issue. The National Oceanic and Atmospheric Administration's South Coast climate division, which includes the LA region, experienced an increase in human ignitions from the early 1900s–1980 as the population grew. However, from 1980 onward, the number of ignitions decreased despite continued population growth, possibly due to the implementation of fire prevention and management strategies (Keeley & Syphard, 2018). Powerline ignitions (*Section 6.4 Wildfire*) have nevertheless shown an increasing trend. Future projections of ignitions are complicated by the various biophysical and socioeconomic factors that contribute to ignition (Prestemon et al., 2013;

Chas-Amil et al., 2015). Ignition potential, however, is tightly coupled with fuel aridity (Ochoa et al., 2024), which is projected to increase for most of the year in the LA region (using soil moisture as a proxy; **Figure 15**) and is taken into account in the projections in **Figure 16**.

2.5 Coastal Hazards

The California Ocean Protection Council's (OPC) Sea Level Rise Guidance provides sea level rise projections for the entire state, including the counties within the LA region (CA SLR Task Force, 2024). The OPC's analysis uses projections that are based on localized scenarios, accounting for both global climate drivers and vertical land motion specific to Southern California tide gauge locations. Localized estimates at the LA and Santa Monica tide gauges provide representative projections for the broader region, including Orange County.

By 2050, using the LA tide gauge, the California OPC guidance projects a rise in sea level for LA and surrounding county coastlines of 0.7–1.1 ft (21-34 cm) by 2050 (for the *intermediate* and *high* scenarios, respectively) and 2.9–6.4 ft (0.8–1.95 m) by 2100 (*intermediate* and *high* scenarios, respectively). The Santa Monica buoy has similar projections with a slight elevation in the *high* scenario of 1.2 ft (36 cm) by 2050. All projections reference a 2000 baseline.

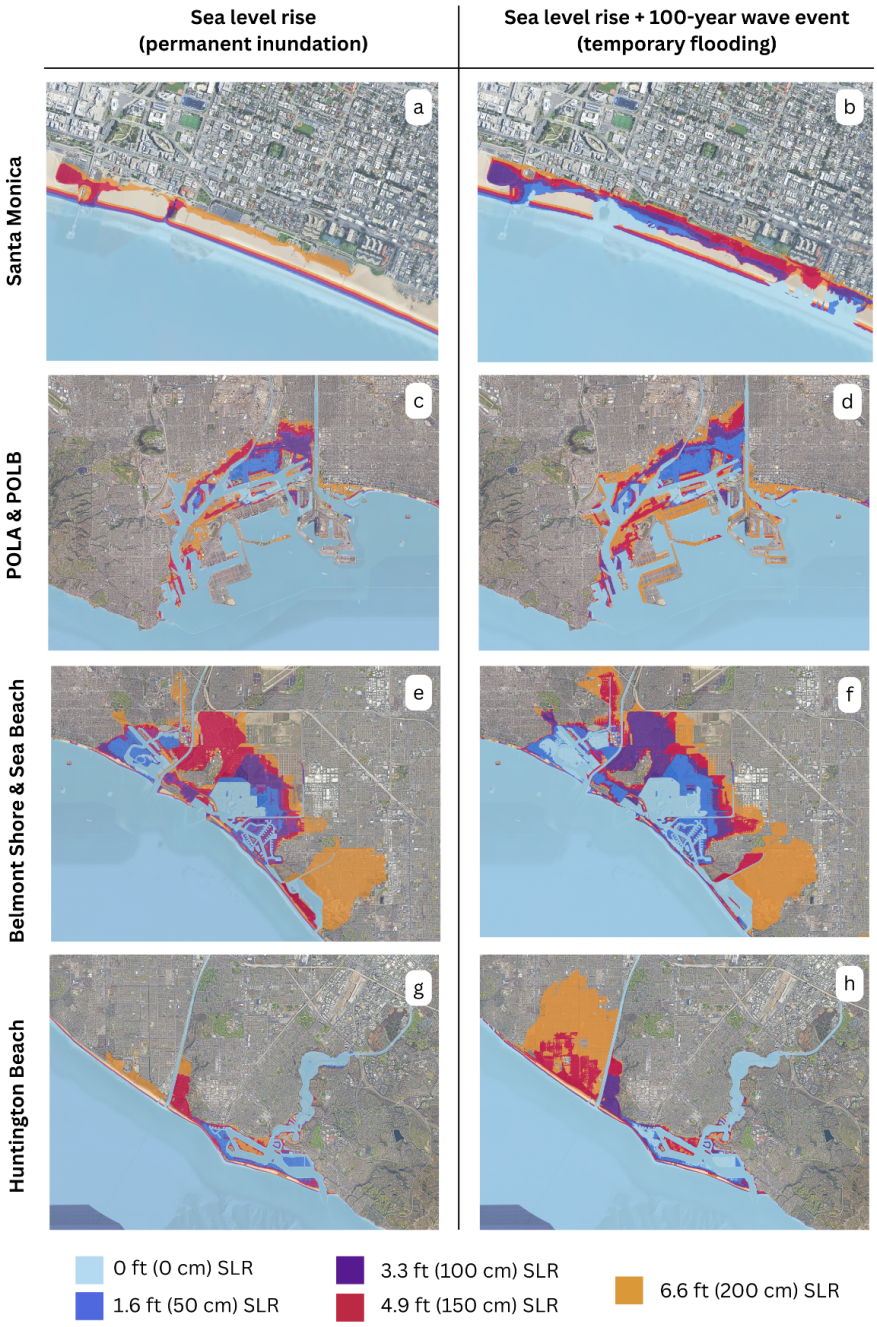
There are other impacts from sea level rise, such as increased flooding during high tides or extreme weather events, increased erosion of sea cliffs, beaches, and other natural barriers, and rising groundwater tables and flooding due to seawater intrusion in coastal aquifers. These impacts are compounded when they occur simultaneously.

Furthermore, original research conducted for the Fifth Assessment found that the impacts of a major tsunami would be significantly worsened under sea level rise. For example, under a 2-m sea level rise scenario, a 500-year tsunami event is projected to lead to 11 times greater coastal inundation than under present-day conditions (Patton et al., 2026).

The LA region faces a variety of coastal hazards, detailed below. In most cases, projections resemble those in other coastal regions of California, although with unique challenges depending on the specific coastline and ecosystems (see the Fifth Assessment's San Diego, Central Coast, San Francisco Bay Area, and North Coast Regional Reports).

2.5.1 Average Sea Level Rise

Sea level rise (SLR) results from the expansion of water due to increasing ocean temperature and the melting of land-based ice sheets and glaciers. The City of LA led one of the first SLR vulnerability assessment studies in California (Grifman et al., 2016). That initial study provided the foundational information that has underpinned much of the subsequent work assessing SLR in the LA region. It also laid the foundation for the region's AdaptLA program (Chapter 6). While the entire coast of the LA region is vulnerable to SLR–driven coastal flooding, some low-lying areas are particularly vulnerable and are mapped in **Figure 17** (Santa Monica Beach, the Ports of LA and Long Beach, Belmont Shore and Long Beach, and Huntington Beach) and **Appendix, Figure A7** (Malibu Lagoon, Venice Beach, and Redondo Beach Pier).



21st-Century Projections of Flood Hazard Under Various Levels of Sea Level Rise Across LA Region's Coastline, Including When the 100-Year Event Occurs

Figure 17: *Flood hazard projections corresponding to 1.6 ft (50 cm), 3.3 ft (100 cm), 4.9 ft (150 cm), and 6.6 ft (200 cm) of sea level rise (SLR) as projected by the U.S. Geological Survey's Coastal Storm Modeling System (CoSMoS). These SLR values provide a range of future water levels, with 1.6 ft (50 cm) expected by 2060 and 3.3 ft (100 cm) expected by 2110 under the intermediate-high SLR scenario (CA SLR Task Force, 2024). The figure highlights flooding hotspots from Southern Ventura to Orange County. Left panels: SLR, indicating the increase in the average sea level. Right panels: SLR plus 100-year wave event, indicating the most extreme wave-driven flooding projected for the 21st century. (a, b) Santa Monica pier; (c, d) the Ports of LA and Long Beach; (e, f) Belmont Shore and Long Beach; (g, h) Huntington Beach. Projections shown for additional locations in* ***Figure A7****.*

2.5.2 Coastal Wave Events

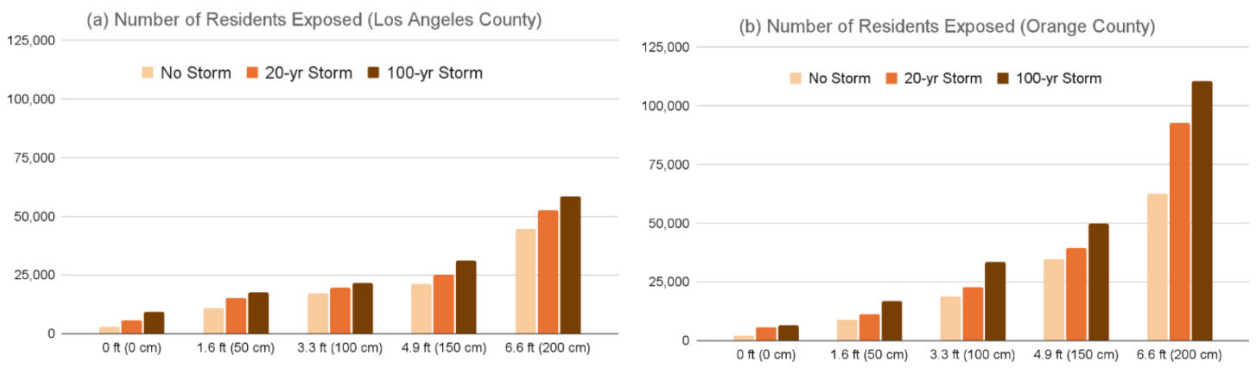
In addition to considering SLR impacts, the coast is also vulnerable to impacts from waves (also referred to as coastal storms, as distinguished from precipitation-based storms). The US Geological Survey's Coastal Storm Modeling Systems (CoSMoS) provides projections of three different types of wave events based on return intervals of 1-year, 20-year, and 100-year (Barnard et al., 2018). These wave events increase flood risk in areas already vulnerable to sea-level-rise-driven flood risks. **Figure 17** and **Appendix, Figure A7** provide a side-by-side comparison of SLR with SLR plus a 100-year coastal storm for seven locations in the LA region. This gives a sense of an increase in potential flooding due to extreme wave events compounded by SLR.

It is important to note that 20-year wave events along the LA regional coastline are rare. The most recent event was during the 2023–2024 winter. While the most newsworthy impact was damage to the Santa Cruz wharf, the LA region also experienced waves measuring over 20 ft (6.1 m), prompting the closure of all beaches and coastal parks in Ventura and all piers from Ventura down through Manhattan Beach (James & Lopez, 2023).

A 100-year wave event has never been recorded along the LA coastline to date. The 100-year coastal storm projections in **Figure 17**, therefore, provide information to coastal professionals as they prepare for the future. They also provide important information about transient flood risk associated with these one-off events or as a proxy for future high-tide flooding, as described in more detail below in *Section 2.5.3 High-Tide Flooding*.

Figure 18 provides estimates of the number of residents exposed to five different rates of SLR, in addition to increased flood potential from 20-year and 100-year coastal storms. Along the LA coastline, SLR has the potential to expose between ~10,000 residents with 1.6 ft (50 cm) of SLR and ~21,000 residents at 4.9 ft (150 cm) of SLR (**Figure 18a**). When a 20-year wave event is added, these numbers increase to between ~15,000 residents at 1.6 ft (50 cm) of SLR and ~25,000 residents at 4.9 ft (150 cm) of SLR. Looking at extreme SLR of 6.6 ft (200 cm), SLR alone could impact ~44,000 residents, with an additional ~12,000 exposed during a 20-year storm. With a 100-year wave event, ~17,000 residents could be impacted with 1.6 ft of SLR, ~31,000 with 4.9 ft of SLR, and ~58,000 with 6.6 ft of SLR.

In Orange County, ~8,700 residents could be exposed under 1.6 ft (50 cm) of SLR, with up to ~34,000 residents exposed at 4.9 ft (150 cm) of SLR. When compounded with a 20-year or 100-year wave, these numbers increase to ~7,700 to ~10,600 residents with 1.6 ft (50 cm) of SLR, respectively, and ~22,000 to ~24,900 residents with 4.9 ft (150 cm) of SLR (**Figure 18b**).



21st-Century Projections of the Number of Residents Exposed to Flooding Under Various Levels of Sea Level Rise, Including When the 20-Year and 100-Year Events Occur

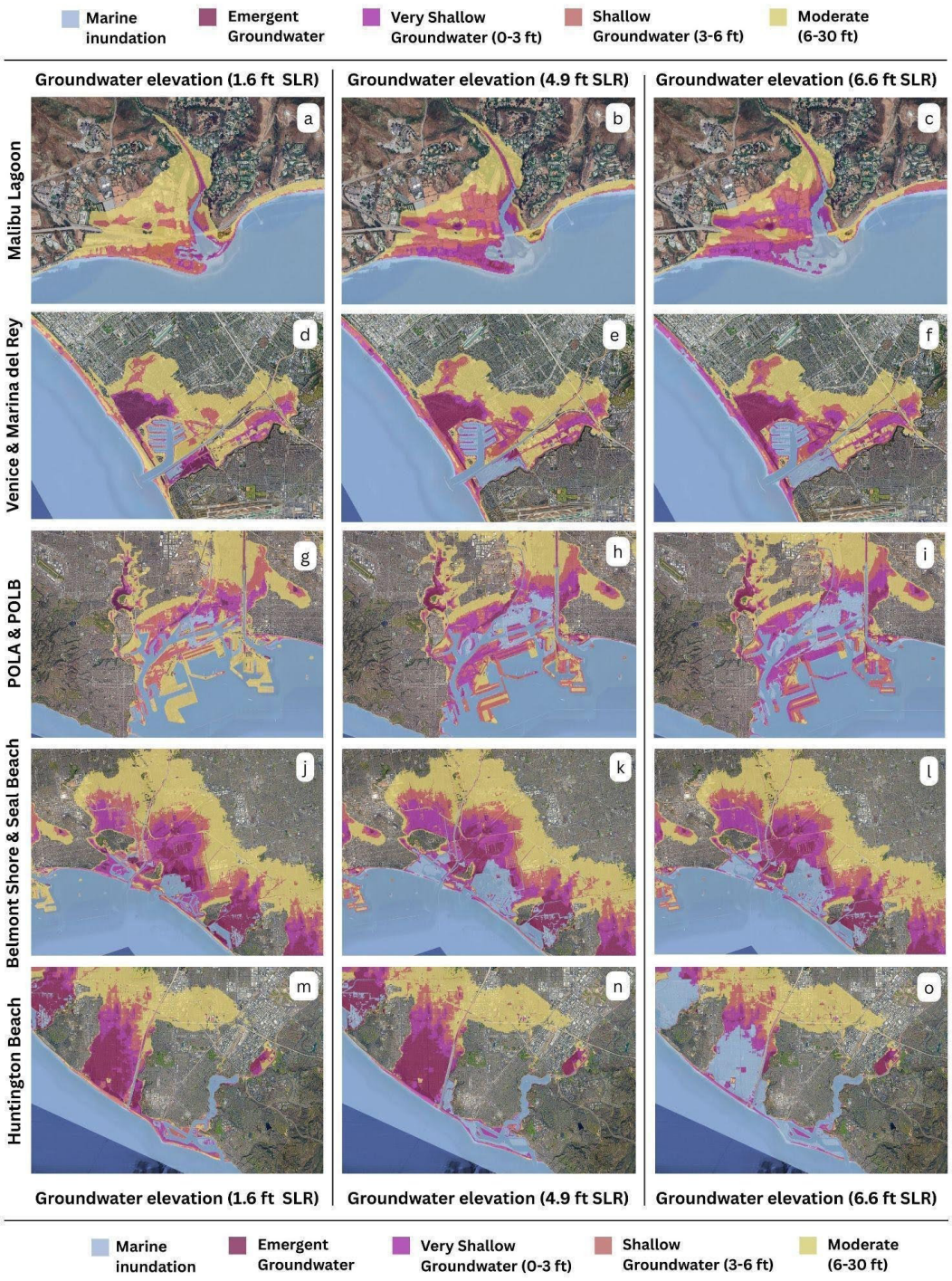
Figure 18: *Shown for (a) LA County and (b) Orange County. Estimates were calculated using the US Geological Survey's Hazard Exposure Reporting and Analytics (HERA) tool.*

2.5.3 High-Tide Flooding

Coastal communities in Southern California will not only be impacted by temporary flooding from coastal wave events. As sea level rises, frequent high-tide flooding already occurs and is predicted to amplify rapidly in the early 2030s, with today's rare flood events potentially becoming annual occurrences by mid-century (Sweet et al. 2022, Taherkhani et al. 2020). For instance, using the LA tide gauge as a reference and deriving water levels from hourly SLR projections developed by Scripps Institution of Oceanography, with ~12 inches (~25 cm) of SLR (expected by about 2060 under the *intermediate* projections), today's 100-year event would be expected to occur every year (Iacobellis & Cayan, 2024). A 20-year event would occur annually with ~5.5 in (~14 cm) of SLR (occurring by 2030 under *intermediate* to *high* projections (Iacobellis & Cayan, 2024; CA SLR Science Task Force, 2024).

2.5.4 Groundwater

Since California's Fourth Climate Change Assessment (Fourth Assessment), new science has emerged that describes the impact of SLR on elevating coastal, unconfined groundwater tables, significantly increasing groundwater-related hazards for shallow infrastructure and ecosystems (Schroder et al., 2022; Befus et al., 2020). Modeling different SLR scenarios, Befus et al. (2020) showed that with 3.3 ft (~1 m) of SLR, areas affected by groundwater flooding could expand 164–427 ft (50–130 m) inland, with low-lying communities most at risk. Local coastal topography plays a major role in controlling how far the rising water tables can move inland. Along about 70% of the state's coastline, natural drainage or low-elevation features help limit the extent of groundwater rise. Ignoring these topography-limited responses can lead to overestimating flooded areas by about 20% and underestimating risks such as saltwater intrusion into freshwater aquifers.



Projected Rise in Shallow Groundwater Tables Across Five Hotspots in LA Region

Figure 19: *Projections taken from the US Geological Survey's CoSMoS-Groundwater model, under various future sea levels, demonstrating groundwater depth. This includes where groundwater will break through to the surface (emergent), groundwater table depth below ground (very shallow, shallow, or moderate depth), and where marine inundation will mask groundwater emergence. Left panels: groundwater tables with 1.6 ft (50 cm) of SLR; middle panels: groundwater tables with 4.9 ft (150 cm) of SLR; right panels: groundwater tables with 6.6ft (200 cm) of SLR. (a, b, c) Malibu lagoon; (d, e, f) Venice and Marina del Rey; (g,h,i) the Ports of LA and Long Beach; (j,k,l) Belmont Shore and Seal Beach; (m,n,o) Huntington Beach.*

Along the LA region's coastline, SLR leads to groundwater rise in five hotspots (**Figure 19**). Along Malibu Lagoon, with 1.6 ft (50 cm) of SLR, groundwater shoals within the aquifer, but does not break through to the surface (**Figure 19a**). With 4.9 ft (150 cm) of SLR, groundwater only emerges through the surface by the pond in the backshore. However, the water table along the coast and along the lagoon is projected to rise to within 3 ft (91 cm) of the ground surface, which could disturb the foundations of existing structures (**Figure 19b, c**). Conversely, in Venice, particularly along the canals, groundwater is expected to emerge with only 1.6 ft (50 cm) of SLR (**Figure 19d**). The footprint of emergent groundwater expands only slightly with 4.9 ft (150 cm) and 6.6 ft (200 cm) of SLR, indicating that projected groundwater rise will have an immediate impact on coastal flood risk hazards in the Venice area.

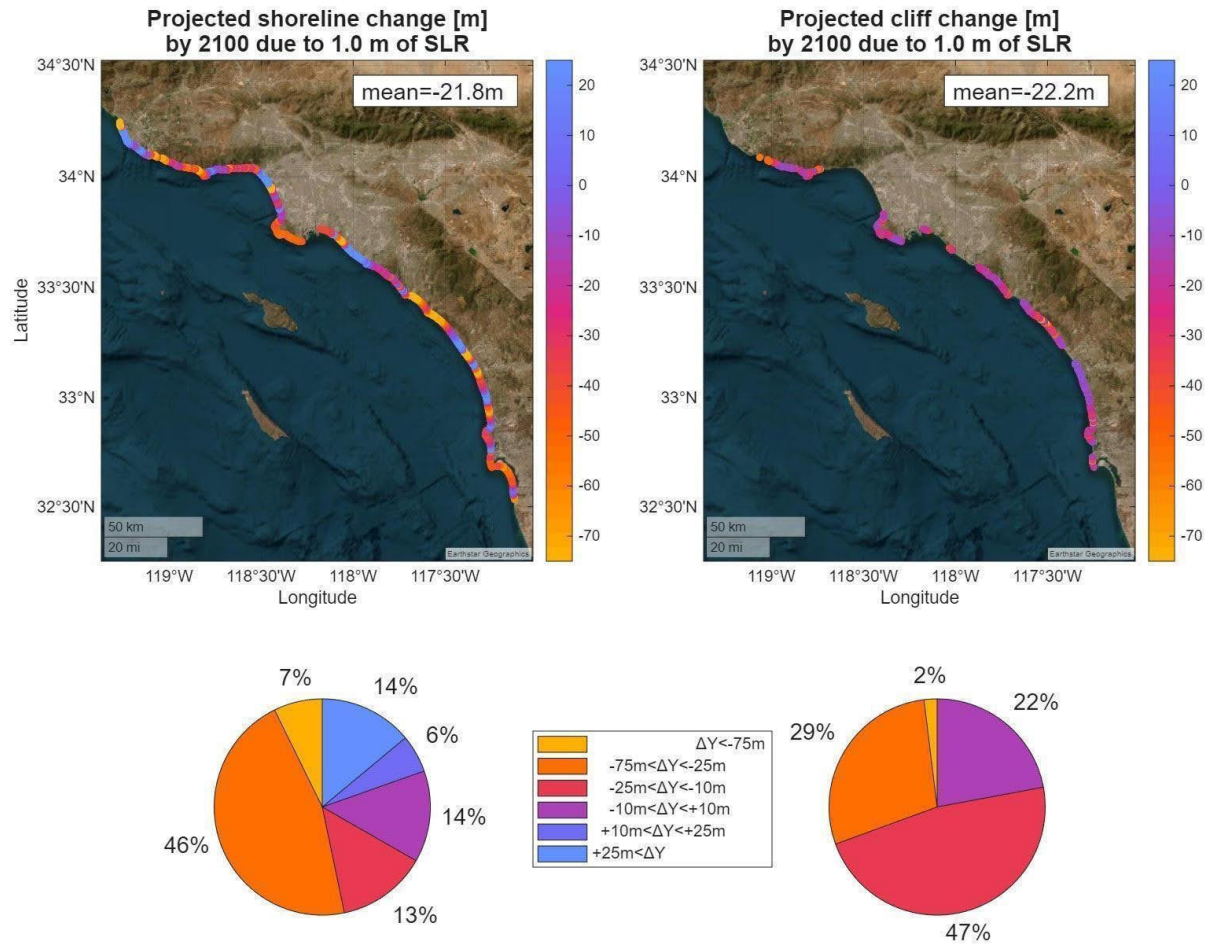
In the near term, with 1.6 ft (50 cm) of SLR, groundwater emergence in the Ports of LA and Long Beach (POLA & POLB) area is limited to the Ken Malloy Harbor Regional Park (near Machado Lake in the upper left quadrant of the map) and a small portion of the City of Long Beach, along Anaheim Street behind the port wharves. In Wilmington, along the back shore of the Port, the emergent groundwater footprint expands with 4.9 ft (150 cm) of SLR, and is ultimately overtaken by tidal inundation with 6.6 ft (200 cm) of SLR. Shallow groundwater tables in Wilmington will become even shallower with rising sea levels, putting much of the infrastructure's foundation at risk (**Figure 19g, h, i**). Most of the backshore of Seal Beach also has shallow groundwater tables that will shoal with rising seas (**Figure 19g, h, i**).

Straddling LA and Orange counties, Belmont Shore/Seal Beach south to Huntington Beach are imminently vulnerable to emergent groundwater under 1.6 ft (50 cm) of SLR (**Figure 19j, m**). In Belmont Shores/Seal Beach, with 4.9 ft (150 cm) and 6.6 ft (200 cm) of SLR, most of the emergent groundwater sites are permanently inundated by the ocean (**Figure 19k, l**). In Huntington Beach, groundwater is very shallow or emergent even today, where the emergent groundwater footprint is similar in size to the emergent groundwater projected with 1.6 ft (50 cm) of SLR (**Figure 19m**). Current local water management strategies, such as French drains and pumps, will likely work to keep much of this potential present-day groundwater emergence from accumulating above ground (K. M. Befus, personal communication, January 10, 2026). This footprint increases only slightly with 4.9 ft (150 cm) of SLR (**Figure 19n**), with the area likely permanently inundated with ocean water with 6.6 ft (or 200 cm) of SLR (**Figure 19l**). Thus, the flood risk along many of the low-lying coastal zones in Orange County is likely to occur sooner due to the shoaling, or emergence, of groundwater tables, even before flooding from overtopping of ocean water occurs.

2.5.5 Coastal Change

SLR along the LA coastline is dramatically intensifying coastal erosion and accelerating shoreline change, threatening both natural habitats and human infrastructure (Vitousek et al, 2023; Swirad & Young, 2022; Vitousek et al., 2021; Limber et al., 2018; Vitousek et al., 2017). As ocean levels continue to rise, waves penetrate further inland, exposing sandy beaches, bluffs, and developed shorelines to greater frequency and intensity of storm surges and waves. These combined impacts are expected to triple local erosion rates in Southern California by 2050, increasing the risks of beach loss and more inland flooding, with estimates of beach loss ranging from 33–67% by 2100 (Vitousek et al. 2017). The LA region's rapid urban development and altered sediment supply further exacerbate these vulnerabilities, raising significant economic and logistical challenges for maintaining beach stability.

SLR will drive an increase in the rate of cliff retreat and beach erosion, and accelerate coastal squeeze in the LA region, where extensive infrastructure pins the back beach location (**Figure 20**). With 3.3 ft (100 cm) of SLR, there is variability in shoreline change along the LA regional coastline, with 20% of sites predicted to have increased shoreline width (symbolized by blue slices of pie chart), while the majority of sites are expected to have decreased shoreline widths (symbolized by yellow, orange, and red circles, **Figure 20a**). The majority of the coast (46%) is expected to lose between 80–250 ft (25–75 m) of shoreline under 3.3 ft (100 cm) of SLR. Cliff retreat is equally dire, with 22% of sites either not retreating or only retreating up to 30 ft (10 m), 46% of cliffs expected to retreat by 30–80 ft (10–25 m), and an additional 22% expected to lose retreat by 80–250 ft (25–75 m) (**Figure 20b**).



21st-Century Projections of Shoreline Change and Cliff Change Along the Coast of the LA Region

Figure 20: *(Top left) Projections of shoreline change calculated at model output points along the coast and (bottom left) summarized across the region. (Top right) Projections of cliff retreat at model output points and (bottom right) summarized across the region. Both projections are for 3.3 ft (1 m) of SLR by 2100 along the LA region's shoreline (graphics developed by Vitousek using the CoSMoS-COAST shoreline change projections, following Vitousek et al., 2023).*

Moreover, vertical land motion due to subsidence and tectonic activity further complicates the geology and future of the LA coastline. Local subsidence—caused by groundwater extraction,

sediment compaction, and crustal extension—can amplify relative SLR, leading to more severe flooding and faster erosion rates than predicted from ocean height alone. Over one million City of LA residents are exposed to subsidence greater than 3 mm (0.1 in) per year, and some parts of Long Beach have subsidence rates that exceed 5 mm (0.2 in) per year (Ohenhen et al., 2025). In reclaimed areas such as Newport Beach, land subsidence is projected to add up to 6 inches (15 cm) to SLR projections for 2050. This combined effect increases the risk of groundwater table rise and saltwater intrusion, especially in unconfined coastal aquifers (Govorcin et al., 2025).

2.5.6 Compound Flooding

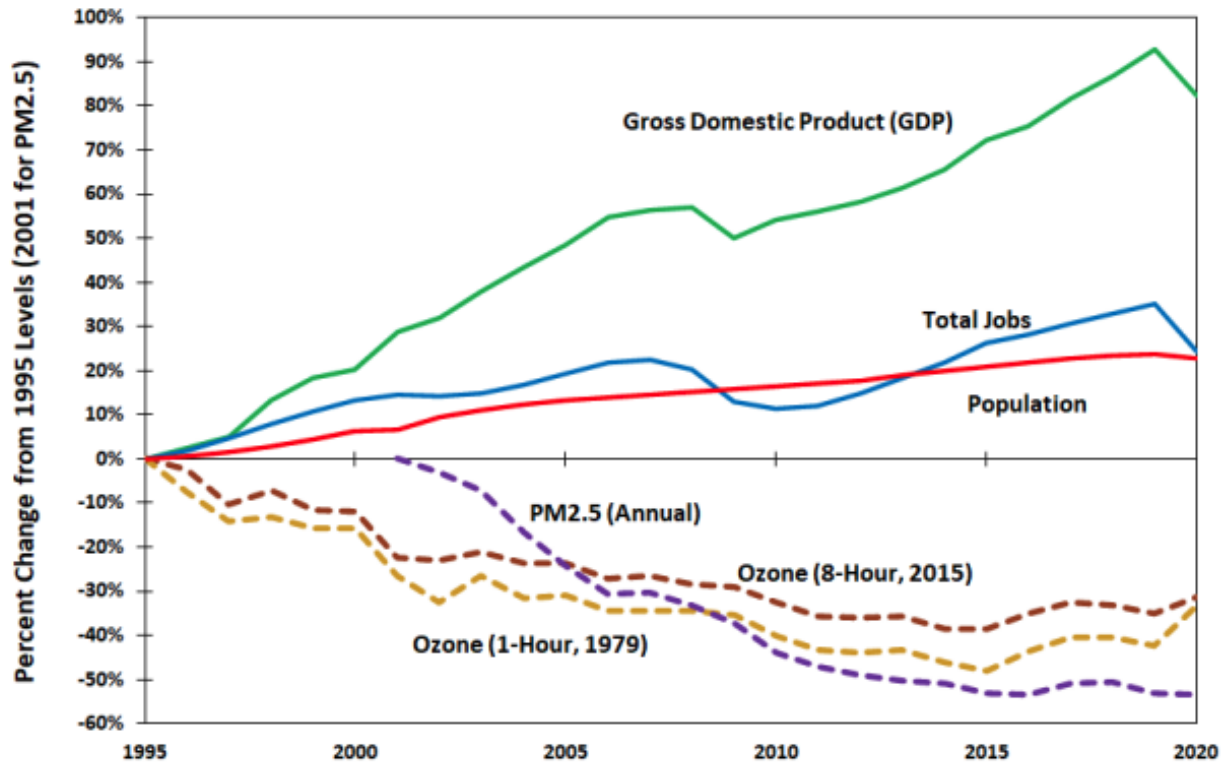
The LA region has primarily relied on FEMA floodplain mapping to assess sites where fluvial (river-based) and pluvial (rain/precipitation-based) flooding converge and create compound coastal flood risk. A recent study by Sanders et al. (2023) presented a detailed analysis of flood risks in LA County, finding that actual exposure to compound flooding is much higher and more inequitable than suggested by federal flood maps. The study combined statistical and high-resolution hydrodynamic modeling of rainfall, streamflow, and storm tides with demographic and socioeconomic data to estimate risks at the parcel level. The results show that between 197,000 and 874,000 people (median 425,000) and $36–108 billion in property (median $56 billion in 2022) are exposed to flooding greater than 1 ft (30 cm) in a 100-year flood event. These projections are associated with significant inequities throughout the region (*Section 5.2.2 Flooding*).

2.6 Air Quality

Another potential hazard associated with climate change in the LA region is an exacerbation of pollution. LA and the surrounding cities experience some of the worst air quality in the United States (US EPA, 2026; SCAQMD, 2026). This results from the high air pollutant emissions from transportation and industry that are trapped near the surface by the prevailing "inversion layer." The inversion layer refers to a layer of the atmosphere, typically a thousand feet or so above the ground, in which temperature increases with height due to cool air near the surface. It is particularly prevalent in the LA region because of cooling of the air near the ground by ocean breezes. Because cool air descends, the inversion layer forms a tight lid on the atmosphere below it, trapping pollution. This situation is exacerbated by the tall mountains surrounding the LA region, preventing the pollution from being dispersed laterally.

Ozone and PM2.5 (airborne particulate matter with aerodynamic diameter less than 2.5 microns in size) are the most well-studied pollutants in LA. These pollutants arise largely from photochemical reactions in the atmosphere of precursor raw emissions (Lu & Turco, 1996; Wakimoto et al., 1986). Exposure to elevated levels of ozone and PM2.5 can lead to significant adverse health effects, affecting most organ systems, including respiratory and cardiovascular (WHO, n.d.; see *Section 5.2.4 Air Quality* for more details on health impacts). It is well established that air quality is heavily influenced by weather conditions that affect removal or dilution, such as improving when it rains and worsening when the atmosphere is stagnant. Thus, under climate change, it is likely that air quality characteristics will change.

Attaining the National Ambient Air Quality Standards (NAAQS), which are federally mandated health-based standards for criteria air pollutants (especially ozone and fine particles, PM2.5), has been a persistent challenge for the LA region, posing health risks for its residents. Nevertheless, progress has been made, with air quality improving over the past decades due to regulatory measures and emissions reductions across various sectors. Despite growth in socioeconomic indicators such as gross domestic product (GDP), employment, and population, ambient concentrations of PM2.5 and ozone have shown a declining trend over the past two decades (**Figure 21**). However, in recent years, disproportionately impacted neighborhoods with significant concentrations of industrial polluting sources have not followed this trend, and more broadly, the rate of this downward trend has stagnated, highlighting the need for sustained efforts. This is especially critical in the face of climate change, which can possibly exacerbate air quality challenges.



Observed Pollution Trends in the LA Region

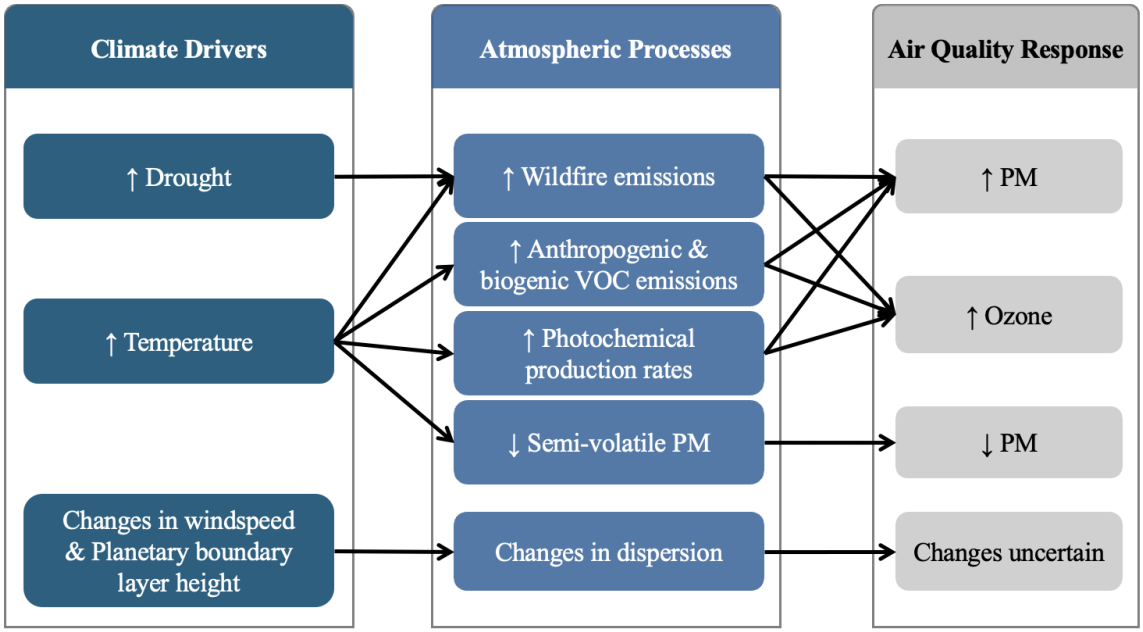
Figure 21: *Percent change in ozone concentrations and socioeconomic variables from 1995 level and percentage change in PM concentrations as compared to 2001 level in the South Coast Air Basin (Figure 1-4 in the South Coast 2022 Air Quality Management Plan; SCAQMD, n.d.).*

Although simulations of air pollution were not conducted for the Fifth Assessment, we review relevant studies that projected air quality trends in the region below. In addition, we analyze relevant meteorological changes based on experiments performed for the Fifth Assessment.

2.6.1 Mechanisms for Climate Change to Affect Air Quality

Climate change influences air quality through multiple mechanisms (**Figure 22**), including increasing human-caused and natural emissions, altering rates and equilibrium of chemical reactions, and influencing meteorological conditions, all of which affect the fate of pollutants in the atmosphere.

The projected increase in temperatures in the LA region (*Section 2.1 Warming*) is likely to impact pollution through multiple mechanisms. Temperature increases can significantly alter both the rates and equilibrium of chemical reactions in the atmosphere, which in turn affects concentrations of ozone and particulate matter (PM). Higher temperatures accelerate photochemical reaction rates, leading to faster production of ozone (Pfannerstill et al., 2024; Pierce et al., 2013). Additionally, elevated temperatures can shift the equilibrium of the thermal decomposition of peroxyacetylnitrate (PAN), a key reservoir of nitrogen oxides (NO_X), thereby releasing more NO_X into the atmosphere (Jacob & Winner, 2009). This further fuels ozone production, since NO_X is a precursor of ozone . For PM, higher temperatures can enhance the evaporation of semi-volatile PM like ammonium nitrate, reducing PM concentrations (Horne & Dabdub, 2017). Emissions of volatile organic compounds (VOCs), particularly those emitted by plants, have also been observed to increase with rising temperatures (Nussbaumer & Cohen, 2020). At elevated temperatures, they become the predominant contributors to both ozone and secondary organic aerosol (SOA) formation, resulting in increased ambient concentrations of ozone and PM. Additionally, certain human-caused VOC emissions also increase with temperature, such as evaporative losses from consumer products and fuels (Pfannerstill et al., 2024).



Mechanisms for Climate Change to Affect Air Quality in the LA Region

Figure 22: *Reduced precipitation can enhance wildfire activity and associated emissions. Higher temperatures can increase human-caused and biogenic VOC emissions and accelerate atmospheric chemical reaction rates, promoting secondary pollutant formation. Temperature-driven shifts in gas–particle partitioning can also reduce semi-volatile PM, leading to decrease in PM (while increasing gas-phase pollutants). Changes in meteorology may alter pollutant dispersion, which further affects PM and ozone, but with more uncertainty.*

In addition to warming itself, climate change is likely to impact air quality through a projected increase of drought (**Figure 10**), during which both ozone and PM increase in the LA region (Wang et al., 2017; Achakulwisut et al., 2018). This results from the combined effects of drought on deposition, chemistry, and natural emissions, such as dust. Perhaps the most significant impact of drought on air quality is the associated increase of major wildfires (*Section 2.3 Water Resources*). Increased frequency, intensity, and duration of fires have led to higher emissions of PM (Xu et al., 2022), as well as NO_x and VOCs (Jin et al., 2023; Wang et al., 2023), which are precursors of ozone (Jaffe et al., 2008; Jacob, 1999). Smoke from wildfires not only affects the burned areas but can undergo long-range transport, affecting the air quality in the entire South Coast Air Basin and beyond. Moreover, if the Palisades and Eaton Fires are an indication of future urban wildfires, smoke will be increasingly toxic (Chapter 5). The LA region may also be impacted by smoke from fires outside of the region, as was the case for the Thomas Fire in Ventura County in 2017. See the Fifth Assessment's "San Diego Regional Report" and "Central Coast Regional Report" for investigations into future fire activity in neighboring regions.

Climate change may influence other meteorological parameters, including surface wind patterns and planetary boundary layer height (PBLH), both of which play a crucial role in pollutant dispersion and transport. In coastal areas, surface wind speeds and PBLH are expected to increase due to climate change during both summer and winter, which would allow the atmosphere to more effectively transport and dilute pollutants (Mahmud et al., 2010), thus reducing pollution

near the surface locally. Conversely, in inland areas (e.g., Riverside County), PBLH is projected to decrease slightly, particularly during winter, which would tend to trap pollutants near the surface. Simulations performed for the Fifth Assessment project a decrease in PBLH in Spring and Fall (**Appendix, Figure A8**), suggesting potential increases in PM2.5 concentrations in the South Coast Air Basin region due to climate change. The change in PBLH is projected to increase in some areas but decrease in other areas, with uncertain impact on PM2.5.

Additionally, climate change may alter land-sea circulation dynamics, which is directly proportional to land-sea temperature contrast, potentially weakening the daytime sea breeze while strengthening the nighttime land breeze. These changes could enhance pollutant removal, reducing summertime pollutant concentrations in the South Coast Air Basin, particularly in coastal areas (Zhao et al., 2011). Simulations performed for the Fifth Assessment in fact predict a weakening of onshore winds for all seasons except summer, with greater reduction inland relative to coastal areas (**Appendix, Figure A9**). This would suggest increases in PM2.5 concentrations for the LA region under the influence of climate change.

2.6.2 Projected Changes in Ozone Concentrations

A few studies have examined the impact of future climate change on ozone concentrations in Southern California (**Appendix, Table A3**). Projections were made using various air quality models, such as CMAQ, UCD/CIT, UCI-CIT, and CAMx. These studies projected the impact for different periods and scenarios, most adopting Representative Concentration Pathways (RCPs; Ramaswamy et al., 2018) 4.5 and 8.5 as future climate scenarios.

In general, these studies projected increases in future ozone concentrations in Southern California, with larger increases for RCP 8.5 (a worst-case scenario for climate change; comparable to the SSP5–8.5 scenario in the Fifth Assessment projections) compared to RCP 4.5 (a realistic scenario for climate change, comparable to SSP3–7.0). For instance, Kim et al. (2015) found that ozone levels in LA County during 2057–2059 would increase by more than 9 parts per billion (ppb) under RCP 8.5 as compared to 2001–2004, but would also increase under RCP 4.5. Given that different studies projected changes in different calendar years, we standardized the change in terms of concentration change per year to make fair comparisons between them (**Appendix, Table A3**). We found inconsistencies among different studies regarding the magnitude of ozone concentration changes. For example, Zhu et al (2019) projected that under RCP 4.5, meteorological changes could increase maximum 8-hour ozone concentration by 13 ppb in the South Coast Air Basin from 2012–2035, while Moghani & Archer (2020) projected increases of lower than 5 ppb from 2016–2050 under RCP 8.5. The differences may be attributed to different climate change scenarios, assumptions for emissions of air pollutants, and choice of air quality models. Regardless, all studies collectively suggest that ozone pollution in the LA region may worsen under future climate change scenarios. Consequently, more stringent air quality control policies may be necessary to mitigate potential health and environmental impacts.

2.6.3 Projected Changes in PM2.5 Concentrations

In addition, some studies have simulated the impact of future climate change on PM2.5 concentrations in Southern California (**Appendix, Table A4**). The studies projected different trends in future PM2.5 concentrations, depending on simulation assumptions and climate

scenarios. Some studies predicted decreases in PM2.5 concentrations, while others predicted increases. For instance, Horne & Dabdub (2017) found that PM2.5 levels in Southern California could decrease by 0.5 μg/m³ with a 1°C temperature increase and by 1.4 μg/m³ with a 3°C increase across Southern California. Similarly, Mahmud et al. (2010) and Sun et al (2015) also projected PM2.5 concentration reductions in LA under climate change scenarios. However, Zhu et al (2019) projected increases in wintertime daily average PM2.5 concentrations under RCP 4.5. Overall, these mixed findings suggest high uncertainty of the impact of climate change on PM2.5 pollution levels in the LA region.

2.7 Compound Extremes

In addition to individual climate hazards, the LA region is especially vulnerable to combinations of different hazards occurring either simultaneously or in quick succession. These so-called "compound extremes" have unique challenges. Studying individual hazards in isolation may underestimate the associated impacts (Fischer & Knutti, 2012; Zscheischler et al., 2018). For example, during the 2012–2016 California drought, the negative precipitation and positive temperature anomalies were both extreme, but in a multi-variate context, the year 2014 was the most extreme on record (AghaKouchak et al., 2014), meaning there had never been a year where high temperature and low precipitation were both so extreme. This combination is particularly damaging for ecosystems (Chapter 3), as well as energy production, agriculture, and water availability (Lund et al., 2003; Zhu et al., 2005; Tanaka et al., 2006; Mandani & Lund, 2010; Connell-Buck et al., 2011; Tarroja et al., 2014). Based on historical thresholds for drought and extreme heat, we projected a regional average 369% and 748% increase in frequency of drought-plus-heat extremes by MC and EC, respectively (**Appendix, Figure A10**).

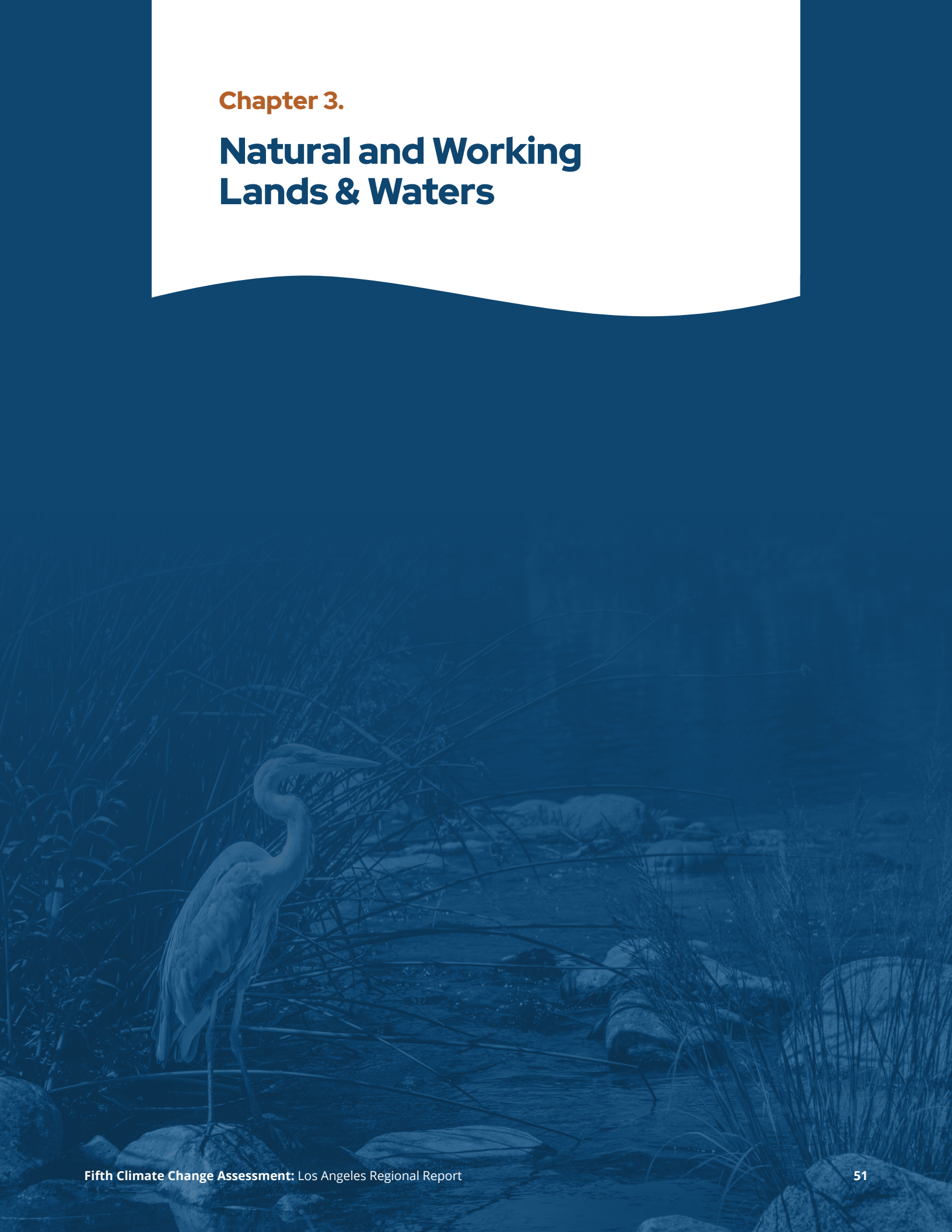
Compound extremes may also arise from precipitation anomalies alone. Recent years offer strong examples of the LA region's characteristic swings between extremely dry and wet conditions (Swain et al., 2018). These include the 2012–2016 drought being followed by one of the wettest years on record in 2017 (State of California, 2021). Drought followed by extreme rain brings unique hazards, including erosion and landslides, particularly in burn scars, given that fires are more likely during the preceding dry conditions (Akosah & Gratchev, 2024). Perhaps the most severe example of this phenomenon is the Montecito mudslides in January 2018, just outside of the LA region, in which heavy rains fell one month after the same ground was burned by the Thomas Fire, claiming 23 lives and causing an estimated $207 million in damages. Within the LA region, this phenomenon has occurred to a lesser extent following the Woolsey, Palisades, and Eaton fires. Based on historical thresholds, we project 16% and 35% increases in the frequency of drought followed by extreme precipitation by MC and EC, respectively (**Appendix, Figure A11**). Thus, the occurrence of heavy rain over burn scars is likely to increase.

Meanwhile, prolonged wet conditions followed by drought are likely to lead to desiccation of the abundant fuels that accumulate during the wet period, which leads to further fire risk (Swain et al., 2025). See *Section 2.4 Wildfire* for more details.

In addition, the LA region is vulnerable to cascading hazards, which refer to a sequence of connected events that lead to unique societal impacts (LA County, 2021). The 2025 wildfires are an example of this phenomenon (Madakumbura et al. 2025a), as discussed in **Appendix, Text A2**. Given that cascading hazards are typically more impactful than individual hazards occurring in isolation, they are used for disaster risk reduction (Pescaroli & Alexander, 2018).

Chapter 3.

Natural and Working Lands & Waters



Key Messages

- Native chaparral is likely to become increasingly stressed due to warming, drought, and wildfire, with corresponding increases in more fire-prone, invasive vegetation.
- Conifer forests in the region are burning more severely, leading to a wide variety of ecological issues, including forest-type conversion.
- Habitat loss (e.g., due to wildfire and subsequent invasive vegetation) is likely to become a major issue for a wide range of species, potentially leading to local extinction.
- Warmer waters will carry an increased threat of water quality hazards along the coast, including harmful algal blooms and ocean acidification.
- The vast majority of wetlands are already lost in the LA region. The few remaining are projected to be nearly completely inundated with moderate sea level rise.
- In this section, we focus on impacts on LA region ecosystems. Although well-adapted to hazards such as drought and wildfire, the region's natural systems have come under increased stress in recent decades as climate change has induced intensification of a wide range of natural hazards.

3.1 Chaparral and Coastal Sage Scrub

California chaparral is the most extensive vegetation type in Southern California (Lippitt et al., 2013; Syphard et al., 2019; Baker & Halsey, 2022). It is found in elevations between sea level and ~7,000 ft (2,000 m), grows on rocky slopes, and generally forms shrubby canopies (Lippitt et al., 2013). Near sea level, typically on south-facing slopes, coastal sage scrub (CSS) is prevalent. While chaparral and CSS are often considered interchangeable, CSS has soft drought-deciduous leaves in contrast to chaparral's hard evergreen leaves. Chaparral and CSS are critical for the ecosystem, stabilizing soil against erosion and regulating the water cycle by recharging groundwater. They also provide a buffer against climate change by removing CO_2 from the atmosphere and storing it for long periods. For Indigenous Peoples of the LA region, chaparral landscapes are home to culturally important species used for food, medicine, tools, and basketry (Anderson & Keeley, 2018). Plant relatives such as white sage (*Salvia apiana*), deergrass (*Muhlenbergia rigens*), and toyon (*Heteromeles arbutifolia*) continue to be gathered and cared for today through traditional stewardship practices, including cultural burning and pruning.

3.1.1 Warming and Drought

The impact of warming on chaparral and CSS is closely related to drought (see *Section 2.2 Precipitation Projections* for precipitation projections). Warming and subsequent lack of soil moisture translates to increased vegetation drying and earlier senescence (vegetation browning), even for chaparral, which is adapted to semi-arid conditions (Dong et al. 2019; MacDonald et al, 2023; Warter et al., 2021). In Southern California, soil-moisture deficits are strongly associated with decreases in Normalized Difference Vegetation Index (NDVI), an effective metric for measuring vegetation health (Okin et al., 2018). This relationship is particularly strong for chaparral, given that it is more dependent on moisture in deeper soil layers than CSS. Thus, prolonged drought, which eventually dessicates those deeper layers, leads to die-off of chaparral. For chaparral, there

is a negative correlation between elevation and sensitivity of NDVI to drought (Okin et al., 2018). Therefore, the lowest elevations at which chaparral exists are likely to be particularly vulnerable.

When a drought occurs in a warmer climate, there is a lower baseline of soil moisture, so that the same drought in a warmer climate leads to greater aridification than in a cooler climate, and, consequently, greater vegetation stress (MacDonald et al., 2023; Berg & Sheffield, 2018; Jiang et al., 2025). This compound impact was experienced in both the 2012–2016 (Warter et al., 2021) and 2020–2022 (Jiang et al., 2025) droughts. Thus, even if meteorological droughts (years of low precipitation) stay the same, they will lead to greater desiccation than historically. Consequently, droughts are likely to cause more die-off of chaparral than has been observed in the past. However, climate models predict an increase in dry years in the LA region (**Figure 10**), implying that chaparral may be doubly threatened by the combination of warming and increased drought.

Soil-moisture deficits also modulate chaparral's recovery from fires. Prior to 2012, a prolonged wet period in Southern California, vegetation recovered rapidly in burned areas but slowed significantly during the subsequent 2012–2016 drought (Kibler et al., 2019). Thus, the impacts on chaparral of warming and more intense/prolonged droughts are likely to be felt even more strongly following fires, which themselves are expected to become more intense, frequent, and widespread (*Section 2.4 Wildfire*).

3.1.2 Extreme Rainfall

An increase in extreme wet conditions (**Figure 10**) is likely to increase flooding in the wildlands of the LA region and impede recovery of chaparral from drought and wildfire. This is particularly likely under "drought-busting" storms, when the soil has become hardened by drought and is thus less absorptive to the subsequent heavy rains. Thus, under the expected future climate with more volatile precipitation, rain will be increasingly likely to fall on drought-stricken soils, which will be more likely to lead to erosion and chaparral die-off. This effect will be amplified in burn scars, where the ground is even less absorptive.

3.1.3 Wildfire

The increasingly frequent and severe wildfires have caused degradation of chaparral (Safford et al., 2022; Molinari et al., 2018). Chaparral is dependent on periodic fire to regenerate (Barro & Conard, 1991), but an increasingly short fire interval (5–10 years) does not allow chaparral to fully regenerate between burns, some of which require up to 40 years to do so. (Lippitt et al., 2013; Safford et al., 2022; Syphard et al., 2019; Baker & Halsey, 2020; Grupenhoff & Molinari, 2021). However, there can also be too much time between burns, given that chaparral becomes more flammable over time, which was a factor in the Palisades Fire, where most of the affected area had not burned for almost 50 years.

Meanwhile, the degradation of chaparral resulting from wildfire, warming, drought, and flooding encourages the growth of non-native grassland and exotic weeds, which are generally more fire-prone (Park et al., 2018; Fusco et al., 2018; Syphard et al., 2019; Baker & Halsey, 2020; MacDonald et al., 2023). This process is known as vegetation type conversion and described by Indigenous practitioners as a disruption of reciprocal relations between fire, plants, and people. It is creating a feedback loop in which increasingly frequent wildfires are converting native

chaparral to grassland, which is more likely to act as fuel for future wildfires (Syphard et al., 2019; Keeley & Syphard, 2018). Type conversion is already occurring in Southern California, and climate projections predict a continuation of this trend (Molinari et al., 2018).

In addition to climate change, chaparral faces threats from humans, for example the poaching of white sage. This is a traditional medicine for Indigenous Peoples and, like other chaparral species, is critical for the health of the ecosystem. The demand for white sage to be sold commercially has given rise to illegal poaching from wildlife reserves. This demand is often at the expense of the Indigenous Peoples, who lack land to grow their own. Due to the unsustainable practices being used to cultivate it, along with poaching, conservationists are concerned about the future survival and distribution of the species. Collaborative restoration projects with Tribes that center Indigenous fire, gathering, and propagation practices offer potential pathways for increasing resilience and renewing cultural relationships with chaparral landscapes.

3.2 Conifers

Conifer forests in the LA region are primarily found in the higher elevations of the San Gabriel, San Bernardino, and San Jacinto Mountains, where precipitation is greater and temperatures are lower than in the surrounding valleys and foothills. These forests are dominated by species such as Jeffrey pine, ponderosa pine, incense cedar, and white fir. These ecosystems are critical for regional biodiversity, hydrological regulation, and carbon storage. They provide essential wildlife habitat, protect soils and watersheds, and contribute to local watersheds by enhancing infiltration and snow retention.

While both chaparral and conifer forests are subject to wildfire, Southern California's conifer forests have a different relationship with wildfire. Conifers generally grow at elevations greater than 5,000 ft (1,500 m) and coexist with foothills and valleys of chaparral, oak woodland, and grassland (Nigro & Molinari, 2019). They also thrive with high precipitation levels, but seem to be less sensitive to a lack of water than chaparral (Kibler et al., 2019; Wang et al., 2022).

Climate change, together with historical fire suppression, has significantly threatened conifer forests. The healthy, pre-suppression fire interval for Southern California conifers was around 14 years (Nigro & Molinari, 2019). Today, half of the conifer forests in the region have not burned in over 100 years, creating a buildup of burnable fuel. These high fuel loads have allowed high-severity crown fires, where the upper canopies of mixed-conifer forests are burned (Kibler et al., 2019; Nigro & Molinari, 2019). Thus, today's fire regime in Southern California's conifer forests is characterized by less frequent, higher severity wildfires (Wang et al., 2022; Nigro & Molinari, 2019; Safford et al., 2022). Perhaps the most prominent recent example is the Bobcat Fire in 2020, burning 115,997 acres, most of which had not burned for 50 years. Severe burning in conifer forests causes soil erosion, stream sedimentation, and other negative consequences on forests' biogeochemical cycles (Safford et al., 2022). Higher severity wildfires also contribute to forest fragmentation as conifer recovery relies on the survival of nearby mature trees (Safford et al., 2022; Nigro & Molinari, 2019). Issues like these may eventually lead to forest type-conversion, and in many areas, replanting will be necessary to restore conifer forests in Southern California (Safford et al., 2022; Nigro & Molinari, 2019). To quote the chair of the LA City/County Native American Indian Commission, "… western-style fire suppression has contributed directly to the current state of ecological imbalance and catastrophic wildfire severity."

Meanwhile, warming is likely to bring an increased threat of disease from exotic pests (Logan, 2007). The time frame of insect adaptation to climate change (years) is much shorter than for the forests (decades). Thus, outbreaks of forest insects, particularly bark beetles, have been occurring at unprecedented levels throughout western North America, which threatens biodiversity and could lead to the loss of entire ecosystems.

3.3 Wildlife

Warming, changes to precipitation, and increased wildfire are expected to have a wide range of effects on Southern California wildlife.

3.3.1 Range Shifts

Across species, projected range shifts generally follow climatic niches, moving poleward and upslope in elevation (Chen et al., 2011; Freeman et al., 2018; Koot et al., 2022). Southern California's pronounced topographic diversity means that species can access markedly different temperature and precipitation regimes over short geographic distances, often by shifting upward along mountain gradients.

However, upward shifts in elevation are often accompanied by reductions in available habitat area (see Elsen & Tingley, 2015, for a global analysis). As populations track suitable climate upslope, they often become smaller and more spatially isolated (MacDonald et al., 2024a, 2024b). Although persistence at higher elevations may give the appearance of stability, increased vulnerability to random events, inbreeding, and reduced adaptive potential can all increase extinction risk (Templeton et al., 1990; Reed, 2003; Staude et al., 2020). This is particularly well-documented in butterflies, whose populations and movements have been shown to be indicative of the impact of climate change on habitats and biodiversity (Fleishman & Murphy, 2009; MacDonald et al., 2017, 2024a; Kerner et al., 2023; Chowdhury, 2023). For example, long-term monitoring in the Sierra Nevada documented significant upward shifts in butterfly elevational ranges, alongside pronounced species richness declines at lower elevations where habitat loss (both due to land use and climate change) is greatest (Forister et al., 2010).

This trend is projected to continue under further warming, threatening the persistence of even the highest-elevation alpine species (Matsunga et al., 2026). Distribution records of the endangered Quino checkerspot butterfly (*Euphydryas editha quino*) in Southern California document climate-associated range shifts to higher elevations (Parmesan et al., 2015). A similar pattern may unfold across the San Gabriel, San Bernardino, and San Jacinto mountain ranges for many species. Here, even under a best-case scenario, species are likely to persist in progressively smaller, more isolated populations with elevated extinction risk.

For wildlife, there will likely be both climatic "winners" and "losers." For example, downscaled climate projections for Southern California indicate that high-elevation, cold-water riparian assemblages are likely to contract as stream temperatures rise and flow regimes shift, whereas lower-elevation, warm-water taxa are projected to expand, reflecting species-specific responses to altered hydrology and thermal conditions (Rogers et al., 2020). In general, it is reasonable to predict that species with highly specialized habitat requirements or limited diets will be

most severely constrained in their capacity to relocate or adapt (Inouye, 2020; Filazzola et al., 2020). For fragmented populations that persist but become increasingly small and genetically limited through increasing inbreeding, genetic rescue—the deliberate movement of individuals among populations to restore gene flow and increase genetic diversity—may represent a viable intervention (Weeks et al., 2011; Ralls et al., 2020). Conservation genomic tools can quantify inbreeding and loss of adaptive variation to determine whether such intervention is warranted (Shaffer et al., 2022; MacDonald et al., 2025). It is also important to consider that population responses and realized range shifts will not be determined by climate change alone; movement and dispersal limitations, biotic interactions, land-use fragmentation, and microclimatic variation may shift responses relative to modeled projections (Travis et al., 2013; Urban et al., 2016; MacDonald et al., 2024a).

3.3.2 Wildlife and Fire

Wildlife in Southern California is well-adapted to wildfire, but the emerging levels of fire severity and extent are increasingly causing habitat destruction. Wildlife is most threatened not by the immediate flames, but by the long-term impacts of wildfire. Fires remove vegetation and logs, leaving animals more vulnerable to heat and predators, and cause hydrological changes that disrupt ecosystems and reproductive processes. Relevant studies specific to the LA region are very few, but statewide findings are likely to apply. Over the extreme 2020–2021 fire seasons in California, 100 vertebrate species experienced fire across at least 10% of their geographic range, 16 of which were species of conservation concern (Ayars et al., 2023). When fire regimes rapidly change, wildlife is unable to respond appropriately, leading to population declines (Kelly et al., 2020). Bird populations in particular have been shown to decline in California forests in and around severe burn zones (Steel et al., 2022). In addition, many species, such as native lizards, snakes, and insects, rely on chaparral for foraging, thermoregulation, and to escape predators (Jennings, 2018). Thus, as fire frequency and invasive grass expansion increase, habitat connectivity and overall suitability for a wide range of wildlife are likely to decline.

Wildlife has long been of cultural, spiritual, and ceremonial significance for the Tongva and other Indigenous Peoples. Animals are viewed as part of a shared ecosystem, rather than a resource or commodity for humans (Salmón, 2000; Barrett & Ham, 2019). The destruction of habitats and shifts in species distribution that have occurred since colonization have disrupted these sacred relationships and impacted ceremony and place-based responsibilities. This trend has been further amplified by the levels of wildfire experienced in recent years. Whereas cultural burning led by Tribes enhances habitats, recent destructive fires have made large swaths of land uninhabitable for a wide range of species for extended periods.

Mountain lions in particular have long faced human-caused threats due to their proximity to high-density human developments. In Southern California, they are currently experiencing low genetic diversity, putting them in danger of extinction (Gustafson et al., 2022). They tend to avoid recently burned areas, often traveling significantly farther in search of suitable habitat, including an increase in road and freeway crossings, greater activity in the daytime, and greater overlap of territory (Blakey et al., 2022). This increased travel often pushes them deeper into human-dominated landscapes, heightening the risk of dangerous encounters with people or vehicles. This issue was exemplified by the famous P-22, who traveled from the west Santa Monica Mountains

to reside in Griffith Park of LA, successfully crossing multiple freeways to arrive there. However, he was ultimately euthanized after suffering traumatic injuries following a vehicle collision.

Mountain lions and other predators are also impacted by the loss of vegetation following major fires. In a study focused on mountain lions in Orange and San Diego counties, the majority of successful kills following a wildfire occurred in unburned areas, underscoring their avoidance of burned areas, especially for hunting (Jennings et al., 2016). Greater awareness of this issue is increasing efforts in habitat connectivity in the LA region. Perhaps the most high-profile example is the Wallis Annenberg Wildlife Crossing over the 101 freeway in Agoura Hills, expected to be completed in 2026.

The 2025 LA County fires highlighted the growing challenges wildlife face as wildfires in the region become increasingly extreme and frequent. The status of many species in the aftermath of the 2025 fires remains largely unknown. One critical issue is air, soil, and water pollution, particularly from urban-area fires, where toxic metals and synthetic materials from infrastructure are released into the ecosystem. These pollutants pose serious health risks to wildlife, especially birds. Given that the toxic debris was washed into the ocean by the subsequent rains, the resulting ocean pollution may lead to severe impacts for the LA region's coastal and marine fauna. In addition, the loss of tree cover and shade has created drier conditions, threatening the survival of amphibians and other moisture-dependent organisms. Many amphibians and fish rely on deep breeding pools, which were already dwindling due to low precipitation and declining water levels even before the fires. Natural pools were further destroyed or severely impacted as post-fire sediment, ash, and mud clogged the streams. These species now face a race against time, and their survival will depend on whether their populations can persist long enough for stream systems to recover and flow again (Sorokin, 2025).

3.4 Coastal Wetlands

Coastal wetlands, including marshes, are vital ecosystems along the California coast, providing critical habitats, numerous ecosystem services, and sustaining long-standing Tribal cultural relationships and stewardship practices (Adam, 2019; Broome et al., 2019; Friends of Ballona Wetlands, n.d.). Coastal wetlands are shaped by their biological and geological elements, providing coastal protection from flooding and erosion, water purification, and carbon sequestration. When their natural processes begin to break down due to submersion by sea level rise (*Section 2.5 Coastal Hazards*), an insufficient sediment supply, and a lack of space to migrate to higher elevations, this storage can instead become a significant carbon source, highlighting the importance of conservation and restoration efforts for these systems (Temmink et al., 2022).

Indigenous Knowledges, alongside historical records, indicate that the vast majority of wetlands in the LA region have been lost over the past 150 years due to urbanization, channelization, and land conversion (Stein et al., 2014). For millennia, the region's wetlands were stewarded by Indigenous Peoples and relied upon for marsh plants such as tule as part of complex land and water management systems that supported ecological function, food systems, and cultural responsibilities. Recognizing this historical loss and disruption of Indigenous stewardship is critical when considering the accelerating impacts of sea level rise, which are already being observed in the region (Thorne et al., 2024; Alizad et al., 2018; Doughty et al., 2019; Doughty et al., 2024).

The state estimates that the annual economic value of wetlands in California (even in their highly impacted state, reduced to 10–15% of their historical coverage) is between $6.3 and $22.9 billion. These values are based on ecosystem services like flood control, water purification, nursery habitat for commercially and recreationally important fish and shellfish species, recreation value, and Tribal cultural significance (California Wetland Monitoring Workgroup, n.d.). The rest of this section focuses on the current ecological science of sea level rise's impacts on coastal wetlands, but we acknowledge that additional ecological threats to wetlands are accompanied by recreational, cultural, and Tribal loss of these important habitats and resources.

3.4.1 Physical Impacts of Sea Level Rise on Coastal Wetlands

Rising seas could result in coastal wetland drowning within decades across much of the United States, including in California (Osland et al., 2024; Thorne et al., 2018). Sea level rise projections show almost complete inundation of many of the LA region's wetlands, such as the Malibu Lagoon and the Ballona and Bolsa Chica wetlands, with 19.7 in (50 cm) of sea level rise (**Figure 19**; Doughty et al., 2019; Southern California Wetlands Recovery Project, 2018; Stein et al., 2020).

The resilience of tidal marshes to sea level rise along the US Pacific Coast is an active area of new modeling (Marcot et al., 2023), and understanding marsh elevation and accretion processes (the buildup of sediment) is crucial for assessing vulnerability across California's varied climate and geography (Thorne et al., 2024). Small river mouth estuaries may be especially vulnerable to the expected changes in watershed runoff and sea level rise. These smaller systems, seasonally closed by bar formation, make up the vast majority of the approximately 110 coastal wetlands in Southern California (Southern California Wetlands Recovery Project, 2025b; Whitcraft et al., 2026).

A recent study by Thorne et al. using long-term, statewide monitoring of accretion and subsidence rates demonstrated that some marshes, particularly those in the Southern California region, are currently able to accrete at or above the pace of sea level rise (Thorne et al., 2024). However, current projections expect the rate of sea level rise to increase from 3.6 mm/yr to 10–20 mm/yr in 2100 (IPCC, 2021). Given that the availability of space for landward retreat is limited by the surrounding geography and encroaching development, especially along the highly urbanized coast of the LA region, these accelerating rates can exceed the buffering capacity of these systems and result in increased vulnerability and loss of ecosystem function (Southern California Wetlands Recovery Project, 2018).

Improving the understanding of the response of these systems requires long-term monitoring, which can be challenging to maintain over a long time. Analysis of data collection via remote sensing techniques shows its capacity for far greater reach with limited resources. While not a replacement for field data, these data sources show promise in providing the decision-makers with broader context and understanding (Ganju, 2024). Coupled with improving modeling techniques, these methodological improvements enhance our ability to predict responses to future conditions and guide restoration design and conservation management (Gourgue, 2022).

3.4.2 Biological Impacts of Sea Level Rise on Coastal Wetlands

In addition to climate change-driven geomorphological impacts on coastal wetlands, there are numerous biological impacts to consider. Climate change-induced stressors on wetland species include but are not limited to: increasing air and water temperatures, increased salinity, changes in rainfall patterns, and changes in habitat and food supply (Burger, 2020). Climate change could affect species distribution, ecosystem function, physiology, and adaptation strategies (Colombano et al., 2021).

A wide range of organisms face growing climate change challenges (Burger, 2020). This is true especially in urban landscapes along the Southern California Bight (e.g., Ballona Wetlands, LA River Estuary, Upper Newport Bay), where there is no room for wetlands to expand inland when sea level rises (Burger, 2020). Many estuarine and coastal bird species are vulnerable to sea level rise, which threatens vital habitat used for nesting, foraging, and migration (Burger, 2020). For example, Belding's savannah sparrows (*Passerculus sandwichensis beldingi*) face habitat vulnerability and potential regional extinction as most of their habitat in Southern California is projected to be gone by 2100 (Brand et al., 2022; Rosencranz et al., 2019; Rosencranz et al., 2018). In some cases, climate change combined with other stressors puts added stress on some species, such as the case with native plants like *Cordylanthus maritimus* (Salt Marsh Bird's Beak) in Upper Newport Bay, that is threatened by both sea level rise and invasive species (Spear et al., 2025).

Fish that depend on coastal wetlands will also be affected by the ability of these habitats to adapt to sea level rise. The Tidewater goby and the Southern California Steelhead are two federally listed species in the region that use coastal wetlands as critical habitat at several life stages (Swenson, 1999). Tidewater goby spend their relatively short lifespan in brackish coastal lagoons, estuaries, and marshes, and may be particularly vulnerable to future changes to streamflow and habitat degradation (Cromwell et al., 2025). Southern California Steelhead, one of the southernmost steelhead populations in North America, have been traditionally, economically, and culturally important to Indigenous Peoples in this region for millennia (NOAA Fisheries, 2025). Historically migrating from the Pacific Ocean to inland tributaries, including the San Gabriel Mountains, steelhead have been impacted by habitat alteration (e.g., the Rindge Dam), increasing surface water temperatures, and changing river flows due to drought and snowmelt impacts (Crozier et al., 2019). The southernmost populations have already experienced severe declines, and, without significant intervention, may face extinction in the near future (Katz et al., 2013). Seasonal lagoons and estuaries are an important habitat for juvenile steelhead (Bond et al., 2008), so sea level rise, especially in areas where there is no room for inland migration of the wetland, could be dire.

3.5 Coastal Water Quality

Coastal water quality is vital to the health of the LA region's marine ecosystems, fisheries, and humans (Schiff et al., 2019; Koehn et al., 2022; Moore et al., 2024). Ocean warming can contribute to the expansion of certain harmful algal blooms, particularly toxic ones (Griffith et al., 2019; Gao et al., 2021; Trainer et al., 2020a; Trainer et al., 2020b). Additionally, up to 25% of human-caused atmospheric CO_2 is taken up by the ocean, leading to ocean acidification, which has consequences for a variety of species in marine ecosystems (Doney et al., 2020).

Coastal water quality is also affected by nutrient and contaminant inputs from land, which are in turn affected by climate hazards. For example, sediment and microbial levels were substantially elevated in the ocean around the LA region following the Woolsey Fire in 2018 (Cira et al., 2022), which was likely dwarfed by the levels of pollution and contamination following the Palisades Fire. And, although not studied in the LA region, more extreme precipitation events are likely to increase toxic runoff from agriculture and sewers (Rik Oldenkamp et al., 2024). Most acutely, land-based nutrient inputs contribute to coastal eutrophication, or an overgrowth of algae, exacerbating acidification and oxygen loss in upwelling systems like the Southern California Bight (Kessouri et al., 2021; Ho et al., 2023).

The following sections provide more information on harmful algal blooms and ocean acidification. In addition, although not caused by climate change, oil spills and dichlorodiphenyltrichloroethane (DDT) contamination also impact coastal water quality in the LA region, and should be considered in combination with the climate impacts. Thus, oil spills and DDT are discussed in the **Appendix, Texts A3 and A4**.

3.5.1 Harmful Algal Blooms

The LA region's coastal ocean is highly productive, with hundreds of different genera of phytoplankton that serve as the base of the marine food chain. Upwelling of nutrient-rich waters drives semi-annual phytoplankton blooms in early spring and late summer/early fall (Venrick et al., 2015), most of which are beneficial and contribute to the regional high productivity and biodiversity. However, some algal blooms can be "harmful," either because they produce toxins or because they use all of the oxygen in the water, causing other species to die. Harmful algal blooms (HABs) also prevent Tribal access to traditional coastal foods and shell material for regalia.

Two species of phytoplankton that often make the news, *Pseudo-nitzschia sp*. and *Alexandrium catenella*, can produce toxic compounds (domoic acid and saxitoxin, respectively) that are released during large blooms and bioaccumulate up the food chain, leading to severe illness and death in marine mammals, marine birds, and sometimes humans. Another species, *Lingulodinium polyedra*, can form large blooms known colloquially as a "red tide" and can lead to low oxygen conditions or spur bacterial growth. This can lead to impacts across the ecosystem, including large-scale fish die-offs, such as in May 2020 (Rogener, 2020).

The California Cooperative Oceanic Fisheries Investigations (CalCOFI) has conducted routine phytoplankton studies since 1990, tracking seasonal shifts, interannual variability, and regional and climate changes (Venrick et al., 2015). The Southern California Coastal Ocean Observing System (SCCOOS) and California HABMAP, a statewide HAB network and forecasting system, track abundances of algal species, providing real-time monitoring at recurring sampling sites and predictions of when and where HAB blooms may occur. The California Department of Public Health monitors HABs and issues advisories to mitigate the risk of potential human health impacts, such as paralytic shellfish poisoning.

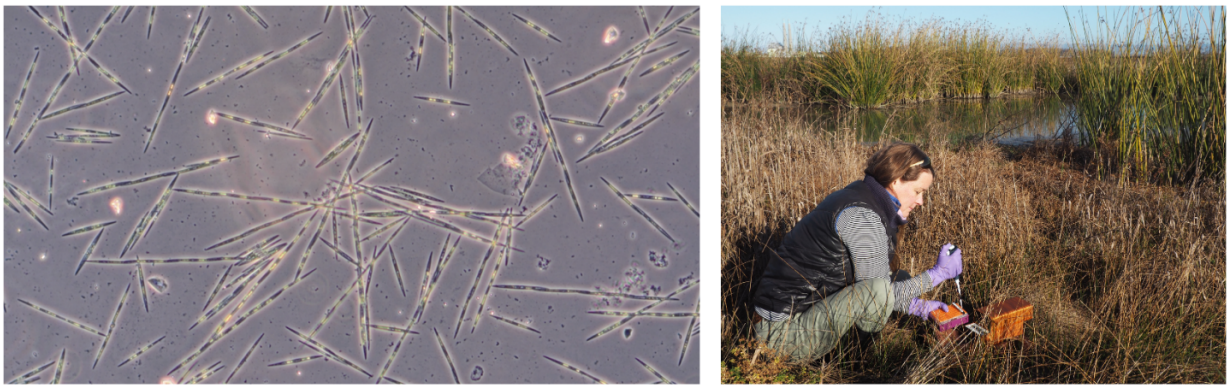
Since the FourthAssessment, the first effort to quantify HAB events across the US was published, showing that the frequency, scope, and variety of toxins associated with HABs have all increased over the last 30 years (Anderson et al., 2021). This is true for the California coast, and scientists point to ocean warming and changes in circulation patterns associated with climate change as

primary drivers of these increases in HAB intensity, frequency, and size (McKibben et al., 2017; Gobler, 2020; Anderson et al., 2021).

Southern California experienced four consecutive HAB events between 2021–2025. Most notably, a February-March (with lingering effects into April/May) 2025 *Pseudo-nitzchia sp*. HAB event was the longest and deadliest bloom period on record, with more than 1,670 stranded marine mammals (over 1,250 in LA, Ventura, and Santa Barbara counties) and major impacts on sea lions, dolphins, and seabirds. Elevated domoic acid levels were detected in sardine and shellfish tissue, leading to state fishery restrictions and advisories. Blooms persisted into autumn, with highly elevated toxins and animal strandings well beyond the typical peak period. Research shows these blooms were fueled by a "perfect storm" of cold-water upwelling (with higher nutrient concentrations) and nutrient-rich runoff exacerbated by winter wildfires near LA.

Researchers are working to better characterize and model the impacts of climate change on the formation and potential increase in HABs. Recent research on *Pseudo-nitzschia australis* blooms (**Figure 23**) found that while it grew equally well under simulated upwelling and marine heat wave conditions, toxin production occurred primarily during upwelling treatments. Using seawater from the long-standing San Pedro Ocean Time Series, researchers determined that nutrients were the most influential drivers of domoic acid production, while temperature and CO_2 had less impact (Kelly et al., 2023). Other research has shown that another species of *Pseudo-nitzschia (P. multiseries)* shows a strong capacity to adapt to rising ocean temperature and acidity (Xu et al., 2023).

Researchers are investigating the use of new, rapid, portable detection technology for HAB species that threaten California coastal ecosystems (Nishimura et al., 2021, **Figure 23**), greatly enhancing sampling efforts on management-relevant temporal and spatial scales. Research is also underway to find genetic markers that can identify toxin-producing *Pseudo-nitzschia* with the goal of providing advanced warning for subsequent blooms (Brunson et al., 2018).



Harmful Algal Bloom Detection

Figure 23: *(Left) Pseudo-nitzschia pungens cells under the microscope (Photo credit: Kyla Kelly). (Right) Dr. Holly Bowers of California State University, San Jose, in the field testing her HAB rapid, portable detection technology (Credit: Bowers Lab).*

3.5.2 Ocean Acidification

Ocean acidification (OA) is a significant and ongoing consequence of atmospheric CO_2 absorption by the ocean, affecting marine ecosystems and the human communities reliant on them (Doney et al., 2020). OA is driven by human-caused carbon accumulation in the atmosphere that is ultimately absorbed by the ocean. This alters the ocean carbon chemistry by lowering the pH (increasing the acidity). Although a 37-year time-series in Southern California shows seasonal nearshore OA and deoxygenation (Osborne et al., 2020; Wolfe et al., 2023; Kekuewa et al., 2022), additional climate change-induced OA poses a serious, growing threat to the coastal ecosystem.

OA can have impacts on important commercial and recreational fishery species, some of importance to Tribal groups, and even whole kelp forest ecosystems (Donham et al., 2021). OA also adversely affects calcifying organisms, such as wild shellfish populations and mariculture (Doney et al., 2020), and there is a great deal of investment into researching the effects of OA on various marine lifeforms (Arroyo et al., 2022). Pteropods (shelled sea snails) are particularly impacted, making thinner shells in the upwelling region of the California Current Ecosystem, such as along the LA coastline (Mekkes et al., 2021). California mussels, used as bio-indicators of OA (Gaylord et al., 2018), also show vulnerability (Rose et al., 2020). Some recent work shows that seagrass meadows offer some buffering potential against OA (Nielsen et al., 2018; Pacella et al., 2018; Koweek et al., 2018).

Researchers are also investigating the combined impacts of OA and HABs (Asefi et al., 2018; Feeley et all., 2024; Feeley et al., 2018; Sunday et al., 2022; Turner et al., 2021) in the coastal ecosystem, especially on calcifying organisms in the earliest life stages. Early work shows that commercially and ecologically important red sea urchin larvae are vulnerable to co-occurring OA and hypoxia at ecologically relevant conditions encountered currently and in the near future along the California Current Ecosystem (Nguyen et al., 2025).

Chapter 4.

Built Systems



Key Messages

- Energy demand during extreme heat events, particularly for air conditioning, is likely to put an unprecedented strain on regional energy systems.
- Reductions in snowpack, together with an increase in year-to-year precipitation variability, will bring major challenges both for flooding and capturing of water in reservoirs.
- Due to climate impacts in remote regions, water imports to LA during dry years are expected to be reduced by 7% and 13% by MC and EC, respectively, assuming current policy and infrastructure.
- In the absence of significant adaptation, similar structural and economic losses as in the 2025 fires are likely to recur.
- Home insurers are increasingly pulling out of fire-prone areas, which could make large parts of the region economically untenable for many people.
- Sea level rise, when combined with rare coastal surges, is likely to threaten billions of dollars' worth of coastal infrastructure, including roads and housing.

In this chapter, we investigate the anticipated impacts of climate change on the LA region's infrastructure and economy. Extreme heat, flooding, drought, reduced snowpack, and wildfires are all likely to impact built systems throughout the 21st century at unprecedented levels. These impacts are expected to be felt in the region's energy systems, reservoirs, flood management systems, housing, and public infrastructure, with significant economic consequences for both the public and private sectors.

4.1 Energy Resources

The LA region has a highly concentrated electricity demand that is geographically constrained and heavily dependent on a limited number of transmission pathways for imported power (DOE, 2002). This energy conveyance infrastructure is managed through a complex, multi-jurisdictional framework primarily dominated by the LA Department of Water and Power (LADWP), the nation's largest municipally owned utility (MOU), and Southern California Edison, a major investor-owned utility (IOU) (Long et al., 2011). These entities operate under the oversight of various state and federal bodies, including the California Independent System Operator and the Western Electricity Coordinating Council, which coordinate the long-distance transmission flows that sustain the basin's economic activity (Nethercutt & Devon, 2021). The physical and operational characteristics of the LA region's electrical grid render it acutely vulnerable to the intensifying effects of climate change (Doss-Gollin et al., 2023). The system's architecture, while historically robust, was designed for a stable set of climatic conditions that are rapidly transforming. Today, the grid must navigate the intersecting threats of extreme heat, catastrophic wildfires, precipitation volatility affecting hydroelectric reserves, and sea level rise threatening coastal assets (Gerlak et al., 2018).

4.1.1 Impacts to Electrical Generators

Different classes of electrical generators exhibit different vulnerabilities due to climate (Sathaye et al., 2012). For traditional thermal generators, which produce electricity from the combustion

of fossil fuels (most commonly gas in California), the principal operational concern is the effect of increased ambient air and water temperatures on plant efficiencies (van Vliet et al., 2016). The amount of useful energy that can be extracted from a combustion process is, in part, determined by the temperature gradient between the interior and exterior of the combustion chamber. If the temperature of the ambient air or water that is being used to cool a thermal plant increases significantly (as anticipated due to climate change), this effectively reduces what is known as the "heat rate" of the facility, requiring it to burn more fuel to produce the same quantity of electrical power (Bartos & Chester, 2015). This is a particularly pernicious issue for grid operations, as this class of generators tends to be relied upon most during periods of extreme heat, when they are temporarily called into service to respond to peak electricity demands. Nuclear generators, which do not involve combustion processes and more typically serve base load power demands, are also considered to be another type of thermal generator. Thus, they are similarly likely to incur efficiency penalties from increases in the ambient temperature of their cooling water supplies (Linnerud et al., 2011).

Another important class of electrical generators whose operations can be significantly impacted by climate change is large hydroelectric stations (i.e., dams) (Tarroja et al., 2019). These facilities produce power by allowing water stored in a surface reservoir to flow down through a turbine, under the force of gravity. In addition to the value of the power that these facilities actually generate over a given period, they also play an essential role in the operational resilience of the grid by providing ancillary services (Forrest et al., 2018). A key type of service is known as spinning reserve. This is when a generation facility with rapid ramping capabilities (such as a hydro station) is contracted to function as a backup to another large generator station of equivalent size if its operations are unexpectedly disrupted. This is a protective measure taken by grid operators to ensure that an unexpected failure of a single generation facility does not result in a cascading grid outage. Large hydroelectric facilities have historically been well-suited to function as spinning reserves for other generator classes due to their unique combination of high power output ratings, large energy storage capacities, and rapid response rates (~ seconds) (Sousa et al., 2005). Changes in precipitation and ambient temperatures resulting from climate change can significantly reduce the amount of water available to recharge reservoirs (Tarroja et al., 2016). This can negatively impact their ability to provide both power and other ancillary services (e.g., spinning reserves, frequency and voltage regulation, etc.) for the electrical grid, particularly when there are other competing uses for this water (e.g., recreation, downstream flows, etc.).

Renewable generators may also be vulnerable to climate change (Schaeffer et al., 2012). The two technologies that currently dominate in the LA region are solar photovoltaics (PV) and, to a lesser extent, wind (Barbose, 2024). Relative to PV, silicon-based panel output efficiencies are well-known to be negatively impacted by higher temperatures (Iqbal et al., 2022). This means that the actual outputs of large PV arrays can be "de-rated" relative to their nameplate capacities if they persistently experience temperatures in excess of those assumed in their design. In terms of wind power, turbine facilities tend to be less significantly affected by extremely high temperatures. However, wind farms tend to be positioned in locations where they maximally exploit historically prevalent wind patterns, for example, in the San Gorgonio Pass, on the border of the LA region. Wind speeds and directions are driven by pressure gradients, which are closely related to temperature gradients. Thus, given that temperature gradients may be altered by climate change in the LA region, for example, with greater warming expected farther inland (**Figure 6**), the power outputs of stationary turbines may be impacted (Martinez & Iglesias, 2024).

4.1.2 Impacts on Electrical Transmission and Distribution Infrastructure

The LA region is particularly dependent on above-ground, high-voltage transmission lines for imported electrical power. These transmission corridors run long distances (typically, hundreds of miles) through unpopulated wilderness terrain. From a design standpoint, the vast majority of these lines make use of bare (un-insulated) braided aluminum cables as conductors, relying on ambient air for their insulation. Such designs are inherently vulnerable to multiple types of climate-related hazards. Most significantly, this infrastructure can function both as an ignition source for wildfires as well as a target of wildfire damage. In the former case, ignitions can commonly occur as a result of electrical arcing caused by "ground faults," where an energized line makes contact with ungrounded foreign objects (e.g., trees or other vegetation), resulting in arcing and fire. This most frequently occurs during extreme high wind events that cause lines to swing or otherwise become downed.

4.1.3 Impacts on Electrical Utility Customers

Projected climate changes in the LA region (Chapter 2) portend several direct and indirect impacts to the state's electric utility customers. First and foremost, anticipated increases in the frequency, severity, and duration of extreme heat events are expected to exacerbate the peak demand for electrical power for cooling systems. These include traditional air-conditioning units, and increasingly, heat-pump-based equipment with much higher energy efficiencies and lower peak power demands. Future incremental increases in peak electricity demand will likely need to be met through increased investments both on the supply side, to augment generation and transmission and distribution (T&D) infrastructure capacity, as well as on the demand side, to increase the scope of load flexibility programs which compensate customers for reductions in usage during key periods (Allen et al., 2016; Burillo et al., 2019; Peplinski & Sanders, 2024). In either case, the need for these types of investments will likely contribute to future utility rate increases.

Wildfires, coupled with the extensive mitigation efforts required of electric utilities, are among the most significant indirect impacts of climate change for the state's electricity customers. As demonstrated by recent cases where wildfire ignitions were attributed to the negligent operations or maintenance of utility infrastructure, the financial liabilities associated with the resulting damages can be so large as to represent an existential risk. In direct response to these events, several significant reforms have been implemented, including the establishment of the California Wildfire Fund, significant expansion of utility T&D infrastructure ungrounding efforts, and requirements for utilities to develop and implement comprehensive wildfire mitigation plans. All of these efforts come with significant costs for utility rate-payers and have been the major contributing factor to much-publicized, and maligned, increases in IOU retail electric rates over the past 10 years.

To date, the LA region has been somewhat insulated from the effects of these wildfire mitigation-related rate increases due to the prominent role that LADWP, a not-for-profit MOU, plays in providing electricity to the region's inhabitants (Singh et al., 2025). As an MOU, LADWP is not obligated to contribute to the state's wildfire mitigation fund, nor is it bound to undertake the same set of wildfire mitigation measures mandated by the California Public Utilities Commission

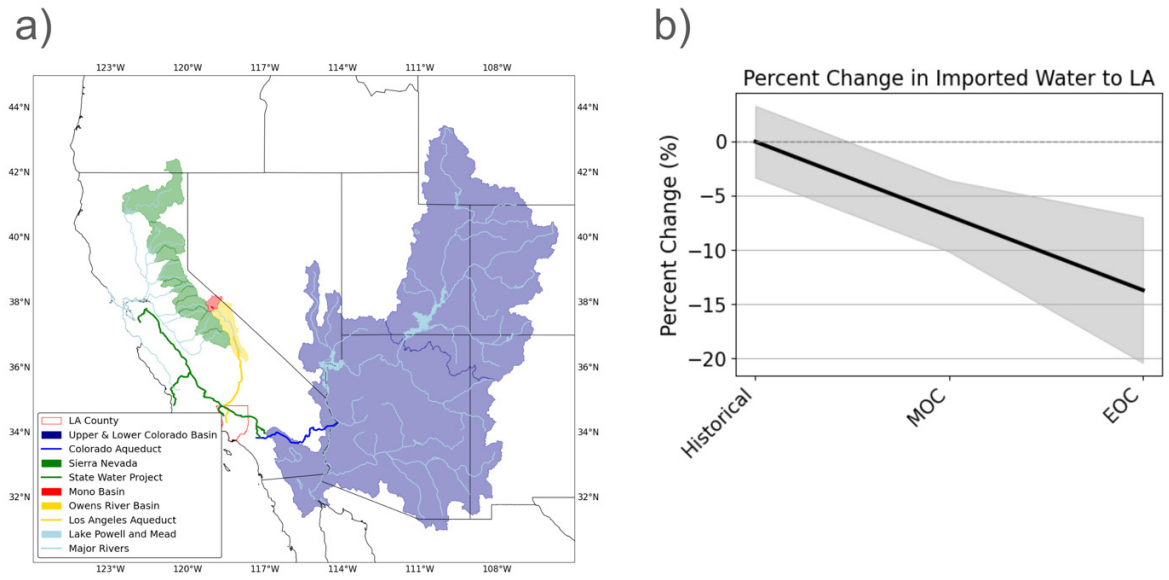
for the state's IOUs. LADWP also faces significant legal and regulatory constraints on its cost recovery mechanisms due to provisions contained in Propositions 13, 218, and 16, which require voter approval for major changes to its rate tariffs and customer assistance programs (Pierce et al., 2023). However, this does not mean that LADWP is immune to wildfire risks. It has recently been taking more deliberate and proactive measures to address these threats through dedicated wildfire response and mitigation planning initiatives (LADWP, 2025). It remains an open question, however, as to how LADWP, or indeed, other similarly structured MOUs, would be able to respond to the incursion of significant wildfire-related damages from an ignition event attributed to their infrastructure. This has recently occurred relative to the state's IOUs (Schmidt, 2024), including the Woolsey and Eaton Fires, but not for LADWP.

4.2 Water Resources

The LA region relies heavily on imported water for its water supply (**Figure 24a**). In an average weather year with conservation goals met, the City of LA imports 48% of its water from the Eastern Sierra Nevada via the LA Aqueduct. This has profoundly affected the landscape, local agriculture, and the cultural life of the Shoshone and Paiute Peoples residing in the Owens Valley. See the Fifth Assessment's "Tribal and Indigenous Communities Statewide Topical Report" and "Sierra Nevada Regional Report" for more information.

Other than the LA Aqueduct, the City of LA obtains water from a range of sources. This includes 32% from the Sacramento-San Joaquin River Delta via the State Water Project, and 9% from the Colorado River Basin via the Colorado Aqueduct. An additional 9% is obtained from groundwater, including stormwater recharge, and roughly 2% from recycled water, a number that is expected to grow with ongoing investments in advanced wastewater recycling (LADWP, 2020). During dry years, surface water supply will likely decrease, with more water obtained from the State Water Project and less from the LA Aqueduct. Projections for the SSP3–7.0 emissions scenario suggest that under current policies and infrastructure, imported water availability during dry years (the 5th percentile) will decrease 7% by MC and 13% by EC (**Figure 24b**). These reductions are primarily driven by reduced imports from the State Water Project and largely reflect projected evaporation impacts on water availability from the Sierra Nevada (see the Fifth Assessment's "Sierra Nevada Regional Report"). They have the potential to stress the regional water reliability. Such analysis is focused on annual changes in water availability, and reductions could be more severe due to projected shifts in snowpack amounts and streamflow timing.

Some neighboring water districts employ distinct strategies. The Orange County Water District has made large-scale, potable reuse central to its supply through the Groundwater Replenishment System, the world's largest of its kind, and is also advancing the Doheny Ocean Desalination Project to diversify supplies. In contrast, agencies in the Inland Empire depend heavily on groundwater basins and surface water capture, facing challenges tied to overdraft, variable hydrology, and water quality. Recognizing these regional differences highlights the diversity of Southern California's water management approaches and unique challenges each water district may face under climate change.



21st-Century Projections of Water Imports into the LA Region

Figure 24: *a) Different aqueducts and associated riverine basins that provide imported water to LA. b) Percent change in overall imported water to LA during dry years (the 5th percentile), assuming existing infrastructure and policies. Based on daily temperature and precipitation from 11 LOCA2-Hybrid downscaled climate models that were subsequently used to drive the Noah-MultiParameterization land-surface model. Line and shading in b) shows mean and plus/minus one standard deviation across models.*

Projected changes in the LA region's hydrology (*Section 2.3 Water Resources*) will lead to notable impacts in the region's headwater basins: a one-third reduction in peak snowpack by MC (**Figure 14**) will likely require shifts in how local water supply and reservoirs are managed. While there is substantial uncertainty associated with shifts in precipitation across the LA region, these snow-influenced areas are more likely to experience changes in the seasonality of runoff that can exacerbate flooding in the winter and reduce water reliability in the summer. This can subsequently influence downstream conditions that rely on spring and summer snowmelt for hydropower, agriculture, and environmental flows that sustain reliable water quality conditions and habitats.

Throughout the LA region, local water supply stress may increase due to hydrological droughts becoming roughly 15% more severe by MC based on an *intermediate* to *high* emission scenario (**Figure 13**). On the other hand, extreme wet runoff conditions are expected to increase substantially by 18–52% by MC. Such increases in extreme runoff are expected to occur during winter months, when water is typically captured by reservoirs and stored for summer release. The reduction in snowpack, increasing intensity of winter precipitation and runoff, and increased severity of droughts will lead to heightened flood risk and reduced local water reliability due to infrastructure that is not designed to capture larger, flashier volumes, particularly for reservoir-dependent communities.

Socioeconomic concerns arise with shifts in imported water reliability. For the City of LA, this includes potential increases in acre-feet/year costs associated with LADWP purchases of water

from the Metropolitan Water District of Southern California, which could increase for a variety of reasons, including reduced water availability from the State Water Project and Colorado Basin and the need to invest in alternative water sources (e.g., recycled water). Water retailers serving the region's many other jurisdictions are also subject to these supply and cost uncertainties. Increased acre-feet/year costs incurred by LADWP could lead to increased water utility costs across the LA region. Furthermore, different portions of LA receive water from the State Water Project and the Colorado Aqueduct. This can lead to different water utility costs and restrictions depending on where someone lives in LA County and the severity of drought in remote riverine basins that deliver water to LA. For example, portions of the LA region that are dependent on the State Water Project experienced water restrictions during a severe three-year drought from 2020–2022, while other areas receiving water from the Colorado Aqueduct were spared. Such events and their increasing likelihood due to projected reductions in imported water reliability during droughts raise a variety of climate justice concerns that will need to be carefully addressed.

Original research for the Fifth Assessment projects whether anticipated drought increases could limit the state's ability to meet housing needs, including a case study on San Bernardino County. The study predicts that through 2050 water supplies are likely to remain sufficient to meet housing demand, thanks to an expected shift toward multifamily housing, declining average household size, and improvements in water-use efficiency (Miro et al., 2026). However, there is large uncertainty associated with all of these factors.

4.3 Housing

Housing is expected to be increasingly at risk from a range of climate hazards in the LA region, primarily flooding and wildfire. The impacts of flooding on housing are discussed in the contexts of coastal infrastructure (*Section 4.4 Coastal Infrastructure*), social inequities (*Section 5.2.2 Flooding*), and mudslides (*Section 2.7 Compound Extremes*). Here we perform a targeted investigation into wildfire impacts on housing in the region. This is done through an economic lens, while the associated social impacts are explored in *Section 5.2.3 Wildfire*.

Data from recent destructive fires in the LA region may be indicative of emerging impacts on housing under climate change. Meanwhile, data from devastating fires elsewhere in California, such as the Camp Fire in 2018 that destroyed the town of Paradise, can also be harnessed to understand potential future wildfire impacts in the LA region.

4.3.1 Structural and Economic Losses

All five of the most destructive wildfire complexes in California history (in terms of economic impact) were in the last 10 years (**Table 1**). This strongly indicates that, as the climate changes and urban development continues to encroach upon the wildland–urban interface (*Section 2.4 Wildfire*), wildfires in California are increasingly becoming urban conflagrations that burn into highly populated areas. Two of these complexes (Woolsey and Eaton/Palisades Fires) were in the LA region and one (Thomas Fire) was just outside. This illustrates that the LA region is potentially in a class of its own in terms of the most destructive fires in the coming decades.

Among the most destructive, the Palisades and Eaton Fires dwarf the economic cost of all the other fires. On one hand, the total acres burned are lower than almost all the other fires in the list, and they destroyed fewer structures than the Camp Fire. However, the simple total loss, representing the total value of all destroyed properties (see Li & Yu, 2025), was $27 billion compared to $4 billion for Camp, the second costliest, illustrating the far greater property value. Furthermore, the total insurance claims, which also include more expensive commercial buildings, schools, and churches, in addition to personal property and living expenses, come to $45 billion compared to $8 billion for Camp. Meanwhile, the total capital loss, including the cost to repair, replace, or reconstruct all assets that have been damaged or destroyed, is likely to range between $76–$131 billion (Li & Yu, 2025).

Table 1: The Five Most Destructive Wildfires in California and Their Losses. *See Li & Yu, 2025, for calculation of Simple Total Loss. Note that the statistics for Palisades and Eaton do not include damages from other small fires in January 2025.*

Wildfire	Date	Counties	Acres Burned	Structures Destroyed	Simple Total Loss, Thous $	Total Insurance Claims, Thous $ (D)
Tubbs	Oct-17	Napa, Sonoma	36,807	5,643	3,668,860	8,760,030
Thomas	Dec-17	Ventura, Santa Barbara	281,893	1,063	609,862	1,520,571
Camp	Nov-18	Butte	153,336	18,804	3,980,470	8,258,256
Woolsey	Nov-18	Ventura, LA	96,949	1,643	1,422,766	2,980,740
Palisades/Eaton	Jan-25	LA	40,644	16,251	27,067,000	45,000,000

4.3.2 Relocation After Fires

En masse relocation following wildfires is historically rare. Based on data on the most destructive wildfires in the contiguous US between 1999–2020, migration effects appear only after very severe events—those destroying more than 258 structures (McConnell et al., 2024). Even after major fires, relocation tends to be modest, for example, following the major wildfires in Northern California in October 2017, including Tubbs, which destroyed or damaged 6,874 residential structures (Sharygin, 2021).

People are often immobilized after wildfires for several reasons. The destruction of household wealth can limit the financial resources needed to relocate, leaving some residents involuntarily trapped in their communities. Others may have the means to move but choose to remain because of social and economic networks, access to local amenities, or confidence in their ability to mitigate hazard exposure. In the LA region, high housing costs in urban areas push many residents to remain in fire-prone rural areas, while desirable neighborhood characteristics can also make people stay despite the risks.

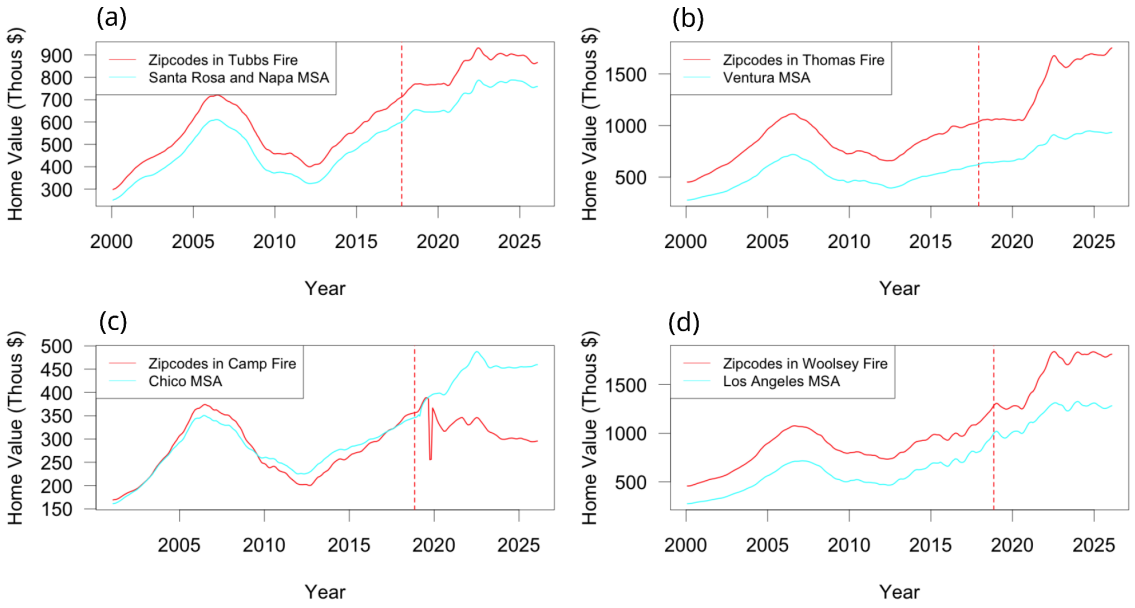
Beyond the impact on gross population flows, wildfire can alter neighborhood composition and housing characteristics over time. For instance, of over 17,000 homes within the 2018 Camp Fire footprint, mobile homes, lower-value properties, and absentee-owned residences were disproportionately destroyed, indicating socially stratified patterns of damage (McConnell & Braneon, 2024). While some of this was linked to density and road proximity, building type itself remained an independent risk factor. They also found that rebuilding within 20 months was more common among owner-occupied and higher-value homes, pointing to emerging cost-burden gentrification. These results highlight how the built environment shapes unequal disaster

outcomes and underscore the need for mitigation strategies targeting vulnerable residents and neighborhoods.

See the Fifth Assessment's "Climate-Induced Human Displacement and Migration Statewide Topical Report" for more in-depth statewide analysis of this issue, as well as **Appendix Text A5** of this report ("Climate-Induced Human Mobility").

4.3.3 Home Value and Housing Affordability

For most residents in the LA region, homeownership is their principal source of wealth. Homeowners affected by wildfires might receive full or partial compensation from insurance companies to rebuild. However, properties exposed to hazards such as wildfires are likely to decrease in value due to reduced demand and increased insurance premiums, compared to similar properties that are not at risk.



Home Price Index for Wildfire-Affected Areas Compared to Surrounding Metropolitan Areas

Figure 25: *Time series of home prices in ZIP Codes affected by the (a) Tubbs, (b) Thomas, (c) Camp, and d) Woolsey Fires compared to neighboring unaffected ZIP Codes. Sources: Zillow and authors' calculation.*

Following major wildfires, home prices have either declined or remained subdued for two to three years (**Figure 25**). Here, we compare wildfire-affected zip codes (red lines) to surrounding metropolitan areas (blue lines). Of these, only the Woolsey Fire was in the LA region, but those in other parts of California provide important context. The most extreme example is the Camp Fire, after which prices in affected zip codes initially plummeted about a third and remain about a third lower than in neighboring Chico (**Figure 25c**). Isolating individual zip codes in Paradise, most of which was destroyed, house prices halved and remain halved more than seven years later (**Appendix, Figure A12**). Prices in other fire-affected areas have increased, but in most cases at lower rates than neighboring areas. For example, zip codes impacted by the Woolsey Fire have

seen 3% lower appreciation compared to the LA Metropolitan Statistical Area (MSA), and areas affected by the Tubbs Fire have seen 8% lower than the nearby Napa and Santa Rosa MSAs. These discrepancies likely represent both the lowered house prices in the affected zip codes, as well as the inflated house prices in the neighboring zip codes due to a spike in demand from those fleeing the affected zip codes. Surprisingly, areas affected by the Thomas Fire exhibit a 12% higher appreciation compared to the surrounding Ventura MSA until 2024.

The impact of the Woolsey Fire on home prices suggests some degree of short-term volatility in land markets following the wildfire, but no long-term depreciation. Instead, values recovered and even increased, which may reflect rebuilding efforts, shifts in housing demand, or broader market trends. The observed resilience—and in some cases, growth—of home prices following the fire suggests that the local housing market may have absorbed the shock relatively well. The long-term impacts in Pacific Palisades and Altadena, following the 2025 fires, remain to be seen.

While wildfires can cause widespread destruction and immediate displacement, the long-term rebound or increase in home prices may indicate several important economic dynamics. First, the post-fire rise in home prices suggests that buyers and investors maintained confidence in the long-term desirability of these communities. This may reflect perceptions of the area's strong amenities, continued demand for housing in coastal California, or the effectiveness of local rebuilding efforts. Second, lenders and insurers may adjust risk assessments based on the wildfire's impact, potentially increasing premiums, tightening mortgage requirements, or pulling coverage, leaving property owners underinsured or uninsured. However, if home prices remain strong, financial institutions might continue to support investment in these areas, reinforcing economic resilience. The post-wildfire economic trajectory in the LA region could influence how policymakers allocate resources for fire mitigation, infrastructure, and zoning. Strong home prices recovery might justify investments in fire-resistant development and emergency response systems, aiming to protect high-value areas in future events.

Unfortunately, this pattern may not hold for lower-income areas. Here, the destruction caused by wildfires can lead to lasting declines in property values due to slower recovery, reduced investor interest, and greater challenges in rebuilding infrastructure. These areas may also face more prolonged reputational damage and insurance affordability issues, compounding the economic hardship and widening disparities in recovery outcomes across communities. Understanding these differences is critical for designing equitable and targeted post-disaster support policies.

Wildfires also can exacerbate the already critical issue of insufficient housing supply in the LA region. Short term, there is a boost in demand in nearby areas, particularly for rentals. Local news outlets have reported an increase in rents post-wildfire, as displaced households urgently seek temporary accommodation. This may lead to rent gouging, as occurred post-Eaton and Palisades (Briggs et al., 2026). Long term, new housing needs to be built to replace the losses. According to the California Department of Housing and Community Development Regional Housing Needs Allocation (RHNA), for its sixth cycle, spanning from October 2021–2029, LA County is required to construct 812,000 units to meet housing affordability goals. Midway through this cycle, only 71,000 units have been permitted, completing just 8.8% of the RHNA target. Furthermore, the 2025 fires destroyed nearly 10,000 houses, which until now is almost half the average number of housing permits issued by LA County annually (generally 20,000–25,000; Li & Yu, 2025).

In response, Governor Newsom issued an executive order on January 12, 2025, to expedite the reconstruction of homes and businesses destroyed by the 2025 fires—this order suspends permitting and review requirements under the California Environmental Quality Act (CEQA) and the California Coastal Act, aiming to speed up the rebuilding and recovery process, fast-track temporary housing solutions, and protect tenants and homeowners. Similarly, LA Mayor Bass has issued a corresponding executive order to facilitate quicker rebuilding efforts.

Despite these measures, the housing affordability issue is expected to worsen in the short term. If LA fails to meet its RHNA obligations, housing affordability challenges are likely to persist in the long term. This issue is complicated by properties post-wildfire being sold to corporate developers. For example, 49% of post-fire sales of parcels affected by the Eaton Fire were to corporate developers, compared to 10% in the previous year.

4.3.4 Home Insurance Markets

In the past decade, the LA region has faced significant challenges with insurance availability as companies have canceled hundreds of thousands of policies in fire-prone areas and stopped issuing new ones. As a result, many residents have turned to the Fair Access to Insurance Requirements (FAIR) Plan for coverage, which provides basic fire insurance coverage for high-risk properties when private insurance is unavailable. Early in 2025, the FAIR Plan reported only a $200 million surplus and $2.5 billion in reinsurance, indicating that it could face losses exceeding its reserves and reinsurance. This scenario could lead to a $1 billion assessment on insurers, which would then be passed on to all policyholders across the state, compounding significant rate increases for Californians.

To address the state's insurance crisis, the California Department of Insurance announced the upcoming implementation of the Sustainable Insurance Strategy on December 30, 2024. This regulation aims to attract more insurers to wildfire-prone areas by permitting them to: (1) Use forward-looking probabilistic models for setting premiums, (2) include reinsurance costs in their rates, and (3) seek approval to assess all state policyholders if claims exceed the FAIR Plan's capacity. In exchange, they must increase the number of policies issued annually by 5% until they reach 85% of their statewide market share in wildfire-affected areas. This shift could lead to a more competitive insurance market, offering more comprehensive policies at more accessible rates in the long term.

Before the new regulation, insurers were facing rare but significant risk due to climate disasters. Specifically, insurers' traditional risk models might underestimate the likelihood of extreme events, leading to insufficient reserves or capital to cover losses. Now the new regulation allows insurers to use forward-looking models to better manage fat-tail risks. Before the LA wildfires, insurers had planned to request major rate increases. After the wildfires, which caused $75 billion in estimated insured losses, even larger increases are expected.

However, while insurers can now increase rates to cover costs of extreme risks, thereby sending a market signal to homeowners to build more resiliently, insurers nonetheless face other regulatory challenges in the future. The growing frequency and severity of wildfires due to climate change still pose a significant threat. Insurers' losses might continue to climb, potentially outpacing their ability to increase rates.

See the Fifth Assessment's "Climate Impacts to the Economy Statewide Topical Report" for further details on statewide economic impacts.

4.4 Coastal Infrastructure

As discussed in detail in *Section 2.5 Coastal Hazards*, sea level rise and climate-induced coastal change hazards have the potential to lead to significant coastal flooding and impacts on the LA region's built systems. The USGS Hazard Exposure Reporting and Analytics (HERA) tools provide the opportunity to overlay projected sea level rise and coastal storm flooding on infrastructure and asset information, which in turn allows planners and public works practitioners to better understand the potential risk to their assets. The sections below provide road, housing, and land parcel value exposure for a range of sea level rise scenarios in combination with coastal storms and astronomic high tides (the highest tides in a calendar month).

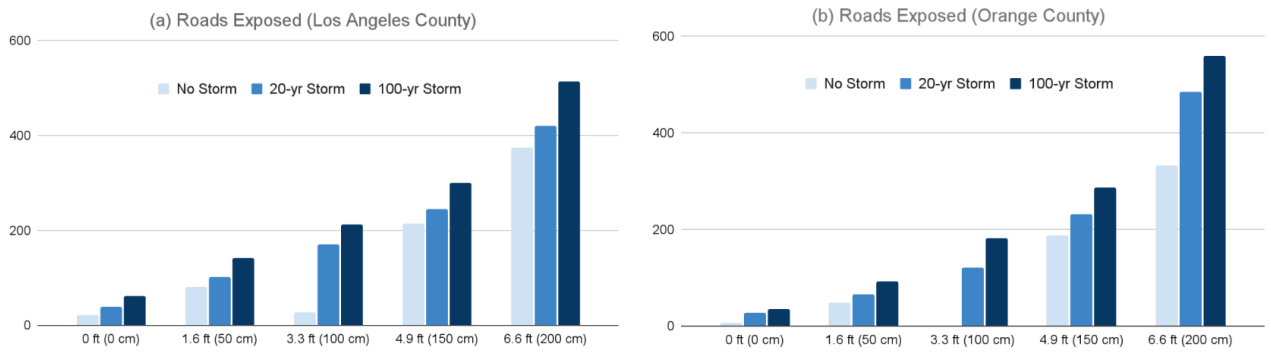
4.4.1 Road Exposure

In LA County, sea level rise alone could make 21 miles (34 km) of road vulnerable to today's astronomic high tide (**Figure 26a**). For a 20-year wave event, 39 miles (63 km) of road become vulnerable or exposed to flooding. With 1.6 ft (50 cm) of sea level rise, the number of roads exposed quadruples to 80 miles (129 km) under current astronomic high tides and nearly doubles again with 3.3 ft (100 cm) of sea level rise (with 145 miles [233 km] of road exposed). Coastal wave events predictably increase temporary road flood exposure—for a 20-year storm event, 100 miles (161 km) of road become exposed with 1.6 ft (50 cm) of sea level rise, and 170 miles (274 km) become exposed with 3.3 ft (100 cm) of sea level rise. The higher rates of sea level rise in **Figure 26a** are unlikely to occur this century but are shown as *worst-case* scenarios.

In Orange County, under current sea level rise conditions, only 5 miles (8 km) of road are vulnerable or exposed (**Figure 26b**), but this temporary exposure quintuples with a 20-year coastal wave event. Recalling the flooding analysis in *Section 2.5 Coastal Hazards*, today's 20-year flood risk is expected to occur annually by 2030, with only 9.8 in (25 cm) of sea level rise (California Sea Level Rise Science Task Force et al., 2024; Iacobellis & Cayan, 2024). Similarly, today's king tides (the highest tides of the year) generally produce a range of 9–12 inches (~20–30 cm) of increased water levels. This implies that while today's road exposure in Orange County is low, a considerably larger road area is at risk from high tide flooding, a big wave event, or a moderately small increase in sea level rise. With 1.6 ft (50 cm) of sea level rise, 48 miles (77 km) of road are at risk of permanent inundation; this more than doubles to 100 miles (161 km) of road at risk with 3.3 ft (100 cm) of sea level rise.

In LA County, coastal wave events equally increase the temporary flood risk, with 120 miles (193 km) of roads exposed with 3.3 ft (100 cm) of sea level rise plus a 20-year wave event. Higher rates of sea level rise lead to equivalently high numbers of 187 miles (301 km) and 337 miles (542 km) of roads exposed under 4.9 ft (150 cm) and 6.6 ft (200 cm) of sea level rise, respectively. Any flooding along a roadway, even if temporary, can have considerable implications, from impacting resident mobility to impeding emergency response (Moser & Finzi Hart, 2018). The most obvious impact of king tide flooding in Orange County is flooding along Highway 1 near Sunset and Huntington Beaches (Whitt, 2025). Depending on where the road is flooded, the impacts could be minor,

merely requiring residents to find alternative routes; but if the flooding occurs on major arteries and access routes, the impacts could be more consequential (Sweet et al., 2022). Thus, a solid understanding of potential exposure of roads is vital for community planning and emergency management (Moser & Finzi Hart, 2018).



Miles of Roads Exposed to Flooding From Sea Level Rise and Extreme Coastal Wave Events

Figure 26: *Shown for (a) LA County and (b) Orange County. Projected risk estimates are calculated using the US Geological Survey's Hazard Exposure Reporting and Analytics.*

4.4.2 Housing and Land Parcel Value Exposure

As with roads, coastal zone housing is also vulnerable to permanent inundation from sea level rise as well as temporary flooding from coastal wave events. Unlike roads, which can dry and be used after a storm (notwithstanding increased pothole and road maintenance needs), dwellings may have lasting impacts from flooding, such as mold and persistent dampness that can lead to respiratory issues (Climate Central, 2023).

In LA County, under current conditions, ~1,700 housing units are located in a potential inundation exposure zone (**Figure 27a**). This number increases to ~6,300 exposed units to permanent inundation with 1.6 ft (50 cm) of sea level rise and ~9,000 units exposed to inundation with 3.3 ft (100 cm) of sea level rise. Meanwhile, the 20-year wave event has the potential to threaten 3,300 housing units, and the 100-year wave event will threaten 5,400 units. With rising seas, 20-year, 100-year, and even annual wave events (data not included here; accessible through the USGS HERA) will equally increase exposure.



Vulnerability of Housing and Land to Flooding from Sea Level Rise and Extreme Coastal Wave Events

Figure 27: *Number of housing units exposed to flooding from sea level rise and extreme coastal wave events in (a) LA County and (b) Orange County. Land value exposed to flooding from sea level rise and extreme coastal wave events in (c) LA County and (d) Orange County (based on FY2020). Projected risk estimates are calculated using the US Geological Survey's Hazard Exposure Reporting and Analytics (https://www.usgs.gov/apps/hera/).*

While the initial number of units exposed to permanent inundation and temporary flood risk is similar in both LA and Orange counties under current conditions, the risk increases more dramatically in Orange County (**Figure 27b**). Considerably more housing units are at risk under the higher rates of sea level rise in Orange County, with more than 22,000 units exposed with 4.9 ft (150 cm) of sea level rise, and 35,000 units exposed with 6.6 ft (200 cm) of sea level rise.

Finally, in LA County, based on Fiscal Year (FY) 2020, an estimated $5 billion in land value is at risk with 1.6 ft (50 cm) of sea level rise, and $8 billion to $9 billion in land value is at risk with 3.3 ft (100 cm) to 4.9 ft (150 cm) of sea level rise (**Figure 27c**). Similarly, in Orange County, 1.6 ft (50 cm) of sea level rise could expose/threaten $7 billion in land value, increasing to $12.5 billion and $17 billion with 3.3 ft (100 cm) and 4.9 ft (150 cm) of sea level rise, respectively (**Figure 27d**).

Chapter 5.

Social Systems



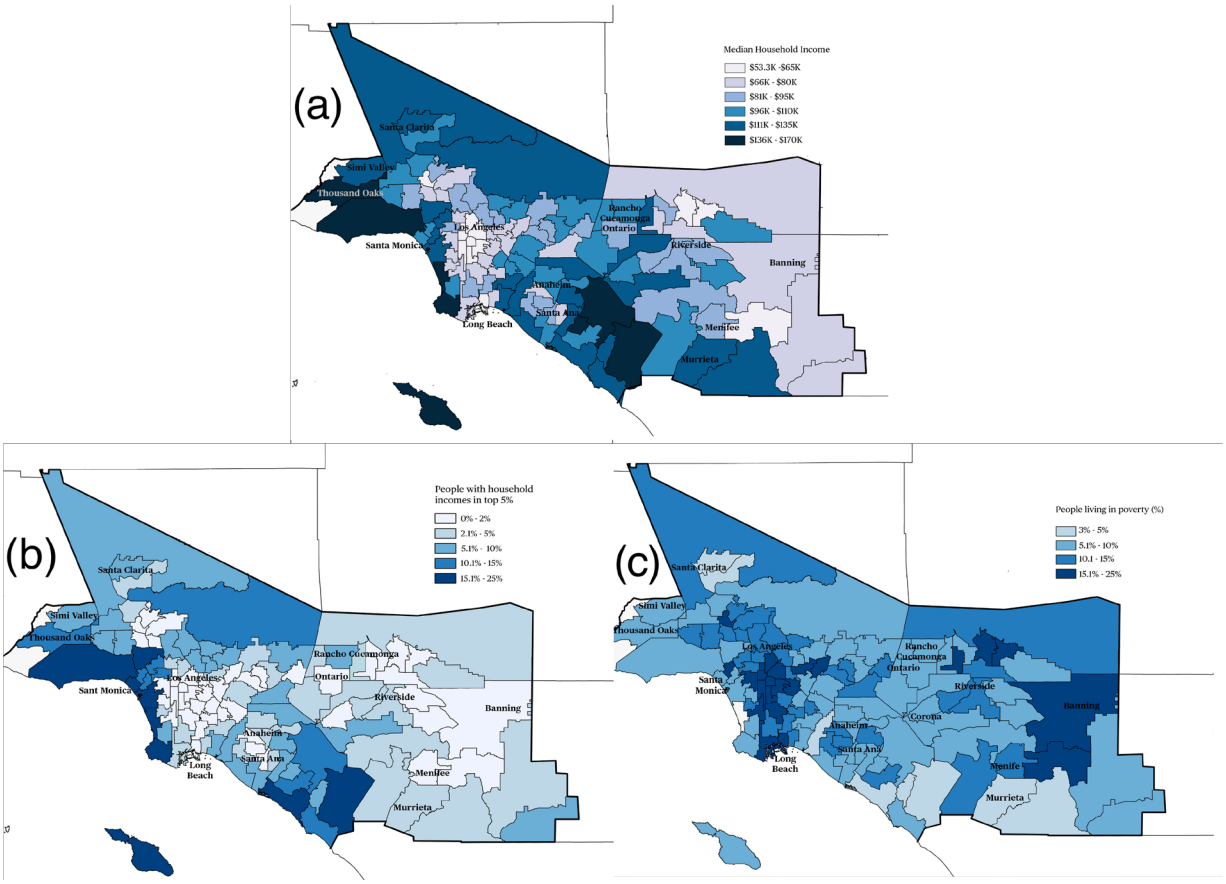
Key Messages

- More frequent, severe, and prolonged heat waves pose a serious threat to public health, particularly for unhoused people and Latino and Tribal communities living further inland.
- One in five people in the region are energy-burdened, paying too high a share of income to cool and power their homes, particularly Black residents and women, which is likely to be exacerbated under continued warming.
- Fires such as Eaton have amplified pre-existing economic inequities, due to resource constraints among lower-income people making them less equipped to recover.
- Episodes of high ground-level ozone and wildfire smoke are likely to become more frequent and prolonged, disproportionately affecting seniors, children, pregnant people, and people with disabilities.
- Populations vulnerable to flooding are concentrated in communities with historical social, economic, and structural disadvantages.
- Limited access to climate change adaptation resources is likely to further amplify inequities.

Everyone in the LA region is facing intensifying climate threats (Chapter 2), but they will experience the effects of climate change differently, depending on where they live or work, their exposure and sensitivity to different climate hazards, and the resources they have to adapt and respond. The state has made it a priority to reduce climate risk, strengthen protections, and increase climate resilience for people and communities, especially those who have less capacity and fewer resources to cope with, adapt to, or recover from climate impacts.

The significant inequities in the region are illustrated by income maps across the region (**Figure 28**). High-income families are clustered on the coast, around Irvine, and in parts of the Northwest San Fernando Valley (**Figure 28a**). Those living in the top 5% of income are concentrated along the coastline of LA County, as well as southern Orange County (**Figure 28b**). Meanwhile, lower income families are concentrated in the Inland Empire and in the urban core of LA (**Figure 28a**). One in nine people in the region live in households with income below the federal poverty line ($24,860 for a family of three) (US DHHS, 2023). These households are concentrated in Downtown LA, South LA, and the Inland Empire (**Figure 28c**).

These income differences are closely related to a high degree of residential segregation, as illustrated by **Figure 29**, showing where Asian Pacific Islander (API), white, Black, and Latino residents live. These maps show that, compared to white and API people, Black and Latino people disproportionately lack sufficient financial resources. Poverty rates are also significantly higher among women than men: one in five Black women and girls, and nearly one in seven Latina women and girls, live below the federal poverty line. Additionally, a majority of renting adults in the LA region are rent-burdened, living in housing considered unaffordable (more than 30 % of household income going toward rent and related housing costs) (**Table 2**), leaving less of a margin for managing climate change impacts. This majority is larger for Black residents, especially for Black women. See **Appendix, Text A6** for more discussion of the socioeconomic profile of the LA region.

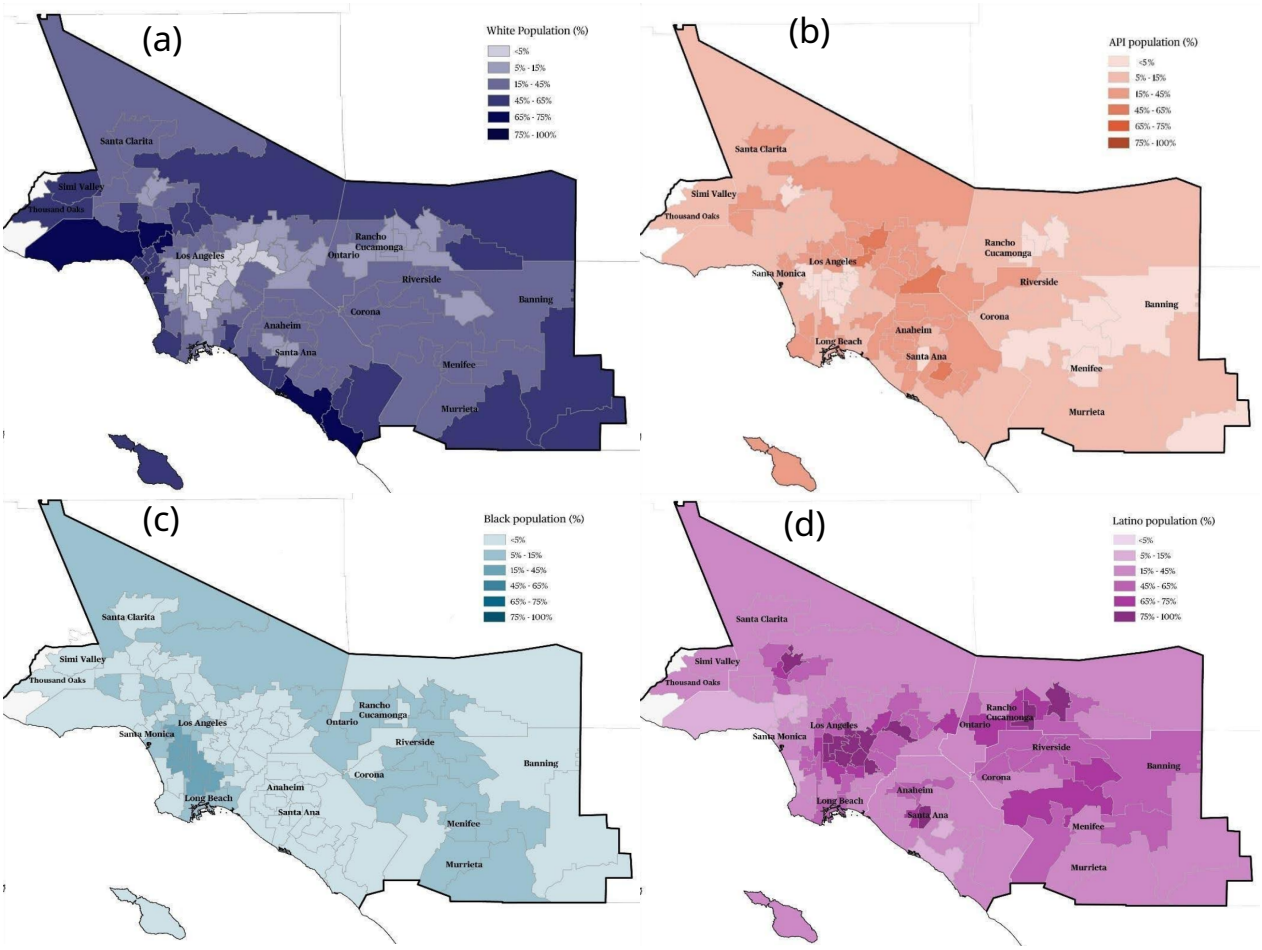


Income Differences Across the LA Region

Figure 28: *(a) Median household income by Public Use Microdata Area (PUMA); (b) the share of the population living in households in the top 5% of income; (c) the share of those living below the federal poverty line. Gray lines represent PUMA boundaries. Each PUMA has a population of approximately 100,000 residents. Based on authors' analysis of 2023 IPUMS ACS.*

Table 2: Adults Living in Unaffordable Rentals, by Gender and Race/Ethnicity, LA Region. *Rent burden rates reflect the share of adults living in households with total housing costs (rent and utilities) that exceed 30% of household income. All gender differences within the same race/ethnicity are statistically significant at the 95% level unless denoted by *. Data on other races/ethnicities excluded due to insufficient sample size. Source: Authors' analysis of 2023 IPUMS American Community Survey.*

	Total	Women	Men
Los Angeles Region	51%	54%	49%
Asian/Pacific Islander (API) *	51%	52%	50%
Black	59%	64%	54%
Latino	50%	53%	47%
White	53%	55%	50%



Geographical Distributions of Race/Ethnicities Within the LA Region

Figure 29: *Geographic distributions of race/ethnicities within the LA region: (a) White population; (b) API population; (c) Black population; (d) Latino population. Gray lines in the four maps above represent the boundaries of Public Use Microdata Areas (PUMA). Each PUMA has a population of approximately 100,000 residents. Based on authors' analysis of 2023 IPUMS ACS.*

In this chapter, we present analyses of demographic, socioeconomic, and other relevant data to examine both the specific climate risks to the people of the region, as well as their capacity to respond and adapt to climate impacts. While highlighting the region's assets and strengths, we also direct attention to the region's profound socioeconomic disparities and social, health, and place-based vulnerabilities. We focus particularly on people and communities defined by California as vulnerable. All demographic and socioeconomic analysis is based on the US Census Bureau's 2023 American Community Survey (ACS; **Appendix, Text A7**), except where otherwise noted. All reported differences are statistically significant at the 95% confidence level. We have not made demographic projections and acknowledge that potential change in the composition of the population by place is not reflected in this analysis. Nevertheless, to deliver on the state's priority goal of climate equity, it is prudent to consider the needs of the current inhabitants of communities at risk in climate resilience and adaptation planning.

Box 8: *Vulnerability to Climate Change*

Vulnerable communities experience heightened risk and increased sensitivity to climate change and have less capacity and fewer resources to cope with, adapt to, or recover from climate impacts. These disproportionate effects are caused by physical (built and environmental), social, political, and/or economic factor(s), which are exacerbated by climate impacts. These factors include but are not limited to race, class, ethnicity, gender, sexual orientation, national origin, income inequality, and disability. People facing multiple forms of marginalization and inequality will confront more intense climate change impacts and barriers to recovery. Learn more about vulnerability to climate change and the Integrated Climate Adaptation and Resiliency Program (ICARP) Vulnerable Communities Platform on the CA Governor's Office of Land Use and Climate Innovation website.

5.1 Climate Vulnerability in the LA Region

Large numbers and shares of the state's climate vulnerable groups live in the LA region. Nearly three-quarters of residents in the region are not White (**Table 3**). Three and a half million children live in the region, with Latino children accounting for 57%. Four in 10 older Californians age 65+ live in the region, among whom women make up a sizable majority of 55%; 58% of those age 75+ are women. Similarly, 1.9 million children and adults with disabilities live in the region, accounting for four in 10 disabled Californians. Approximately 665,000 LGBTQ+ adults live in LA County, making up 9% of the county population, according to a survey conducted by the Williams Institute and the LA County Department of Public Health (Data on LGBTQ+ people is not available for other counties in the region) (Sears et al., 2024).

Box 9: *Native Peoples in the LA Region*

Approximately 536,000 people who identify as American Indian/Alaska Native (AIAN) on the US Census live in the LA region, making up 3% of the population. Native people are more likely to identify as multiracial, and more than three-quarters (78%) also identify as Latino. Only about 5% of the regional Native population, or roughly 30,000 people of all ages, identify as AIAN only. To avoid underestimating the number of people who identify as Native in the region, Native American in this section includes any person who identifies in part or in whole as AIAN. This definition uses a different methodology than the chapter's other findings by race/ethnicity, and therefore, the population estimates for Native Americans here are not directly comparable to those for other groups. See **Appendix, Text A9** for more details.

Table 3: Residents, by Race/Ethnicity, LA Region. *Race and ethnicity are categorized as mutually exclusive groups. Latinos can be of any race. Native Americans, individuals who identify as more than one race, and all other races are combined due to small sample sizes. Resident counts are rounded to the nearest thousand; estimates may not sum to totals due to rounding. Source: Authors' analysis of 2023 IPUMS American Community Survey.*

	Population	% of LA Region
Asian/Pacific Islander (API)	2,554,000	15%
Black	965,000	6%
Latino	7,753,000	46%
White	4,672,000	28%
All Other Groups	747,000	4%

Black and Latino people in the LA region are more likely to be economically insecure and live in environmentally-burdened places, exacerbating their exposure to the compounded effects of climate change (Vega Varela et al., 2024). The disproportionate impacts of climate change and pollution on people of color have been amply documented in academic literature. Structural racism, operating in communities of color through historic government-sanctioned mechanisms such as redlining, mortgage discrimination, and other zoning and infrastructure siting decisions, has led to high concentrations of polluting sources and their associated health, environmental, and economic harms on the people who live and work in those neighborhoods. In a recent synthesis, the authors observe that communities of color today often "have worse air quality, minimal green space, and higher risks of heat-island effects, as well as elevated rates of cardiovascular disease, asthma hospitalizations, poor birth outcomes, and other diseases" (Morello-Frosch & Obasogie, 2023). See the Fifth Assessment's "Racial Equity and Climate Justice Statewide Topical Report" for further discussion.

The disproportionate impact of climate change on women has also been documented extensively in the academic literature over the past fifteen years. First, on average, they earn less and hold less wealth than men, implying fewer resources to respond and adapt to climate change. Second, women are disproportionately responsible for taking care of children and other vulnerable family members, and working mothers spend 62% more time than working fathers taking care of children (Gender Equality Policy Institute, 2025). One in four women in the LA region are mothers of infants, toddlers, or school-age children. When schools or childcare and eldercare centers are disrupted or closed due to climate hazards, women are more likely to be responsible for ensuring the safety and health of others, thereby disrupting their work and potentially reducing their income. Third, women make up a sizable majority of older adults, a group highly sensitive to the health impacts of climate change. Among adults age 65+ in the LA region, 55% are women; 58% of 75+ seniors are women. Fourth, climate hazards such as extreme heat, drought, floods, vector-borne disease, and wildfires have negative impacts on the health of pregnant and postpartum women and people. The LA region is home to 44% of California's reproductive-age women. The disadvantage women in the LA Region experience by virtue of their gender is compounded by other factors of vulnerability. A substantial majority of women in the region are Latina or Black, and they are more likely to be low-income, rent burdened, or living in environmentally disadvantaged communities. More than half of the region's reproductive-age women are Latina, raising critical concerns about reproductive justice and racial health disparities under worsening climate conditions.

At the same time, women play a critical role in ensuring climate resilience in the region, as three-quarters of California's health workers and care workers are women. Care workers, particularly those in home care who work with older adults or people with disabilities or chronic medical conditions, often serve as first responders in climate-driven emergencies and disasters. The LA County Climate Vulnerability Assessment has classified the County's healthcare system as critical infrastructure in the face of climate hazards (LA County, 2021). For these reasons, global climate agreements now include commitments to analyze and address how climate change affects women, men, and gender diverse people differently, in order to mitigate the gendered impacts of climate change, support more effective climate solutions, and advance equity (e.g., UN, 2025).

The LGBTQ+ community is particularly vulnerable to climate change because of the compounding issues that many in the community already face. LGBTQ+ youth and young adults are over-

represented among the unhoused population—one study found a 2.2 times greater risk of homelessness, compared to their non-LGBTQ+ peers (Romero et al., 2020). Two thirds of LA County LGBTQ+ residents are people of color. LGBTQ+ adults in the County have higher rates of food insecurity, housing instability, disability, and mental health conditions than their non-LGBTQ+ peers. About a third are living below 200% of the federal poverty level (Sears et al., 2024). Data is not available for any of the other counties in the LA region.

LGBTQ+ people face heightened vulnerability during climate-driven disasters. They can face harassment, exclusion from emergency services, and lose access to medical care. In California from 2022–2023, LGBTQ+ individuals experienced disaster displacement at twice the rate of their cisgender, heterosexual counterparts. LGBTQ+ individuals' displacement experiences also differed in key ways: they were twice as likely to report fear of crime, 2.5 times as likely to experience unsanitary conditions, and 3 times as likely to be permanently displaced (Geiger et al., 2023). National-level research has found that LGBTQ+ people face worse outcomes during and after disasters due to policy gaps and bias in the delivery of disaster response and recovery services. This may be exacerbated by the outsized role anti-LGBTQ+ religious organizations often play in disaster relief (Goldsmith et al., 2022).

Another climate vulnerable group in the region is the unhoused. Unsheltered homeless people are particularly exposed and vulnerable to extreme heat and other climate hazards. LA County has one of the largest unhoused populations in the nation. In 2025, more than 80,000 people in the region experienced homelessness, with an estimated 72,308 on a given night (LA County, 2025). Unhoused people were disproportionately men (66%) and disproportionately Black (29%), 10% were minors, and Latinos made up the largest number of the unhoused.

People with disabilities are also particularly vulnerable to climate hazards. They are up to four times more likely to be killed in a weather-related disaster than those who are not disabled (National Council on Disability, 2023). In the LA region, this greater vulnerability was exemplified by the 2025 wildfires: among the 19 direct fatalities in the Eaton Fire, 16 were disabled, elderly, or had limited mobility. There is a lack of relevant studies specific to the LA region, but national data reveal stark contrasts in negative outcomes beyond the immediate loss of life compared to the general population. People with disabilities are far more likely to be evacuated following a disaster (31% among adults who cannot care for themselves compared to 1% of the general population) and even after they have evacuated, their outcomes are immeasurably worse (Frank, 2023). They experience issues including food and water shortages, a lack of electricity, isolation, unsanitary conditions, a fear of crime, and exposure to financial scams at rates five to ten times higher than evacuees without disabilities. Unlike other evacuees, the majority of disabled people never return home after a disaster and can face permanent institutionalization. Nursing home populations have been shown to spike after a range of disasters, including wildfires (National Council on Disability, 2019).

5.2 Impacts of Individual Hazards

The significant inequities discussed previously are likely to lead to major discrepancies in groups' abilities to adapt to climate change and recover from climate disasters. Below, we discuss in more detail the vulnerability of the region's people in the face of specific hazards.

5.2.1 Extreme Heat

Exposure to extreme heat falls unequally on the people of the LA region; those with fewer resources are more vulnerable to health and economic harms. This issue is exacerbated by geographical differences in extreme heat projections (*Section 2.1 Warming*), income differences across the region (**Figure 28**), and racial segregation (**Figure 29**). Vulnerable individuals and communities, such as older adults, infants, and Black people, are more susceptible to these negative health impacts (Basu & Ostro, 2008). We illustrate extreme-heat vulnerability in the LA region in **Table 4**, showing projections in individual cities, together with the cities' median incomes and ethnic compositions.

Table 4: Increase in Extreme Heat Days, by Median Household Income and Race/Ethnicity, Selected Areas, Los Angeles Region.
*Note: Average increase of days >95°F (35°C) is calculated as the difference between modeled mid-century (2041–2070; **Figure 8b**) projections and the historical baseline (1981–2010; **Figure 8a**). All projections are averaged over 14 LOCA2-Hybrid downscaled climate models under the SSP3–7.0 scenario. The statistics for each location are based on the closest grid cell on the 3-km LOCA2-Hybrid grid to the given Public Use Microdata Area (PUMA)'s central location. Share of population by race/ethnicity is estimated from IPUMS ACS 2023. See **Figure 1** for city locations. See **Appendix, Table A2** for projections of more temperature metrics in more cities in the LA region.*

	Average increase of days >95°F (35°C)	Median Household Income	Asian/ Pacific Islander	Black	Latino	White
Santa Monica	0	$110K	12%	4%	12%	62%
San Clemente	0	$128K	5%	1%	19%	67%
Big Bear Lake	0	$75K	6%	2%	34%	53%
Long Beach	4	$64K	20%	12%	50%	14%
Irvine	5	$139K	52%	3%	8%	31%
Downtown LA	10	$70K	19%	7%	59%	11%
Anaheim	15	$98K	18%	3%	51%	24%
Bell Gardens	20	$62K	1%	0%	97%	1%
Pasadena	33	$100K	18%	8%	32%	36%
El Monte	36	$70K	25%	1%	68%	4%
Northridge	37	$102K	24%	5%	34%	33%
Santa Clarita	37	$110K	11%	3%	40%	42%
Ontario	39	$85K	10%	7%	70%	11%
San Bernardino	39	$60K	4%	7%	78%	7%
Riverside	40	$85K	5%	6%	64%	20%

In general, low-income, disproportionately Latino areas are projected to experience the greatest increase in extremely hot days. For example, El Monte is 68% Latino, and the median annual household income is $70,000; it is projected to experience 36 additional extreme heat days per year. By contrast, Irvine is 52% API, and the median annual income ($139,000) is one of the highest in the region; it is projected to experience 5 additional extreme heat days. San Clemente, which is projected to experience no additional extremely hot days, is 67% white and the median income is $128,000 annually.

Access to cooling is essential during heatwaves. This is exemplified by the fact that in the US, nearly half of extreme heat-related deaths take place at home (Kutz, 2024). In the LA–Long Beach

area, 18% of occupied housing units lack primary air conditioning, including 23% of rentals and 12% of owner-occupied units. In the Riverside–San Bernardino area, where the most drastic extreme heat projections are made (*Section 2.1.3 Extreme Heat*), 5% of all occupied units lack air conditioning, including 6% of rentals and 4% of owner-occupied units (US Census, 2023).

More than 2.2 million adults in the LA region live in households spending an unaffordable share of income on home energy costs and are considered energy-burdened by standard definitions (**Table 5**). Nearly half of these energy-burdened adults (1 million) are Latino. More than half (1.2 million) are women. Black adults and women age 65+ have the highest energy burden rate (28%). In all race/ethnicity groups, women are more likely than men to be energy-burdened. About one in five adults in the LA region residing in LA, Riverside, and San Bernardino counties are energy-burdened (**Table 6**). Energy burden rates for those in Orange and Ventura counties are lower at 12% and 13%, respectively.

Table 5: Energy Burden Rates, All Adults by Gender and Race/Ethnicity, LA Region. *Energy burden rates reflect the share of adults living in households with total energy costs (electricity, gas, heating fuel) that exceed 6% of household income. All gender differences within the same race and ethnicity are statistically significant at the 95% level. All differences across race and ethnicity are statistically significant, with the exception of differences between Latino and White. Source: Authors' analysis of 2023 IPUMS American Community Survey.*

	Total	Women	Men
Los Angeles Region	18%	19%	17%
Asian/Pacific Islander (API)	14%	14%	13%
Black	28%	31%	24%
Latino	19%	20%	18%
White	18%	20%	17%

Table 6: Energy Burden Rates, All Adults by Gender and County, LA Region. *Energy burden rates reflect the share of adults living in households with total energy costs (electricity, gas, heating fuel) that exceed 6% of household income. All gender differences within counties are statistically significant at the 95% level unless denoted by *. Data for Riverside, San Bernardino, and Ventura reflect only the portions included in the LA region. Source: Authors' analysis of 2023 IPUMS American Community Survey.*

	Total	Women	Men
Los Angeles Climate Region	18%	19%	17%
Los Angeles	19%	21%	18%
Orange	12%	13%	11%
Riverside	21%	22%	20%
San Bernardino	20%	22%	19%
Ventura *	13%	13%	12%

For low-income or energy-burdened households, cooling expenses can consume an excessive share of household income, forcing difficult trade-offs, such as paying utility bills instead of buying medicine (WHO, 2006; Maxim & Grubert, 2022). A lack of cooling can put people at risk of heat illness (Hernández, 2013; Chen et al., 2022b).

Research shows that predominantly low-income neighborhoods, where Black and Latino families are concentrated, are more likely to experience intensified surface, urban, heat island effects (Ndugga & Artiga, 2023). These neighborhoods often lack adequate green space and tree

cover, and their homes tend to be poorly insulated and less equipped to maintain safe indoor temperatures (Gabbe & Pierce, 2020).

More than 2.3 million students attend public schools in the region (EdData, 2023; LA County Office of Education, 2025). Exposure to extreme heat has been linked to sharp drops in academic performance. One study found test scores declined by up to 14% on hot days (Park, 2022), while another showed that every degree increase in average temperature led to 1% less learning (Park et al., 2021a). According to one study, 5% of the nationwide gap in academic achievement between white and Black students was attributed to heat and air conditioning disparities (Park et al., 2020).

In addition, extreme heat can force schools to suspend outdoor recess and athletics, or in extreme events, to close to protect student and teacher health. A striking 58% of parents say their children's physical health or emotional well-being has been negatively affected by extreme weather, and 49% report negative impacts to their own well-being (Rapid Survey Project, March 10, 2025).

Extreme heat poses serious threats to public health, particularly to vulnerable individuals and communities who lack access to cooling strategies like shade and air conditioning (Bedsworth et al., 2018; Hulley et al., 2021). There are on average 65.5% more deaths in LA County under extreme heat risk (Baker & Sturm, 2024). One study estimates that under some climate scenarios, an additional 6,700–11,300 heat-related deaths in California could occur by 2050 (Ostro et al., 2011).

Outdoor workers (e.g., construction, landscaping, delivery, farming, emergency response, etc.) are particularly at risk, given their prolonged hours of exposure paired with greater physical exertion. They are often faced with a binary choice of losing income by taking time off or putting their health in danger. Exposure to extreme heat increases risk of dehydration, and heat stroke and is the leading cause of accidents and injuries on the job (Park et al., 2021b). Workers with underlying health conditions, of older age, with disabilities, or experiencing greater socioeconomic disadvantage are at greater risk due to heightened exposure, weaker physiological defenses, and fewer resources or agency to protect themselves (CDC, 2024). Licker et al. (2022) project that outdoor worker exposure to extreme heat will triple nationally by mid-century, with an estimated loss of $39.3 billion in earnings compared to the late 20th century. Indoor workers in particularly hot environments, such as factories, industrial plants, and warehouses, are also at greater risk for the same reasons (CDC, 2026).

Heat waves increase the risk of harm to pregnant individuals and newborns, with compounding effects on women of color and of lower-income. Prolonged exposure to extreme heat has been associated with serious maternal and neonatal complications, including pre-term births, low birth weight, eclampsia, and miscarriage (He et al. 2018; Bekkar et al. 2020; Chersich et al. 2020; Wyrwoll et al., 2023). A California study found an 8.6% increase in preterm delivery associated with a 10°F (6°C) increase in weekly average temperature, with the greatest effect on Black, Asian, and younger mothers. Even where there is widespread access to air conditioning, "heat waves increase the fraction of babies with abnormal conditions related to maternal stress, as well as the fraction of mothers who experience pregnancy-related adverse health conditions" (Cil & Cameron, 2017). A report commissioned by the California Department of Insurance conservatively estimated that 344 cases of adverse pregnancy or birth-related outcomes were linked to specific extreme heat events from 2013–2022 (California Department of Insurance, 2024). Another study in LA found that the

risk of babies being born small for gestational age was almost doubled with early pregnancy heat stress exposure in more climate-vulnerable neighborhoods (Khalili et al., 2025).

Older adults are especially vulnerable to heat-related illnesses and deaths due to pre-existing medical conditions, mobility limitations, and diminished physiological resilience. These risks are further compounded by race and income inequality. Older adults living on fixed incomes or in poorly insulated homes face greater difficulty managing indoor temperatures and accessing cooling. Due to women's longer life expectancy, they are overrepresented among the elderly and are particularly vulnerable to heat-related health impacts (van Steen, 2019; Ballester et al., 2023).

5.2.2 Flooding

Since the Fourth Assessment, researchers have focused specifically on communities that are vulnerable to flooding in the LA region. For example, some communities face the combined challenge of marine inundation and groundwater shoaling because of old or inadequate infrastructure's diminished drainage capacity (Fleming et al., 2023). The same study found that many of the communities at highest social risk are also most exposed to climate hazards, and that access inequities to adaptation resources further intensify this vulnerability. Additionally, **Figure 17** and **Figure 20** show that erosion and flooding often overlap, disaster routes and critical infrastructure are at high risk, and newly developed areas remain exposed to erosion and fire risk. This highlights the crucial need for specific, equity-focused flooding adaptation interventions across the region.

Flooding risks are disproportionately borne by under-resourced populations. In the LA region, Black, Latino, and Asian residents are, respectively, 79%, 17%, and 11% more likely than white residents to experience severe flooding (waist-high water) during a major event (Sanders et al., 2023). Low-income and marginalized communities are less protected and face longer, more difficult recoveries after floods due to unequal access to government aid and infrastructure investments. This is due to strong correlations between socio-demographics and coastal zone habitation throughout the region. Cities such as Long Beach, Paramount, Carson, Bell Gardens, and South Gate are particularly at-risk, with large shares of Black, Indigenous, and People of Color (BIPOC) residents and high levels of social disadvantage. Given that extreme runoff is estimated to increase by up to 50% by MC (*Section 2.3 Water Resources*), these inequities will likely increase within the region. Similarly, socially marginalized populations in the US are more likely to be impacted by flooding related to sea level rise, where there is a greater presence of hazardous sites, such as industrial sites, wastewater facilities, and other polluting sources posing significant widespread contamination and health concerns (Cushing et al., 2025).

Flooding also poses significant public health risks such as injury, disability, mortality, widespread distribution of contamination from existing pollutants, or increased long-term exposure to mold. Although studies specific to the LA region are lacking, Lynch et al., (2025), analyzed 35.6 million complete death records between 2001–2018 from the US and found that very severe rain-related flooding was associated with increased mortality from infectious disease and cardiovascular diseases. Flooding is also associated with greater risk of hospitalization for skin diseases, nervous system disorders, musculoskeletal conditions, injuries, poisoning (Aggarwal et al., 2025), low birthweight, and stillbirth (Mallett & Etzel, 2018).

5.2.3 Wildfire

In recent years, wildfires have emerged as an increasingly serious threat to the communities of the LA region, as described in *Section 2.4 Wildfire* and *Section 4.3 Housing*. Wildfires in LA County have recently impacted families with higher diversity and lower household incomes (Ong et al., 2025). This is in contrast to historically, where fires have disproportionately affected high-income, white, and older groups (Wibbenmeyer & Robertson, 2022). A closer look at Altadena during the 2025 Eaton Fire further highlights how pre-existing economic inequities amplify these risks. According to a UCLA data brief, 61% of Black households in Altadena were located within the Eaton Fire perimeter, and nearly half of Black homes were destroyed or severely damaged (Ong et al., 2025). The combination of geographic exposure and financial constraints has placed Black households in an especially vulnerable position, making post-disaster recovery particularly challenging. Among Black homeowners in Altadena, 45% were spending more than 30% of their household income on housing costs, and 28% were spending over 50% (Ong et al., 2025). These financial pressures, coupled with soaring insurance premiums and high reconstruction costs, threaten the post-disaster recovery of low-income families, particularly Black and Latino households (Ji & Bills, 2025). *Additionally, loss of homes from the fire disrupts* of property transfers to younger generations, further obstructing efforts to maintain and build generational wealth (Ong et al., 2025).

Wildfires significantly affect workers in low-wage occupations that depend on in-person labor, such as service, retail, and manual trades. These workers are especially vulnerable to temporary job interruptions during wildfire events and could face permanent job loss if their workplaces suffer major damage or destruction (González et al., 2025). Latino workers in the LA region are overrepresented in occupations that cannot easily adjust to wildfire-related disruptions, increasing their risk of income loss and long-term economic instability. More than eight in 10 construction and household workers are Latino. Nearly half of Latino household workers are self-employed and not covered by unemployment insurance, thus they are especially vulnerable to the loss of wages. Only 7% of Latino workers in LA County are able to work from home putting these workers at greater risk of unemployment and financial disruption (González et al., 2025).

Beyond the immediate loss of income, many low-wage Latino workers face lasting financial hardship due to health complications from repeated smoke exposure. In LA County, Latinos are two to three times as likely to lack health insurance, compared to their white, Black, and API counterparts. Immigrant and migrant workers are particularly vulnerable, as they often have few pathways for recovery assistance from disaster-related job losses (González et al., 2025).

During LA's devastating 2025 fires, nearly every school district in LA County closed, many for a full week. Parents of these 1.3 million public school students had to either stay home from work (losing income) or pay for alternative childcare. Data shows that mothers in California spend more time than fathers on childcare, suggesting that the responsibility for childcare during the school closures caused by the fires fell disproportionately on women (Gender Equity Policy Institute, 2025).

Older adults and people with disabilities face particular vulnerability during wildfires, including limited mobility, dependence on medical equipment, and difficulty evacuating quickly. Without accessible evacuation plans and specialized support services, these groups face risk of injury, health deterioration, and death (Melton et al., 2023).

For those not directly impacted by wildfires, the pollution transported beyond the burned area is a major hazard. As discussed in *Section 2.6 Air Quality*, increases in major fires have led to increased episodes of hazardous air quality. Increased exposure to wildfire smoke and the associated ozone and PM2.5 could lead to a heightened risk of respiratory and cardiovascular diseases and mortality (Reid et al., 2016a; Connolly et al., 2024). Wildfire-specific PM2.5 may be more harmful than PM2.5 from other sources, even at the same exposure levels, according to an analysis of respiratory hospital admissions in Southern California during the period 1999–2012 (Aguilera et al., 2021). It also should be noted that the combustion of human-made materials in wildland-urban interface fires has raised concerns about the toxicity of fire smoke due to emission of hazardous air pollutants. During the 2025 LA County fires, a 110-fold increase in lead levels was recorded by air quality monitoring stations (Baliaka et al., 2025).

Research shows that the health consequences of wildfire exposure are particularly severe for older adults. A scoping review found increased hospitalizations and mortality due to cardiovascular and respiratory complications during or after wildfire events. For example, Medicare enrollees in the western US experienced a 7.2% increase in respiratory hospital admissions on intense smoke days, and 34% of elderly participants showed lung function impairment. One study on the 2008 California wildfires found that among those over age 65, women were more likely than men to visit the emergency room for asthma-related conditions (Reid et al., 2016b). These impacts are even more acute among senior women and BIPOC seniors, revealing how interconnected disadvantages can heighten wildfire-related health risks (Melton et al., 2023). Finally, many studies have shown that prenatal exposure to wildfire-related PM2.5 or smoke is associated with poor birth outcomes (Picciotto et al., 2024: Khalili et al., 2025; Sherris et al., 2025).

5.2.4 Air Quality

As climate change intensifies, in addition to wildfire-related air pollution, high-pollution events like worsening ground-level ozone and secondary PM2.5 formation are potentially becoming more frequent and prolonged. Exposure to PM2.5 and ground-level ozone have been linked to asthma, cardiovascular disease, birth complications, and premature death (World Health Organization, 2026). Pregnant women, children, older adults, outdoor workers, and low-income families living in environmentally-burdened communities are particularly vulnerable to these negative health impacts.

Given the expected increase in ozone in the LA region (*Section 2.6 Air Quality*), ozone needs increased attention as a public health concern, while the long-term health impacts of PM2.5 remain more uncertain. Additionally, rising atmospheric CO_2 levels and higher temperatures have been shown to enhance pollen production, thereby increasing the prevalence of allergic reactions and asthma (Albertine et al., 2014; Zhang & Steiner, 2022).

In addition to the above impacts, when considering indoor health, we may also include risks such as elevated emissions of VOC from building materials, furniture, and household products (Nazaroff, 2013). Furthermore, the expansion of mosquito habitats due to rising temperatures has led to increased use of indoor insect repellents, which release hazardous pollutants such as PM2.5, benzene, and formaldehyde, further exacerbating indoor air quality concerns (Poole et al., 2019).

Children are particularly susceptible to air pollution due to their developing respiratory systems and the greater amount of time they spend outdoors (Aithal et al., 2023). Long-term exposure to pollutants can cause lasting damage to lung function among children. One study estimated that nitrogen dioxide (No2) exposure accounted for 16% of all new pediatric asthma cases in urban areas (Anenberg et al., 2022). A study of children in Southern California found that those growing up in areas with higher air pollution levels experienced significantly reduced lung function, with effects persisting into adulthood (Gauderman et al., 2004). In LA County, children exposed to higher levels of traffic-related air pollution were more likely to be diagnosed with asthma and had reduced lung function, particularly those living in lower socioeconomic status neighborhoods (Ritz et al., 2009).

Children living in low-income communities face additional risks. A study of high-ozone communities in Southern California found that children who regularly engaged in outdoor sports were more likely to develop asthma than equally active children in areas with better air quality (McConnell et al., 2002). Latino and Black children are more likely to live in areas with elevated traffic pollution and lack access to private health insurance (Delfino et al., 2015). In the LA region, 24% of Latino and 34% of Black children live in low-income families.

Older adults are also at elevated risk from air pollution, due to declining lung capacity, weakened immune systems, and the prevalence of chronic conditions such as cardiovascular disease and diabetes (Ailshire & Brown, 2021). One study on older adults in California found that long-term exposure to fine particulate matter (PM2.5) significantly increases cardiovascular risk and mortality (Liao et al., 2021). Research has also linked air pollution, especially PM2.5, to cognitive decline and dementia. Living in areas with elevated PM2.5 concentrations has been associated with poorer cognitive function and more rapid declines in memory and attention among older adults (Ailshire and Brown, 2021).

This is especially troubling for Black and Latino older adults, as national research has shown that they are more likely to live in areas with greater air pollution. Among older adults in the US, 25% of Latino and 13% of Black people ages 60-64 lived in neighborhoods exceeding the national PM2.5 standard, compared to only 7% of their white counterparts (Ailshire & Brown, 2021).

Pregnant women face heightened risks from air pollution, with exposure to pollutants like PM2.5 and No2 (nitrogen dioxide) linked to serious complications for both mother and baby (Rani & Dhok, 2023). A California-based study found that increases in air pollution levels were significantly associated with a higher risk of preterm birth (Wu et al., 2016). Another Southern California-focused study revealed that maternal exposure to No2, ozone, and PM2.5 was consistently tied to a greater risk of spontaneous premature rupture of membranes, a dangerous condition that can drastically raise the likelihood of maternal and neonatal mortality and morbidity (Jiao et al., 2023).

Air pollution can also take a toll on mental health and cardiometabolic health. The Maternal and Developmental Risks from Environmental and Social Stressors (MADRES) study examined the relationship between pregnant women's prenatal exposure to air pollution and postpartum mental health outcomes among predominantly low-income Latina women in LA (Hu et al., 2024). The study found that pregnant women exposed to higher levels of No2 or PM10 during their second trimester were nearly four times as likely to experience postpartum depression than those with lower exposure. Similarly, preconceptional and prenatal exposure to PM2.5, PM10, and No2

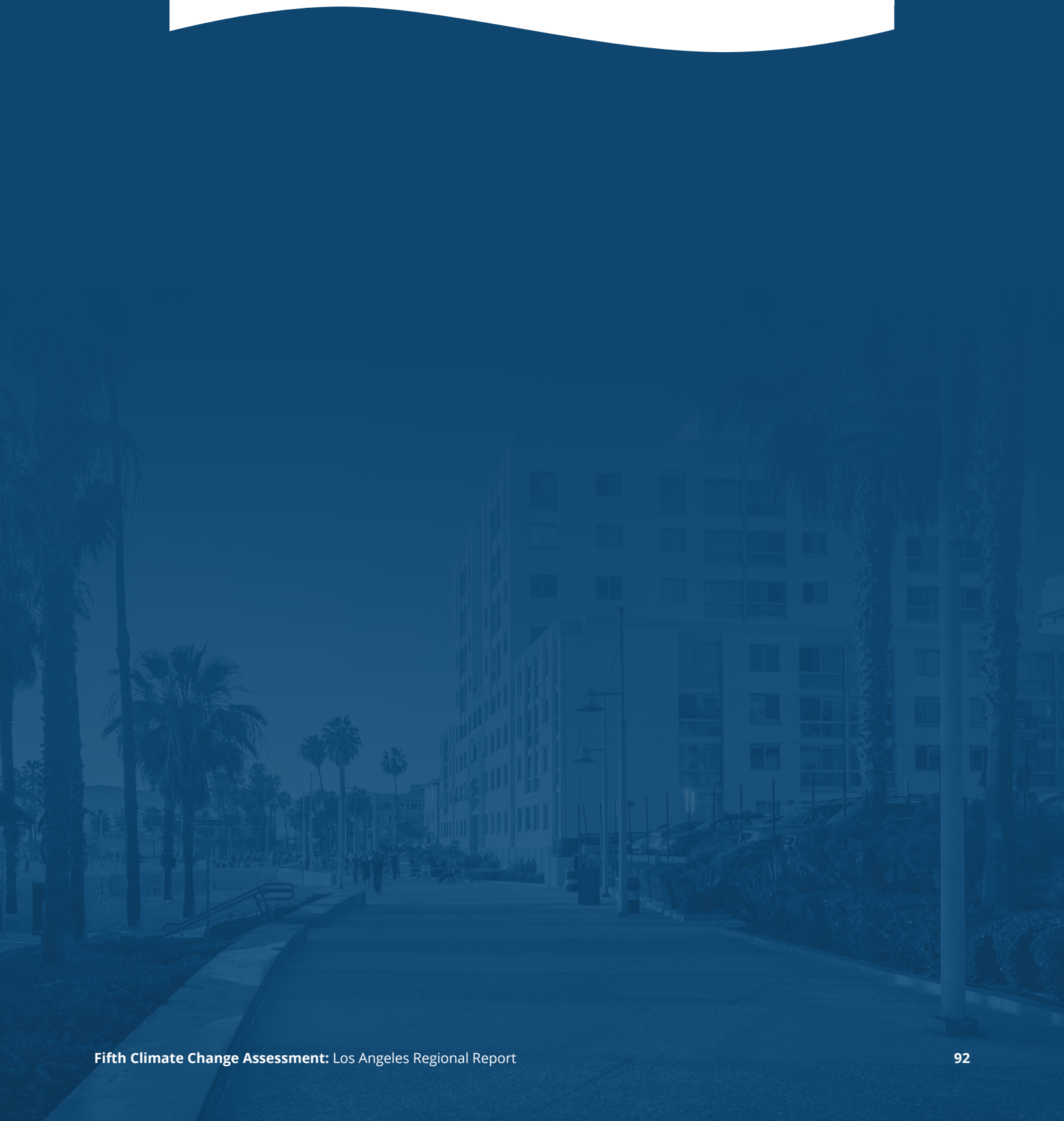
are associated with greater gestational diabetes in pregnant women enrolled in the LA MADRES study (Niu et al., 2023).

People who work outdoors, such as in construction or agriculture, are likewise vulnerable to air pollution, due to their prolonged exposure during physically demanding tasks, often performed in high-traffic or industrial areas. Exposure to pollutants such as PM2.5 and ground-level ozone has been shown to significantly impair cognitive function, diminish mood and motivation, and increase the incidence of workplace injuries (Lu 2020).

Air pollution also carries important economic consequences, reducing employee productivity and increasing absenteeism across a range of industries (Graff Zivin & Neidell, 2012), either by causing illness among workers or by requiring them to care for dependents such as young children and older adults (Ostro, 1983; Aragón et al., 2017; Meng et al., 2023). Those who work indoors can also be affected by air pollution, as certain pollutants, particularly PM2.5, can easily travel indoors and reduce productivity even in enclosed settings (Lu, 2020).

Chapter 6.

Adaptation Strategies



Key Messages

- Measures such as laying cool pavement, installing cool roofs, and increasing tree canopy, combined with increased public education and public cooling centers, are likely to mitigate the impacts of extreme heat for the most vulnerable.
- An increase in water recycling and storm water capture are likely to mitigate drought, together with improved infrastructure to handle increasingly volatile precipitation.
- Potential adaptation measures to wildfire include power shutoffs, burying or fortifying power lines, managed land retreat, increased buffer zones, and home hardening.
- Tribes are revitalizing sustainable Indigenous stewardship practices to reduce the risk of major fires, including cultural burns and native plant restoration.
- Measures to reduce pollutants, including electrification of transportation and more renewable energy, together with reducing public exposure during hazardous air quality episodes, are likely to be beneficial.
- Adaptation options to sea level rise are being explored, including beach nourishment, wetland restoration, hard infrastructure (seawalls, levees), and nature-based solutions (dunes, living shorelines).

Given the wide range of climate hazards that are expected to intensify (Chapter 2) and the wide range of impacts that may be experienced across the region (Chapters 3–5), measures to mitigate and adapt to climate change will be increasingly necessary. Fortunately, a wide range of adaptation measures have already been implemented, which we discuss below. However, some impacts are likely to be well beyond what has been experienced in the region to date, and thus, we discuss potential opportunities as we transition to a warmer, more volatile climate through the 21st century. The purpose here is not to prescribe policy, but to summarize potential adaptation measures, along with their advantages and disadvantages, so that the public and policymakers may be as informed as possible.

A vital component of climate resiliency in the LA region will be Tribal sovereignty and leadership. Tribal climate leadership is grounded in technical knowledge, as well as governance systems and relational concepts such as reciprocity and kinship, which inform long-term stewardship and adaptation strategies. Therefore, honoring their ancestral knowledge and supporting Indigenous stewardship is critical in understanding regional ecosystems and returning to a way of life where human infrastructure and land/water management do not amplify the impacts of climate change. For example, the Fernandeño Tataviam Band of Mission Indians (FTBMI) has released a Tribal Climate Resiliency Plan for the region. This plan proposes to "invest in actions that will mitigate extreme heat, wildfire, flooding, and challenges to our energy systems by using Traditional Ecological Knowledge and the best available science and data." It outlines specific policy recommendations to mitigate the worst impacts of extreme heat, flooding, drought, and wildfire, while adapting the region's energy infrastructure and use of natural resources.

6.1 Extreme Heat

Adaptation to the impacts of extreme heat (*Section 3.1 Chaparral and Coastal Sage Scrub, Section 4.1 Energy Resources,* and *Section 5.2.1 Extreme Heat*) will primarily focus on initiatives to cool homes

and public places. Tribal leadership is pivotal in adapting to extreme heat, given the sustainable adaptation of Indigenous Peoples to the region's high temperatures over thousands of years. The FTBMI's Tribal Climate Resiliency Plan outlines an expansion of access to air conditioning and insulation retrofits, as well as the installation of shade and water structures and an increase of canopy coverage in public places as vital measures. Given their ancestral knowledge and close community ties, the FTBMI and other Tribal organizations are ideal partners for the planning, development, and implementation of these programs.

6.1.1 Home Cooling

Given that a significant portion of the LA region lacks home air conditioning, even in the most heat-prone areas (*Section 5.2.1 Extreme Heat*), this is a major area for equity-driven adaptation to extreme heat. Existing programs for installation include LADWP's Cool LA and Southern California Edison's Energy Savings Assistance. In addition, LA County is implementing an ordinance to mandate rental units to maintain a maximum indoor temperature of no more than 82°F (28°C). However, even for those who have it, air conditioning is likely to be prohibitively expensive in the coming decades. Based on community outreach for this report, residents who do have air conditioning are worried about its cost moving forward, especially as they feel an increasing need to use it. Therefore, assistance with utility bills could be extremely impactful in reducing vulnerability, particularly for the significant number of energy-burdened people in the LA region (**Table 5** and **Table 6**). Potentially one of the most impactful measures will be programs that allow residents to install solar panels for free (**Box 10**), which could enable liberal use of air conditioning during heat waves.

Box 10: *Climate Story: Watts Solar (Excerpt, Watts Rising 2024 Progress Report)*

Moneik Johnson is a longtime and active member of the Watts community, where she has owned her home for more than two decades. With fewer green spaces than other parts of the region, Watts is a disproportionately hot community—and it's only getting hotter due to climate change.

Despite the heat, Johnson has never had air conditioning in her home. She has struggled to pay her electricity bills, even without the major expense of cooling her home to a comfortable level. But this is changing. After having solar panels installed on her home for free through Watts Rising's home solar program, she is already experiencing major benefits.

Once the panels were turned on, she immediately began seeing a difference in her electricity bill. "...This last bill was the best bill. I've never seen a bill like that since I've been a DWP customer," Johnson said. Before having solar installed, Johnson was making monthly payments to pay off her electricity bill debt. Now, she can pay the bill in full.

Lower electricity bills mean that Johnson can now afford to keep her home cooler. "I know that now it'd be affordable for me to get air conditioning. I've been wanting it because it's so hot." Johnson has been sharing her positive experience with installing solar to encourage others in her community to sign up for the program. "I've been telling all my neighbors that I know. It's a good thing to have."

See the full version of the climate story in **Appendix, Text A10**.

6.1.2 Public Heat Mitigation

To mitigate extreme heat in public places, measures are being taken at city, county, and community levels, as well as collaborations across all of the above. LA County is developing a County Heat Action Plan which engages with residents in heat-vulnerable communities to identify

priority policies and investments for heat resilience. These policies will include urban greening, shade, building improvements, and emergency communications and services. Meanwhile, Room to Grow, a Community Forest Management Plan, is being implemented by the County as an actionable, long-term strategy to plant and manage trees in the unincorporated communities of LA County.

Vulnerability assessments can be effectively implemented in extreme-heat adaptation. For example, the City of Santa Monica conducted a vulnerability assessment across various sectors of the community, analyzing how people, buildings, infrastructure, and the economy will be affected by heat and other climate hazards. Subsequently, their Climate Action and Adaptation Plan identifies City hotspots where investment in climate change mitigation is likely to be the most effective. However, climate adaptation plans are not legally enforceable and may face barriers to effective implementation, including funding, staff capacity, expertise, technical assistance, partnerships, and political will (Macey et al., 2025). The same study makes recommendations for policy changes for the successful implementation of climate planning, including targeted hazard mitigation, stronger evacuation planning, and prioritizing vulnerable populations and high-risk areas.

The City of LA is in the process of developing a wide range of programs to mitigate extreme heat (**Box 11**). However, elsewhere in the LA region, measures taken by the City may not be applicable, particularly for the more inland parts of the region, where extreme heat is likely to be far worse than in LA (*Section 2.1 Warming*) and where equity-driven plans are gaining momentum. For example, the City of Rialto's Climate Adaptation Plan uses an equity assessment to inform the selection of adaptation strategies, including how heat uniquely impacts different vulnerable groups (Chapter 5), where current capacity exists to address those vulnerabilities, and where new capacities need to be developed. Similarly, the University of California's "A Framework for Incorporating Environmental and Climate Justice into Climate Action" is being used for adaptation plan development, prioritization, and implementation.

Meanwhile, the City of Thousand Oaks' 2024 Climate Action Plan outlines its adaptation and resilience goals to address extreme heat, which include expanding the urban canopy with native trees, modifying city ordinances to allow contractors to begin working before 7 a.m. and/or after 7 p.m. on high heat days, and exploring alternative pavement options for city infrastructure. The City of Corona's General Plan details efforts to reduce extreme heat impacts through elements like reflective roofs or pavement, vegetated roofs, pervious pavement, shading trees, and revegetation of paved areas.

Box 11: *Extreme Heat Mitigation in the City of Los Angeles*

The City of LA is taking a comprehensive approach to adapting to extreme heat by reducing immediate risks, building long-term resilience, and centering equity in adaptation strategies. Its Cool Pavement Program has laid over 181 miles of cool pavement in communities vulnerable to heat, and LADWP has expanded cool roof installations to mitigate the urban heat island effect. To guide decision-making for targeted interventions, the City utilizes its internal infrastructure data, the Bureau of Engineering's Infrastructure Equity Scorecard, and the 2024 Climate Vulnerability Assessment, which identifies the neighborhoods at greatest risk from extreme heat. During extreme heat events, the City operates cooling centers, including a pilot program with the LA Public Library, to offer immediate heat relief and serve as community hubs. Nature-based solutions, such as drought-tolerant landscaping and stormwater capture projects, are being scaled up to enhance shade, reduce surface temperatures, and improve overall neighborhood livability.

Community partnerships are shaping the City's program priorities, from tree planting to cool surfaces to resilience centers. For example, the City's partnership with ShadeLA, a campaign led by USC Public Exchange and UCLA Luskin Center for Innovation, leverages the attention and investment coming to the region in advance of mega-events culminating in the 2028 Olympic and Paralympic Games to increase shade in LA. Multiple City offices are actively supporting ShadeLA to streamline projects through permitting reform and other pathways. In addition, LADWP and LA Sanitation are collaborating with community organizations to increase tree canopy in historically under-resourced communities with limited shade and high social vulnerability.

The City is also developing a Landscape and Site Design Ordinance that would integrate cooling and resilience standards into new development and urban design. Together, these tools provide a foundation for ensuring that future investments reduce heat risk while creating co-benefits for health, safety, and quality of life.

6.1.3 Community Initiatives

Community-based organizations (CBOs) are also leading efforts to cool concrete-heavy neighborhoods. In April 2023, Climate Resolve, in collaboration with many partners, began GAF Cool Community Project–Pacoima to modify the streets to retain less heat. Specifically, they coated 18 square blocks of street, a school playground, and a recreation center parking lot with StreetBond, a water-based epoxy pavement coating that blocks the pavement from absorbing much of the sun's radiation, thus reducing surface temperature. Research has shown that cool pavement reduces midday surface temperature by 4.5–8.4°C, relative to traditional asphalt. However, it increases heat stress if walking on or near the pavement, due to the reflected sunlight (Vanos et al., 2026), illustrating that reflective pavements are not a silver bullet for extreme heat.

Extreme-heat adaptation will also include community heat education. Communities nearer the coast may have minimal experience of coping with extreme heat and may be unprepared for this issue in the future. Meanwhile, inland communities, although already accustomed to extreme heat, are likely to experience a frequency and intensity of extreme heat that is unprecedented. Collaborative efforts across governments and non-governmental organizations can foster learning. For example, a collaboration is underway between LA County, Rising Communities, and the Fernandeño Tataviam Band of Mission Indians through a grant from the LA Regional Collaborative for Climate Action and Sustainability (LARC) to train community health workers to provide heat education and resources through door-to-door outreach and community engagement. Meanwhile, LA County is developing a Heat Preparedness Guide and piloting it with healthcare partners in three high-risk communities in the County.

Another vital measure will be to make the public aware of where they can go to escape extreme heat, especially if they work outside, are unhoused, or lack home air conditioning. The County

is updating the user-friendly Ready LA County "Excessive Heat" Cooling Center interactive map, an online public tool to easily reference where County cooling centers are located, with links to additional heat action resources, including pools, splash pads, and educational materials. Cooling centers in LA County are used for 1.1–1.7 times longer during heat events than other days, although informal cooling centers, such as shopping centers, are used far more often (Derakhshan et al., 2023). The same study also found that centers farther from public transit stops are used less. Meanwhile, residents in vulnerable communities are more likely to use centers in other vulnerable communities. These findings highlight critical components of cooling-center design and placement as the climate warms.

The LA region is also building "resilience hubs," centers that enhance a community's capacity to adapt to climate hazards while strengthening local resilience, thanks to funding from the California Strategic Growth Council (SGC)'s Community Resilience Centers (CRC) Program. Resilience hubs are designed to help vulnerable communities receive timely communication about available cooling centers and provide solutions for a wide range of climate hazards. A survey by Getting Residents Engaged in Empowering Neighborhoods – Madison Park Neighborhood Association (GREEN-MPNA) and the UC Irvine Community Geoscience Initiative found that 70% of respondents had never before heard of a cooling center, and that resilience hubs and cooling centers will attract more users if they provide culturally sensitive resources, programs, and conveniences. Notably, most respondents deprioritized cooling centers compared to green space expansion and energy bill assistance programs when ranking potential City-sponsored heat adaptations (Staudmyer et al., 2026).

Box 12: *Climate Story: Community Resilience to Extreme Heat*

I'm a climate resilience leader in the Southeast Los Angeles County region, also known as the "Gateway Cities." I grew up in Long Beach, California, a city of almost 500,000 people and a core hub of goods movement, air quality issues, and climate adaptation. Long Beach is adjacent to the largest port complex in the US, carrying almost 20 million containers of materials a year. It's a location where shipped goods from the rest of the world crisscross neighborhoods via diesel trucks and trains.

With extreme heat being one of the highest impacts in the Southeast Los Angeles County Region, communities that already deal with a burden of air pollution will have effects exacerbated. My mom was a kindergarten teacher in west and north Long Beach for 19 years, where elementary schools and homes were in close proximity to high-traffic roads and refineries. The communities are predominantly made up of low-income households that suffer from air contamination, and consequently health issues like asthma. Over the years, parents, teachers, and local governments have collaborated for solutions like air filters and ventilation in classrooms, adding vegetation barriers near roadways, and school gardens.

I also have a large Latino family of outdoor workers, who are disproportionately affected by extreme heat. For example, my husband, a sanitation worker, was spotlighted in the Los Angeles Times for his attempts to stay cool during the hottest, longest heat wave in California in 2022 (article). Outdoor workers like him have limited access to shade and air conditioning during extensive physical labor hours. I frequently share extreme heat cooling tips to my family from ListosCalifornia.org, the State's website on emergency preparedness for climate events.

Because of climate experiences with community and family, I participate in climate change solutions every day. I have worked with nonprofit organizations like Climate Resolve to advocate for more trees, shade canopies, bus shelters, cool pavement, and hydration stations. Now I work with the Gateway Cities Regional Climate Collaborative, which is identifying climate projects and plans, uplifting community-informed research, and increasing resources for equitable, sustainable change.

I'm sharing my story to shed more light on climate change impacts and collective hope for solutions.

See the full version of the climate story in **Appendix Text A11**.

6.2 Energy Resources

In the face of increasing climate hazards affecting the LA region's energy infrastructure (*Section 4.1 Energy Resources*), significant mitigation and adaptation efforts are underway.

6.2.1 Shift to Renewable Energy Sources and End-Uses

The LA region's electrical system is currently undergoing profound structural transformation in direct response to emergent climate threats. This shift is characterized by a transition from a centralized, fossil-fuel-dependent model toward a more decentralized and renewable-heavy architecture (Vine, 2011). This transformation is not merely a technical upgrade but a socio-technical process involving decarbonization, decentralization, and democratization (Geels et al., 2017). As the region moves toward a target of 100% carbon-free energy over the next two decades, legacy infrastructure is being repurposed or retired with a growing emphasis on distributed energy resources, such as rooftop solar and localized battery storage systems (Feldman et al., 2023; Cochran et al., 2024). This transformation can provide significant co-benefits in addition to greenhouse gas emissions reductions, in terms of enhanced resilience and operational flexibility, but involves careful planning and coordination with rate-payer and community representatives to ensure that cost and equity concerns are suitably addressed (Dunlap et al., 2025). This shift toward renewables is occurring in conjunction with the passage of state Senate Bill 100 (SB 100, 2018), the state's Renewable Portfolio Standard (CEC, 2026), requiring the state's investor-owned utilities (IOUs) to supply an increasing percentage of their power sales from renewable resources, in pursuit of a long-term goal of fully decarbonizing the state's power system by 2045. This has significant implications for the operations of Southern California Edison, a major IOU electrical provider that serves approximately 15 million customers within the LA region (SCE, 2026b).

Furthermore, on the demand side, efforts are underway to switch existing gas and other fossil-fuel powered end-uses to electrical equipment (Ebrahimi et al., 2018; Sun et al., 2020). Many modern electric appliances (particularly those based upon heat-pump technologies) can be significantly more energy efficient than the existing fossil-fuel combustion equipment that they are designed to replace, leading to meaningful reductions in primary energy demand. Additionally, electrical equipment can be supplied by renewable generation sources, enabling "deep decarbonization" benefits that emanate from multiple levels of the energy system (Steinberg et al., 2017). Efforts are ongoing to increase rates of end-use fuel substitution through changes to municipal building codes and appliance energy emissions standards. Notably, in the latter case, the South Coast Air Quality Management District (SCAQMD) recently passed new regulations (Rule 1146.2) which specifically require the use of zero-emissions equipment for water heating end-uses in newly constructed residential and small commercial buildings (SCAQMD, 2024). To help offset the up-front costs associated with the replacement of fossil-fueled equipment in existing buildings, SCADMD has also initiated the GO-ZERO program, which provides $1,000–$4,000 rebates for qualifying homes and small businesses pursuing space and water heating electrification projects (SCAQMD, 2024). Other similar incentive programs are also available at the state and local utility levels to provide supplemental funding for customers interested in undertaking end-use electrification (TECH, 2026; LADWP, n.d.; SCE, 2026b; Switch is On, 2026).

6.2.2 Incorporation of Climate Forecasts into Energy Infrastructure

One of the most important strategies that can be used to mitigate climate risks involves the use of climate model forecast predictions for design-relevant variables (temperature, pressure, precipitation, etc.) and the uncertainties therein. These projections are used to develop the engineering specifications/tolerances for new electrical power generator equipment and systems. Some current equipment can be tuned to structurally adapt to many types of climate hazards. However, the ongoing shift to more distributed and renewable forms of electricity generation provides greater resilience to climate hazards. This is because renewable generation technologies tend to be far less negatively impacted by climate hazards, including extreme heat, wildfires, and sea level rise. Moreover, the distributed deployment of these technologies and smaller scales of deployment naturally reduce the likelihood of large-scale, catastrophic disruptions occurring.

Climate forecasts are also being utilized for electricity load forecasting. For example, the state's central energy planning agency, the California Energy Commission (CEC), has recently begun integrating climate model forecast data into its electricity load forecasting products, primarily through its California Energy Demand forecast, which is part of the biennial Integrated Energy Policy Report (Rahimi, 2022; Lumen Energy Strategy, 2025). Previously, the CEC relied solely on historical weather data to develop future load forecasts that were used to inform system capacity investment planning processes. This shift to a more climate-informed energy demand forecasting approach reflects a significant effort on behalf of the state to plan for an evolving, and potentially unprecedented, set of power system conditions as a direct result of climate change.

6.3 Water Resources

Future changes to water availability, both locally and in regions from which water is imported to the LA region, are inevitable (*Section 4.2 Water Resources*). Thus, adaptation is likely to be necessary to prepare for future conditions.

6.3.1 Water Supply

Continued reliance on imported water is likely; however, LADWP and surrounding water districts are planning for reductions in imported water supply reliability via investments in increased conservation, advanced treatment of recycled water for eventual direct potable reuse, desalination, stormwater recharge, and groundwater replenishment. The fraction of water LADWP plans to obtain by 2045 from recycled water is projected to increase (in an average water year) from roughly 2% to 6% and stormwater recharge from roughly 0% to 2% (LADWP, 2020). Such efforts will improve LA's ability to produce local water along with other co-benefits.

Additional changes that could have an impact on the region's water supply include the potential construction of the Delta Conveyance Tunnel. This would aid in capturing projected increases in winter streamflow in Northern California (see the Fifth Assessment's "North Coast Regional Report" and "Sacramento Valley Regional Report") and increase State Water Project reliability. The Colorado Aqueduct currently provides roughly 8% of LA's water; however, this resource is becoming unreliable given historical and projected declines in Colorado streamflow (e.g., Bass et al., 2023; Wang et al., 2025).

Projected increases in wet extremes, including an 18% to 52% increase in runoff during 95th percentile events for SSP2–4.5 to SSP3–7.0, respectively, are likely to threaten the LA region's stormwater drainage infrastructure. Adaptation efforts to increase the capacity and improve the performance of stormwater and reservoir infrastructure that can be overwhelmed during flood events could also support local water supply. For example, green infrastructure that supports infiltration and stormwater recharge can reduce flood risk while also increasing water supply and improving water quality conditions. Reservoir management, in terms of when water is stored vs. released, will likely need to adapt for LA region headwater basins, as well as Sierra Nevada basins. Here, the increased flood risk will need to be balanced with water supply needs, particularly given summer-to-winter shifts in streamflow due to reductions in snowpack (**Figure 14**). Given the combination of projected increases in extreme runoff and wildfire events, post-fire debris flow or "sediment-laden floods" will need to be planned for. To reduce impacts from such events, continued efforts will be required after wildfires to clear stormwater drainage systems and debris basins and potentially resize such infrastructure to handle the increasing frequency and severity of these compound events.

6.3.2 Water Management

Since the Fourth Assessment, the LA County Water Plan was completed, consisting of four key focal areas: 1) regional water supply reliability; 2) groundwater management and quality; 3) small at-risk system resilience and drinking water equity; 4) and watershed sediment management. The plan includes strategies, such as mitigating wildfire effects on water supply and quality, establishing consistent drought preparedness measures with cities and other organizations, and facilitating regional groundwater recharge initiatives. This plan is an example of long-term regional-scale measures that, if implemented consistently over the region this century, could allow the region's water to remain stable and clean under a changing climate.

An investigation performed for the Fifth Assessment examines how 28 court-adjudicated groundwater areas in California (12 in the LA region) align with California's sustainability and equity goals (Langridge et al., 2026). Because areas are exempt from the state's Sustainable Groundwater Management Act, this study evaluates them individually with regard to management, equity, sustainability, and climate resiliency. These areas constitute a significant portion of the LA region's groundwater, and, thus, these lessons highlight weaknesses and opportunities to make groundwater infrastructure more equitable and climate resilient.

Other cities and counties in the region are also taking steps to manage and improve water efficiency. For example, the City of Rancho Cucamonga's 2021 Climate Action Plan highlights strategies to reduce city-wide water use, including encouraging single-family households to install water-efficient landscaping and increasing the percentage of recycled water in the City's water supply to 6% in 2030 and 12% in 2040.

6.3.3 Community-Based Work

The involvement of CBOs also contributes to climate resiliency of the region's water resources. For example, the Just San Bernardino Collaborative has devised a People's Plan for Economic Justice which includes reducing water pollution by offsetting or subsidizing protection methods,

such as air and water filtration systems, vegetation, and physical barriers to toxic sites. The plan also values regularly updated, accessible data about air and water pollution levels and refusal of any projects that bring in more air or water pollution to the City of San Bernardino. The desire for better communication between local government and communities is also underscored in East Yard Communities for Environmental Justice's *H2Ours: People Protecting Water*, a community-based assessment of water in Southeast LA, which reports that water agencies offer limited opportunities to community residents to engage in policy debates and decision-making. In the wake of the Eaton and Palisades Fires, do-not-drink advisories were put in place for the most directly impacted districts, but for neighboring districts where residents were also concerned, little information was given.

Using their place-based knowledge and long-standing water stewardship practices, Indigenous communities are taking leadership in water adaptation under climate change. The FTBMI's Tribal Climate Resiliency Plan calls for a wide range of water adaptation, including enhanced floodplains, nature-based stormwater infrastructure, increased water recycling, and encouragement of the public to conserve water. Tribal leaders are also increasingly being appointed to management positions within government agencies. For example, Rudy Ortega Jr., the Tribal President of the Fernandeño Tataviam Band of Mission Indians, was recently appointed to LADWP's Board of Water and Power Commissioners. Tribal perspectives on water resources were highlighted by the 2025 documentary film, *Our Water Ways* (**Box 13**), and is intricately linked to the movement to restore the LA River (**Box 14**). Similar initiatives are underway for the Santa Ana and San Gabriel Rivers. Lessons of natural river restoration are also being learned from elsewhere in California, for example, the removal of the Klamath River Dam in 2024. The dam's removal, made possible through the leadership of local Tribes and advocacy from various partners, has led to the return of salmon to the river and is expected to increase water retention and quality, as well as reduce fire risk. See the Fifth Assessment's "North Coast Regional Report" for more details.

Box 13: *Our Water Ways*

The 2025 documentary film produced by the Sacred Places Institute for Indigenous Peoples tells the story of Indigenous water management in California prior to colonization and the perspectives of Indigenous Peoples to subsequent Western water projects. The film highlights the ways in which they protect sacred waters that have been taken from them and mismanaged. The documentary includes pieces of interviews with Tribal members detailing the importance of water, the Native connection to water, and their frustration with the disrespect to water displayed by non-Native people, while highlighting their resiliency in maintaining their ways of life and illustrating the role of Tribal leadership in restoring the natural waters against the threat of climate change. These issues are exemplified by the following quotes from the film.

- *"They look around and it's this concrete jungle and so surely there could be no Native homelands there…Understand that before it was a concrete environment it was our homeland and we've learned how to live amongst you as everyday people whether we wanted to or not."*
- *"They're wasting it; they're wasting this water; they're not taking care of it properly; they're not showing the love and respect to that water as they should because without that water, they can't live."*
- *"This is not how it's supposed to be: the river is sick and as long as the river is sick, the people will be sick."*
- *"We need to pay attention because we're either going to lose the water, or we're going to lose the power, or we're going to lose both."*
- *"This [the river] is a vein, like a vein in your arm taking blood to different parts of your body."*
- *"We're not going anywhere; I don't know if they know that; they tried to get rid of us and we're very persistent and very resilient and we're not going anywhere."*
- *"Our cultures are supposedly wiped out and we're wiped out; I don't feel like that at all."*

A section of the film is dedicated to the LA River, whose history, challenges, and opportunities are further discussed below.

Box 14: *The Los Angeles River*

The LA River presents a major challenge and opportunity for making the region's water resources more sustainable under climate change. Since being concretized in 1938, much of its natural ecological function has been disrupted, limiting its capacity to support the human and wildlife communities that depended on it for millennia. The resulting degraded riparian conditions and limited ecological function have long constrained Tribal relationships to land, water, and more-than-human kin within the region. Tribal organizations have long since campaigned for it to be returned to its natural state. Gradually, this has increased awareness throughout the region. For example, Friends of the LA River have been instrumental in restoration initiatives. Their vision is "…a Los Angeles River that supports vulnerable communities in climate adaptation … transformed into a dynamic, functioning ecosystem that reduces flood risk, cleans the air, cools temperatures, and supports the biodiversity essential to our collective well-being." To achieve this goal, they have used tens of thousands of volunteers to restore natural habitats, while campaigning for policies that protect the river and its surrounding communities, and providing K–12 education programs on the history and importance of the river as an ecosystem. Thanks to such efforts and resulting greater public awareness of the river's importance, LA County has released the LA River Master Plan, a series of projects to restore sections of the river to its natural state. This includes replacing miles of concrete with permeable soil, habitat restoration, and an increase of green spaces along the banks. This is likely to reduce flood risk, diversify the ecosystem, improve local water resilience, and improve water quality. The current version of the Master Plan was developed in consultation with Tribes, but more work is needed to include Indigenous communities. Meanwhile, there are concerns that the restoration will lead to gentrification. Nevertheless, the LA River represents a great possibility for progress in sustainability and climate resilience in the region.

6.4 Wildfire

A number of investigations and initiatives are underway to prepare for and mitigate the impact of future fires, especially those as destructive as the Eaton and Palisades fires. For example, the Blue

Ribbon Commission on Climate Action and Fire-Safe Recovery, a collaboration between UCLA, city officials, and nonprofit organizations, wrote a report outlining a detailed path toward rebuilding/recovering from the 2025 fires and ensuring future community resilience. Meanwhile, community organizations, such as California Forward, have detailed future practices to ensure that the LA region is prepared for fires of this magnitude in ways that it fundamentally was not prior to January 2025. Adaptation and mitigation to the expected future intensification of wildfires in the LA region may broadly fall under the categories below.

6.4.1 Reducing Ignitions

Utilities are increasingly burying or fortifying power lines to reduce ignitions. Between 2016–2020, 19% of acres burned in California were caused by power lines (usually by trees or branches falling). Significant, overwhelming financial damages stemmed from these catastrophes. **Appendix, Table A5** lists the damages, liabilities, and notable impacts from six major wildfire complexes over just the past decade in which electric utility infrastructure was determined to be at fault for ignition. These fires combined caused in excess of $100 billion in damages.

In California, there are 40,000 miles of bare power lines in wildfire-prone areas. The cost of hardening all of these would be astronomical (burying power lines underground is estimated at $1.85–$6.1 million per mile) and likely to be passed from the power companies to customers. However, as demonstrated by the Eaton Fire, ignited by faulty power lines and causing an estimated $25 billion in damages, the economic cost of fires is increasingly likely to exceed the cost of preventative measures. In the wake of the 2025 fires, local community organizations have demanded that power lines be buried in the most vulnerable areas. In response, the California State Legislature passed Senate Bill 884 (SB 884, 2023), which established the Electric Expedition Program, directing the California Public Utilities Commission to implement a slate of measures facilitating undergrounding projects to proceed (CPUC, 2026).

Public safety power shutoffs are another measure being used to address utility infrastructure-related wildfire ignition risks. The decision of whether to cut the power requires a complex balancing of fire prevention with the detrimental societal impacts of doing so. Cutting off power could impact medical equipment (e.g., oxygen masks and dialysis), air cooling, and filtration needs during wildfires and heat waves, and carbon monoxide detectors (Casey et al., 2020). Thus, older residents are particularly vulnerable to shutoffs. Burrows et al., (2025) found that concurrent or compound extreme heat and public safety power shutoffs were concentrated in California neighborhoods with a greater proportion of older adults and mobile home residents who are at greater heat-related health risks. In addition, shutoffs may prevent vital communications from reaching the public, particularly during extreme events (Ptak et al., 2024).

From 2013–2021, there were 67 power shutoffs in California, affecting more than 3.6 million customers, predominantly in fire-prone, rural areas. But in the heavily urbanized LA region, power shutoffs have traditionally been deemed unnecessary. As recently as 2019, LADWP stated that it "…does not turn off power to customers before or during wind events…Due to our location in a highly urbanized area with far fewer wildfire-prone areas, we do not face the same threat of wildfire…"

However, following the Eaton and Palisades Fires, this paradigm is shifting, and the decision not to cut the power prior to these fires, as well as LADWP's lack of a program in place to do so, has been fiercely criticised. When vegetation remains abnormally dry later into the autumn, there is an estimated 70% increase in the Northern California population affected by shutoffs, relative to an average year (Abatzoglou et al., 2020). Thus, under climate change, as severely dry vegetation becomes more frequent in the LA region, a combination of updating power lines, using power shutoffs where conditions are particularly high risk, and installing infrastructure and measures for the public to cope with shutoffs, is likely to be beneficial.

Deep alterations to the regional power system (*Section 4.1 Energy Resources*) may also reduce the risk of ignitions. For example, the creation of islandable microgrids and the increased deployment of distributed energy resources (i.e., rooftop solar, batteries, smart appliance controls). At present, the research community is working to better quantify the co-benefits of these new technologies and deployment architectures to justify their expanded use as an alternative to the above measures.

Many fires, such as Palisades, are ignited by other human activities, including arson, debris burning, smoking, recreational activities, equipment operation, and vehicles (Keeley & Syphard, 2018; Short, 2022). Thus, increased public education and increased staffing and enforcement are likely to be strongly beneficial (Minor & Boyce, 2019; Vinyeta & Bacon, 2024; Edgeley et al., 2025).

6.4.2 Reducing the Spread of Fires

Fires may be made less destructive by reforming public and private land management. Recent studies have found that prescribed burns lead to a reduction of subsequent burn severity and PM2.5 emissions and are likely to be particularly beneficial under climate change (Lake & Christianson, 2019; Stephens et al., 2021; Adlam et al., 2022; El Asmar et al., 2024; Kelp et al., 2025). This has been well-known by Indigenous Peoples for thousands of years, but until recently, the outlawing of cultural burning had prevented their stewardship. Government agencies are increasingly recognizing the merits of traditional land management, for example, from lessons learned in Sequoia and Yosemite National Parks, where natural fire management zones were established in 1968 and today support greater vegetation and species diversity, increased soil moisture, and decreased drought-induced tree mortality (Stephens et al., 2021). See the Fifth Assessment's "Sierra Nevada Regional Report" for more information.

Given their history of stewarding ecosystems through cultural burning, Tribes are highly qualified to provide leadership in wildfire resiliency planning. For example, the FTBMI's Tribal Climate Resiliency Plan includes the eradication of invasive species in natural lands, collaboration between Tribes and fire departments, and engagement and education of the community with regard to responsible building and landscaping practices. This is likely to be aided by recent state legislation supporting Tribal-led burning and reducing regulatory barriers.

The state has agreed to burn one million acres per year and the California Environmental Quality Act now explicitly requires lead agencies to consult with Tribes. Thus, awareness of the benefits of Tribal land stewardship is growing, offering promise for preventing future destructive fires.

The issue of prescribed burns may be more complex for chaparral. The California Chaparral Institute is opposed to prescribed burns of chaparral, given that climate change is already causing

it to burn too frequently. There is a narrow window in late spring when prescribed burns are both safe and effective, when the chaparral is sufficiently dry to carry fire but not so dry as to risk the fire becoming uncontained. However, this is the chaparral's growth season, when it is particularly vulnerable. Thus, prescribed burns can cause significant damage to plant growth tissues and destroy seeds in the soil, preventing the chaparral from ever coming back (Knapp et al., 2009). On the other hand, due to fire suppression, some areas of chaparral have not burned frequently enough, thereby becoming more flammable (*Section 3.1 Chaparral and Coastal Sage Scrub*), implying that reform of chaparral management will be beneficial in reducing fire spread. Note that prescribed burning, typically used for removing dead vegetation, is not the same as cultural burning, which is conducted by Indigenous practitioners and designed to enhance ecosystems, with different ecosystems requiring different burn methods.

Box 15: *Returning Land and Stewardship Permissions to Indigenous Peoples*

In addition to climate change, a century of fire suppression has caused fires to be more destructive. This has included an outlawing of cultural burns and a failure to recognize fire as a natural and healthy component of ecosystems. The Tongva are the original inhabitants of the LA Basin and still lack a reservation or official federal recognition. Thanks to recent Landback programs, the Tongva are beginning to resume traditional stewardship on patches of their ancestral land. For example, in 2022, a one-acre property in suburban Altadena became the first parcel of land returned to the Tongva people. Parts of the property burned in the Eaton Fire, but the damage was likely less than it would have been, thanks to restoration performed on the property, including removing 97 fire-prone Eucalyptus trees. In turn, the relatively modest damage to the property reduced the potential for embers to spread to further properties. Since the fire, significant progress has been made to restore the land, aided by community volunteers and the Tribal use of Traditional Ecological Knowledge. This example makes a strong case for returning land to native vegetation and drawing on ancestral stewardship practices to reduce the spread of fires in the wildland–urban interface when they occur. This movement is aided by organizations such as the Tongva Taraxat Paxaavxa Conservancy, which campaigns not just for land to be returned to Indigenous Peoples, but for members of the public to re-landscape their properties with native plants. The first Tribally-Operated land conservancy in LA, the Tataviam Land Conservancy, is conducting projects such as the Puhawvit Native Plant Nursery, which is "focused on growing and planting culturally significant native trees throughout the region" and was created from an abandoned lot in Pacoima. See their annual report. Similarly, the Acjachemen Tongva Land Conservancy is a collaboration between Acjachemen and Tongva descendants to reacquire and preserve Tribal lands. More broadly, a new California policy aims to bring at least 7.5 million acres under the care of Tribes, representing the acreage the US promised and failed to hold for Tribal reservations. Tribal-led efforts such as these are a critical part of adaptation to an intensification of wildfire and other natural hazards under climate change.

6.4.3 Reducing Fire Exposure and Vulnerability

A home's vulnerability depends not only on its own features but also on the conditions of neighboring parcels and the surrounding landscape. At the parcel level, building codes such as California's Chapter 7A mandate fortification measures in designated fire hazard severity zones, including ignition-resistant materials for roofs, siding, windows, and decks, and covering vents to prevent embers from entering the home, which substantially lowers the probability of structure loss. Creating defensible space, particularly clearing the first 5 ft (1.5 m) around a home of combustible material, is critical for preventing ember ignition, while thinning vegetation and ladder fuels within the 30–100-ft (9.1–30.4 m) zone further reduces fire intensity.

Research shows that mitigation measures, including home hardening and defensible space, can effectively reduce wildfire risk, providing strong justification for continued investment in mitigation. For example, Baylis & Boomhower, (2021) reveal remarkable resilience effects of building codes, initially prompted by the deadly 1991 Oakland Firestorm, on own and neighboring

structures. Zamanialaei et al., (2025) took advantage of CAL FIRE's unique damage inspection database (DINSc), which includes data from on-the-ground surveys of all structures that were damaged or destroyed in major California wildfires since 2013. The study focused on the 2017 Tubbs and Thomas Fires, 2018 Camp Fire, 2019 Kincade Fire, and 2020 Glass Fires to explore the impact of each mitigation measure and how they interplay. Their research identified structure separation distance as the most influential factor driving structure loss, especially in densely built areas where wildfire spreads from building to building. In addition, exterior siding and window materials substantially contributed to the vulnerability of structures.

At the community scale, strategies to reduce fire vulnerability include clustering development away from the wildland–urban interface and potentially not rebuilding following fires in certain areas. The case for so-called managed retreat has been made for decades. The scientific literature has explored the viability of this approach to protect the public from wildfire and other natural hazards (Hino et al., 2014; Mach et al., 2019; Koslov, 2016; McConnell and Koslov, 2024), and the approach has gained traction in more remote parts of the state, for example following the destruction of the town of Paradise by the Camp Fire. Since the Eaton and Palisades Fires, communities have discussed managed retreat, but this is typically not deemed feasible in the LA area where lower-income communities, with residents who cannot afford to go elsewhere, are increasingly being affected. Others have discussed building a non-flammable buffer zone around the wildland–urban interface. However, even this measure may not have prevented the spread of the Eaton and Palisades Fires, where flying embers ignited homes miles downwind. Less transformative, but potentially highly effective measures include maintaining fuel breaks or shaded fuel breaks around neighborhoods, and ensuring redundant road access for evacuation. Governance mechanisms, such as homeowner associations (HOAs) enforcement of Covenants, Conditions, and Restrictions (CC&Rs) or municipal defensible space ordinances, are key for coordinating these actions.

Strengthening collective risk mitigation requires communities, governments, and private actors to coordinate investments and incentives. Local governance structures, such as municipalities, fire districts and HOAs can also play a central role in organizing defensible space projects, enforcing building codes, and maintaining shared infrastructure that reduces wildfire exposure. For example, firewise community planning allows residents and stakeholders to work together to enhance their local area's wildfire resilience. Public-private partnerships further expand capacity by aligning insurers, utilities, and government agencies around shared resilience goals, pooling resources for fuel management, evacuation planning, and rapid recovery systems. By leveraging both local governance and cross-sector collaboration, communities can achieve risk reductions that no single actor could deliver alone, while also creating the institutional trust and financing mechanisms necessary for long-term adaptation.

Another major aspect of wildfire adaptation is emergency preparedness of the public. CAL FIRE has a Wildfire Action Plan designed to educate residents about the dangers their homes may face, while preparing them for evacuation and other considerations when fires are active. However, such resources, as well as the best practices contained within them, may be poorly understood by the public. This is likely to be a particular issue for those living in neighborhoods that have historically been deemed safe from wildfires, which Palisades and Eaton have demonstrated may no longer be the case. Greater preparedness is likely to be necessary for vulnerable members of the community, such as children, seniors, and disabled people.

Early warning systems, which until now have lacked widespread adoption in the LA region, are another possible option for reducing vulnerability. During the 2025 fires, the Watch Duty App was widely used by residents to monitor fires and the associated evacuation warnings and orders. But its use did not become widespread until the fires were already raging. The National Weather Service currently issues Red Flag Warnings under severe fire risk, but, arguably, this failed to represent the severity of conditions before the Eaton and Palisades Fires. A scoring system could thus be adopted for fire risk, based on the combination of aridity and Santa Ana winds, such as has been implemented for atmospheric rivers (Ralph et al., 2019), with corresponding public education and recommended actions under different risk categories.

Box 16: *Climate Story: Native Landscaping*

"I grew up in Park La Brea, Los Angeles, and although most of my long-term concerns are about water conservation, drought, increasing temperatures, and public transit, what I want to talk about today is community resilience through urban agriculture.

I didn't grow up knowing where my food came from or how it was grown, and it wasn't until high school that I first learned about composting and organic farming. In 2019, my parents had the privilege to be able to move up to Altadena, and it was the first time we lived in a place where we had soil that we could grow from. We started tearing up as much of the lawn as we could by ourselves to start growing three sisters blends like corn, beans, and squash, as well as greens, strawberries, tomatoes, potatoes, and other plants.

We began shifting our diets towards ones that were more local and organic, and it was a great experience to not only tear up useless lawn that was wasting water, but also to start planting native plants and turning the lawn into a green space and a natural space.

The wildfires directly impacted our soil, and now we're no longer able to grow and eat out of our soil safely. An idea that's been on my mind a lot recently is a community program that helps people remediate their lawns with plants, using things like corn and sunflowers over the course of a few seasons to heal their soil, which was done to LA State Historic Park in Chinatown by Metabolic Studio. I'd love to see opportunities for communities to get together to learn about this process and to potentially convert a lot of what were once invasive green grass lawns into wild spaces with native plants after they've been rehabilitated."

See the full version of the climate story in **Appendix, Text A12**.

6.4.4 Insurance Reform

Wildfires pose escalating risks to communities, homeowners, and insurers, and traditional insurance alone often struggles to provide adequate or affordable coverage. Financial innovation can play a critical role in mitigating wildfire risk by expanding the pool of available capital, providing new ways to spread and absorb wildfire-related losses, and creating faster, more predictable recovery mechanisms. By aligning financial incentives with resilience and enabling quicker recovery, financial innovation can not only strengthen the safety net after disasters but also encourage proactive investment in mitigation and adaptation.

For example, parametric insurance provides quick, predefined payouts once a measurable disaster threshold known as a “trigger” is reached. Because it relies on objective indicators such as rainfall, temperature, or wind speed, it avoids the costly and time-consuming process of assessing property damage, making it more efficient than traditional insurance. Payments can be issued immediately after the trigger is met, without the need for on-site loss adjustment. Also, since coverage is not linked directly to property damage, beneficiaries extend beyond individual property owners.

Catastrophe bonds and related financial products also create innovative ways to transfer risk into global financial markets, beyond the insurance and reinsurance markets, as insurers recognized that disasters could be far costlier than previously anticipated, which sparked demand for risk capacity. Innovative investment firms, equipped with improved models to quantify these risks, found receptive demand among institutional investors seeking assets uncorrelated with broader financial markets. Over the past three decades, the market for insurance-linked securities has expanded steadily, with catastrophe bond and reinsurance returns remaining largely independent of market cycles.

To encourage homeowners to invest more in mitigation, insurers in California are now required to offer financial incentives such as discounts to homeowners who invest in resilience measures such as fire-resistant building materials or sprinkler systems. While these discounts come with costs, they can reduce the risk of homes being destroyed by wildfires.

6.5 Air Quality

6.5.1 Reducing Emissions and Concentrations of Air Pollutants

Policies aimed at reducing emissions at the sources are critical to improving outdoor air quality. California has been a pioneer in implementing policies aiming at reducing emissions from a variety of sectors. These policies not only reduce greenhouse gas emissions, serving as a climate change mitigation strategy, but also bring overall co-benefits of reducing criteria air pollutants that impact air quality and public health.

Within the transportation sector, regulatory initiatives such as the Zero-Emissions Vehicle Program and the Advanced Clean Trucks were designed to accelerate the transition to zero-emission vehicles. Additionally, the Low Carbon Fuel Standard targeted a reduction in the carbon intensity of transportation fuels. California also deployed incentive-based programs, such as the Clean Vehicle Rebate Project, providing financial support for cleaner vehicle adoption. Overall, transition to electric vehicles in California is anticipated to reduce NOx, PM, and ground-level ozone concentrations, although ozone sometimes is predicted to increase due to lower NOx emissions and non-linearity of ozone chemistry (Garcia et al., 2023; Mousavinezhad et al., 2024). Note that brakes and tire wear also contribute to vehicular emissions (Jalali Farhani et al., 2022; Wei and Kumar, 2025), and thus, electrification will not remove all pollution from transportation.

Around the region, cities and counties are taking steps to minimize emissions. As detailed in their 2024 Preliminary Climate Plan, Orange County is developing an EV Infrastructure Master Plan, increasing the use of solar at buildings throughout the county, and working to expand its transportation network by 80 miles as part of its Active Transportation Plan (ATP), “OC on the Move.” In Riverside County, the City of Murrieta outlines goals and policies in the Air Quality Element of their general plan update. Examples of such efforts include planting rows of fine-needle conifer trees along portions of the freeways near sensitive land uses, re-routing truck routes away from streets that pass through sensitive land uses, and implementing stricter construction regulations that comply with current South Coast Air Quality Management District guidelines.

In the industrial and energy sectors, policies such as the Cap-and-Invest Program and the California Global Warming Solutions Act (AB 32, 2006; SB 32, 2016) impose limits on greenhouse gas emissions. Additionally, the Renewable Portfolio Standard mandates a progressive increase in renewable energy procurement. Adopting renewable energy and promoting electrification in LA could result in lower PM2.5 and NOx concentrations, but higher ozone concentrations due to the non-linearity of ozone chemistry (Li et al., 2024). Further NOx and VOC reductions are needed to reduce ozone concentrations in LA (Skipper et al., 2023). Policies will continue to play a critical role in improving air quality in LA. In addition, urban oil drilling is being phased out in the LA region. This industry has been a source of exposure to air pollution and related health effects that have disproportionately affected Black and Latino residents living in proximity to the drilling sites (Shamasunder et al., 2018).

During community outreach for this report, community members expressed wanting equity-centered development of public transport. Communities understand that enhanced public transportation reduces reliance on cars, which decreases greenhouse gas emissions, promotes walkability in cities, and improves mobility for residents, which is challenging in the sprawling, car-dependent LA region. Increasing public transportation connects riders to employment, workforce training, childcare, and healthy food options. CBOs are encouraging cities to increase non-gas-powered public transportation options, such as the Alliance for Community Transit–LA's Transit for All: Achieving Equity in Transit-Oriented Development. In partnership with the Los Angeles Department of Transportation, the Green Together Collaborative is electrifying the DASH Pacoima bus fleet, including 14 new electric buses and seven electric chargers added.

6.5.2 Reducing Exposure to Outdoor Air Pollutants

Reducing exposure to outdoor air pollutants, especially during wildfire days, requires a multi-pronged approach that combines public health readiness, environmental planning, and policy innovation. One of the foundational steps is enhancing air quality monitoring systems. Expanding real-time monitoring of pollutants like ozone and PM2.5, along with issuing timely public alerts during high pollution or heat events, can empower communities to take protective actions. Community-based sensor networks can also help fill in data gaps and provide more localized insights, especially for underserved or disproportionately impacted neighborhoods.

From a public health perspective, education and preparedness are key. Public awareness campaigns can inform people about ways to reduce exposure, such as limiting outdoor activity on high-pollution days or using indoor air purifiers. Schools, employers, and healthcare providers can also implement protocols to reduce health risks during pollution spikes. In parallel, there will be a great benefit to better preparing healthcare systems to respond to increased respiratory and cardiovascular health issues, particularly during extreme heat or wildfire events that exacerbate air pollution.

Urban planning plays a crucial role in long-term adaptation. For example, expanding urban green spaces and tree cover as well as adopting cool roofs in LA could reduce air temperatures and ozone concentrations (Kalkstein et al., 2022; Tayyebi & Darrel Jenerette, 2016; Vahmani et al., 2016). However, they may, if deployed at a massive scale, increase PM2.5 concentrations due to reducing mixing height of pollutants and increasing production of nitrate (Zhang et al., 2019).

6.5.3 Reducing Exposure to Indoor Air Pollutants

Indoor air quality is influenced by variations in outdoor air pollutant concentrations, changes in building operations, and modifications in human behavior in response to climate change (Nazaroff, 2013; NASEM, 2022c). To mitigate exposure to indoor air pollution, residents are advised to enhance indoor ventilation and filtration systems to maintain air quality standards (Jerrett et al., 2024), while also increasing ventilation and dilution of indoor emissions at times when outdoor air quality is improved. High-efficiency particulate air (HEPA) filters remove 99.97% of particles with a diameter of 0.3 micrometers, with efficiency increasing for smaller and larger particles. While filtration does not remove volatile compounds and gases, it will be highly beneficial for all homes, businesses and public buildings to have a HEPA filter in advance of future hazardous air quality episodes, whether from wildfire or general particulate pollution. To this end, distribution programs are underway, such as the South Coast Air Quality Management District's distribution of HEPA filters to residents in certain low-income communities. Lessons may be learned from elsewhere, for example, the State of Oregon has made HEPA air filters, as well as air conditioners, an insurance-eligible medical device.

Furthermore, government agencies can implement adaptation measures, such as establishing clean air shelters, to provide safe environments for the public, particularly for vulnerable populations, including children in under-resourced communities (Jerrett et al., 2024; Wright et al., 2024). Resilience hubs (*Section 6.1.3 Community Initiatives*) are also designed to protect the public from poor air quality.

6.6 Coastal Hazards

There is a significant amount of work already in progress in the LA region to mitigate, adapt, and prepare for rising sea levels, flooding, and erosion. The fourth iteration of the California Coastal Adaptation Needs Assessment was released in 2025 (Grifman et al, 2025). This survey is the only longitudinal survey of its kind in the US with prior surveys completed in 2007, 2011, and 2016. The results are intended to help the state determine where more guidance, financial resources, and science resources are needed in LA and other coastal regions. In the Southern Region, which comprises LA and Orange counties, most respondents (47%) indicated they are in the planning phase of coastal climate adaptation. Only about 21% of respondents indicated their community is in the implementing stage. Notably, the Southern Region's findings largely mirror statewide averages, with only 22% indicating they are in the implementing phase (Grifman et al., 2025).

6.6.1 Coastal Adaptation in LA County

The AdaptLA Program, led by the University of Southern California Sea Grant, began in 2011 as a federal- and state-funded project, which includes a variety of local municipalities, agencies, and community-based organizations (CBOs). AdaptLA results provide the latest science and modeling on the potential impacts of sea level rise to local coastal jurisdictions in LA County.

Building on the initial AdaptLA work, Aerts et al. (2018) studied a mix of adaptation strategies such as beach nourishment, wetland restoration, hard infrastructure (seawalls, levees), and nature-based solutions. The study emphasized that maintaining resilience in the long term will

require integrating green infrastructure, refining permitting for experimental projects, continued monitoring and evaluation, and incorporating social equity in adaptation investments.

In addition, De Ruig et al. (2019) studied the direct and indirect economic damages of flooding as well as the benefits of ecosystem services, by simulating different sea level rise scenarios and adaptation strategies tailored to coastal segments. The study identified "investment tipping points," crucial moments where transitioning to a new adaptation strategy after making initial adaptation investments can lead to more effective use of limited financial resources, underscoring the importance of timing and flexibility in long-term planning. In most scenarios and regions, early adaptation was found to be economically desirable, particularly in highly exposed and densely populated areas, while nature-based solutions like beach nourishment delivered significant co-benefits in tourism and coastal ecosystem services.

A 2022 study by Schroder et al. revealed that dual protection strategies, such as combining beach-front (dunes or seawalls) with inlet (sluice gates) protection, are most effective at reducing flooding, economic damages, and resident impacts across both everyday and extreme storm conditions. The analysis, however, also identified important trade-offs and unintended consequences. Some strategies, particularly those focusing only on inlets, can increase flooding in other communities by redirecting water rather than reducing overall risk. Economic priorities may favor strategies that reduce flood volume—thus minimizing total damages—while social risk reduction priorities may favor those that reduce flooded areas and the number of people exposed. Beach-focused and hybrid strategies generally offer greater protection for the population—including vulnerable groups—at lower cost and with substantial co-benefits compared to gray infrastructure like seawalls, which are much more expensive and less flexible in adapting to changing conditions.

Finally, the LA Regional Collaborative for Climate Action and Sustainability (LARC) recently launched the "Multi-Objective Assessment of Flood Adaptation Options in Los Angeles County" study, which builds on the exposure risk identified by Sanders et al. (2023) that assessed the impacts of combined river and rain-based flood hazards (referenced in Section 2.5.5 of the report, LARC, n.d.). This project worked with community partners and the City of LA to co-create three county-wide flood risk adaptation strategies: (a) raising levees, (b) widening channels, and (c) capturing stormwater. The goal was to then assess those strategies' effectiveness in reducing flood risk from the combined impacts of intense rainfall and undersized mainstem flood channels. LARC and the research team held four workshops from 2023 to 2025 that identified potential adaptation strategies, helped modelers fine-tune model projections, and provided recommendations for next steps. Initial findings suggest that decreasing imperviousness across LA County will likely have the most benefit to reducing flood risk, as compared to only naturalizing the river or raising levees, but final analyses are still underway (LARC, 2025).

Box 17: *Adaptation Planning in the Ports*

As the biggest port complex in the US, the Ports of LA and Long Beach are economic engines that employ millions of people and bring in billions of dollars in commerce. The two ports together are responsible for over 1 million jobs in the five closest counties and more than 2.7 million US jobs (Port of LA, 2025). As of 2024, the two ports are responsible for a trade volume of $104.3 billion throughout California and $340.3 billion throughout the United States (Port of LA, n.d.).

In 2018, the Port of LA published "The Port of Los Angeles Sea Level Rise Adaptation Study" to assess climate change risk and resiliency at the Port. The study included sea level rise projections for 2030, 2050, and 2100 to inform a vulnerability assessment which was used to identify vulnerabilities and create specific adaptation strategies (Port of LA, 2018).

The Port of Long Beach also published a Climate Adaptation and Coastal Resiliency Plan in 2016, which served as a framework to incorporate adaptive strategies into policy, infrastructure design, and construction (Port of Long Beach, n.d.). The sea level rise exposure analysis was updated in 2022. At the time of the Fifth Assessment, the Port of Long Beach started a new project to develop a more comprehensive adaptation plan based on the most recently updated 2024 CA OPC sea level rise projections.

6.6.2 Coastal Adaptation in Orange County

Orange County has engaged in a number of adaptation projects through living shoreline projects, channel stabilization projects, and beach nourishment. The County Department of Public Works recently finished its first living shoreline project in Talbert Channel, removing the concrete, eroding walls, and creating 0.6 acres (2,428 m²) of salt marsh habitat to help protect the adjacent Orange County Sanitation District Treatment Facility and public trail from future flooding (Orange County Department of Public Works, 2024). The County also completed a small living shoreline project at the Bolsa Chica wetlands, where a critical access road has eroded, and is completing the final design and permitting for a living shoreline adaptation project at Capistrano-Doheny Beach. The project plans to construct a 1,150-foot system of vegetated sand dunes over a cobble berm along the shore to address coastal erosion (OC Parks, n.d.). Additionally, local nonprofit groups in partnership with local organizations and state agencies, embarked on a project to restore degraded eel grass beds in the Upper Newport Bay in 2012, restoring 0.3 acres (300 square meters) in the Upper Newport Bay to date (Orange County Coastkeeper, n.d.). Orange County is in the early stages of permitting and planning several other channel stabilization projects to accommodate flooding by restoring more natural riparian conditions or restoring marsh acreage (Orange County Public Works, 2022; Orange County Public Works, n.d.).

Elsewhere along the Orange County coastline, beach nourishment (adding sand to a beach from outside sources via pumping or trucking) continues to be a main strategy to combat beach erosion, to encourage sand dune growth, and to raise the endangered Least tern habitat above high tide inundation. Orange County is working on a program, which will, if permitted, allow the County and any other beach owner in Orange County to place sand removed from County flood facilities onto beaches (Orange County Public Works, 2025).

6.6.3 Nature-Based Adaptation Solutions

Nature-based solution is a term referring to the use of natural or restored ecosystems to address challenges. A type of nature-based solution used commonly on the CA coast are *living shorelines*, which are shoreline stabilization techniques that emphasize the use of natural habitats and

processes such as sand dunes to provide erosion control and flood protection while preserving ecosystem services.

SAND DUNES

After decades of beach grooming practices, a process of cleaning and flattening beaches using heavy machinery, the City of Santa Monica, in partnership with The Bay Foundation, implemented a pilot nature-based solution in 2016. They restored a three-acre section of Santa Monica Beach to allow native dune systems and plants to grow. The restored dune site buffered storm waves and restored native habitat for rare and endangered species. The project was so successful that another five acres were restored in 2024, and the City of Santa Monica staff has proposed a third phase which would restore an additional 38.5 acres of dunes across different sections of Santa Monica beach (City of Santa Monica, n.d.).



Santa Monica Sand Dune Restoration Sites

Figure 30: *Santa Monica Sand Dune Restoration Sites (Photo credit: USC Sea Grant)*

The Santa Monica dune restoration sites have demonstrated the efficacy of nature-based solutions as options for coastal adaptation and resilience planning. Within a few years of stopping grooming, native plants expanded coverage, and the endangered Western Snowy Plover was seen nesting in the restoration sites after not having been seen in the area for over 70 years (City of Santa Monica, 2022; Johnston et al., 2023). Additionally, wave runup during storms was significantly reduced at dune restoration sites as compared to adjacent groomed sites (Emery et al. 2024).

Similar projects have been implemented in Manhattan Beach as well as Zuma and Point Dume beaches in Malibu. The Manhattan Beach project, which began in 2022, restored three acres of dune habitat (City of Manhattan Beach Environmental Sustainability Division, n.d.). The Malibu restoration project also restored three acres of dune habitat in the winter of 2020-2021 (The Bay Foundation, n.d.; California Coastal Dune Science Network, n.d.).

The LA County Department of Beaches and Harbors has also led work to assess the risk to beaches through their initial 2016 Sea Level Rise Vulnerability Assessment, and their subsequent 2023 LA County Coastal Resilience Study reaffirmed the 2016 vulnerability findings. In August of 2025, the LA County Department of Beaches and Harbors received $5.1 million from Measure A for restoration projects at Zuma, Redondo, and Dockweiler beaches. These living shoreline projects will use native plants for dune and shoreline habitat restoration with the goal of protecting LA's coastline from sea level rise and storm surge (LA County Department of Beaches and Harbors, 2025).

WETLAND RESTORATION

There are many ongoing efforts to combat sea level rise by constructing, protecting, and restoring coastal wetlands in the region. From native oyster reef reconstruction and eel grass planting in Alamitos and Upper Newport Bays (OC Coastkeeper, n.d.), to Phase 1 of the 154-acre (62 hectares) Los Cerritos Wetlands Restoration Project (Into Los Cerritos Wetlands, n.d.), natural and nature-based solutions are being widely used to enhance habitat, improve water quality, and provide a critical buffer to rising seas and eroding shorelines.

A substantial number of additional projects are also moving through various stages of environmental planning, design, and review. The Ballona Wetlands Restoration Project, currently in revision on the final environmental impact report, is intended to enhance 566-acres of the ecological reserve, restoring ecological function to one of the region's largest and most severely degraded wetlands (California DFW, n.d.). The planned removal of the 100-ft Rindge Dam and corresponding restoration of the Malibu Creek ecosystem will re-open 15 miles (24 km) of native habitat for endangered Steelhead and release approximately 780,000 cubic yards (596,500 cubic meters) of impounded sediment that can be used to rebuild and nourish the beaches to which its flow has been disrupted for decades. The current schedule expects the removal to be complete by 2035 (California Trout, n.d.).

Box 18: *Southern California Wetlands Recovery Project*

Since the Fourth Assessment, significant collaboration has begun on wetland restoration throughout Southern California. The Southern California Wetlands Recovery Project is a partnership of 18 State and Federal agencies, chaired by the California Natural Resources Agency and supported by the California State Coastal Conservancy. As of 2025, the Southern California Wetlands Recovery Project has 39 ongoing projects located from Santa Barbara down to San Diego, with the majority of projects in LA and Orange Counties. These 39 projects have the potential to restore 2,570 acres of wetlands and 92 miles of stream habitat. The Southern California Wetlands Recovery Project has additionally developed a series of monitoring approach frameworks in order to coordinate and standardize data collection across the wide variety of agencies and non-profit entities, making results more generalizable and accessible through a new data portal (SCWRP, 2025a; SCWRP, 2025b).

Box 19: *Climate Story: LA Compost*

"I'm born and raised in South Central LA with deep roots in both art and land stewardship. I serve as LA Compost's South LA Regional Coordinator, overseeing food scrap collection and compost processing across the greater South Central region. Growing up surrounded by concrete, I watched my family turn our small front yard into a thriving garden, where we grew food and shared it with our neighbors.

As I got older, I saw the deeper issues at play—parks left neglected, air pollution that made it harder to breathe, trash piling up in empty lots. I started asking, "Why does my community look like this?" The answer was a long history of disinvestment and environmental injustice. Volunteering at Carver Middle School was a turning point for me. That's where I learned about composting, not just as a way to reduce waste, but as a tool for healing land and building community power. Now, through LA Compost, I get to do this work every day, making sure people in South Central have access to sustainable solutions that actually work for us.

South Central LA faces serious environmental challenges, and inadequate waste management is one of the biggest. Overflowing trash bins, illegal dumping, and lack of proper waste services don't just make our streets look neglected—they create health risks and deepen existing inequalities. Climate change only makes it worse, with extreme heat, worsening air pollution, and rising food costs making it harder for families to access fresh, affordable food. To help address this, LA Compost provides resources and support for residents in South Central. Through farmers' market food scrap drop-offs, composting workshops, and volunteer opportunities, we're giving folks real ways to be part of the solution.

One of my favorite success stories is of a high school student who volunteers at Carver Middle School Garden. He not only brings his family's food scraps every week, but he's gotten his mom and siblings involved too. Seeing young leaders like him step up reminds me why it's so important to create opportunities for the next generation—opportunities I didn't have growing up. For me, composting isn't just about keeping food waste out of landfills—it's about proving that we have the power to create the healthy, thriving neighborhoods we deserve."

See the full version of the climate story in **Appendix, Text A13**.

Chapter 7.

Conclusion



As part of the Fifth Assessment, this LA Regional Report summarizes the state of climate change projections, expected impacts, and opportunities to adapt through the 21st century. The LA region is home to a significant fraction of California's most climate-vulnerable populations, including 40% of the state's children, large populations of adults over age 65, and Black and Latino families in environmentally-burdened neighborhoods with limited resources to adapt to climate change.

Significant warming has occurred over the region and is expected to continue under all scenarios of human activities through the 21st century. Annual maximum temperatures are expected to increase faster than average temperatures, exceeding 115°F (46°C) in some inland areas by mid-century, with over 100 days per year above 95°F (35°C). Lower-income residents and those of color, in particular, Latinos—the majority of residents in the farthest inland cities—are expected to be far more vulnerable than higher-income, coastal residents. Significant numbers of residents in inland cities still lack air conditioning, and 20% of residents in LA, Riverside, and San Bernardino counties are already energy-burdened. Extreme heat is also expected to strain the regional electrical grid, while raising the peak demand for power for cooling systems and highlighting the importance of programs providing free residential solar power. Mitigation measures such as cool pavement, cool roofs, increasing tree canopy, and adding more public cooling centers may help.

In addition to warming, precipitation patterns are changing, with more wet and dry years, and heavy precipitation events, with a likelihood of extreme flooding and drought. People of color are far more likely to experience flooding and face longer and more difficult recoveries. Meanwhile, increased drought is likely to put severe stress on ecosystems, leading to habitat destruction, and widespread tree die-off. Changing precipitation patterns will also disrupt water resources, both locally and in remote regions from which LA imports water. Reservoir operational changes and flooding infrastructure updates will likely be necessary, along with additional investments in water recycling, stormwater recharge, and groundwater replenishment. Tribes and communities are leading efforts to return the region's waters, particularly the LA River, to a more natural state, reducing flood risk, and improving local water resilience and water quality.

Wildfires are expected to intensify, with multiple impacts, including native vegetation die-off and spread of invasive, more flammable vegetation. Resulting habitat destruction and fragmentation can lead to inbreeding and, ultimately, extinction for many species. Meanwhile, fires burning deeper into the urban landscape will threaten more lower-income neighborhoods. Home insurers are increasingly pulling out of fire-prone areas; without major insurance reform, large parts of the region could become economically untenable for many residents. Mitigating and adapting to increased wildfire will be one of the greatest challenges for the LA region through the 21st century, and historical fire prevention and mitigation measures will likely be inadequate. The merits of cultural burning, sustainably practiced by Indigenous Peoples for thousands of years, and replanting native vegetation, are increasingly gaining traction. Other potential new initiatives may reduce ignitions, spread, and residents' exposure and vulnerability.

Sea level is rising, and combined with large coastal wave events, is already causing significant flooding in some areas. This will threaten tens of thousands of residents, tens of billions of dollars in property, and hundreds of miles of roads. Erosion rates may triple by 2050, with up to 67% of beaches lost by 2100. While most wetlands in the region—which provide habitat, coastal protection, carbon storage, and Tribal cultural value— have already been lost or degraded, and

accelerating sea level rise threatens to inundate the rest. Evidence suggests early adaptation is more cost-effective, and nature-based approaches provide multiple co-benefits.

High-pollution events like worsening ground-level ozone and wildfire smoke are becoming more frequent and prolonged, threatening vulnerable populations such as seniors, children, and pregnant women. Pollution may be reduced, for example, by electrification of transportation and enhancement of renewable energy, along with wildfire mitigation measures. Exposure to hazardous air-quality episodes may be reduced by issuing timely public alerts during high pollution events and offering incentives for purchasing indoor HEPA filters. Finally, healthcare systems will benefit from preparing to respond to increased respiratory and cardiovascular health issues during extreme heat or wildfire events.

Altogether, this report is intended to convey that a wide range of unprecedented climate hazards are beginning and likely to continue in the LA region through the 21st century, but that equitable climate adaptation is possible. Cooperation between counties, cities, Tribes, community organizations, private companies, and individuals will be critical. As awareness grows and some adaptation strategies are successfully implemented, the LA region shows promise for future climate resiliency.

Appendix

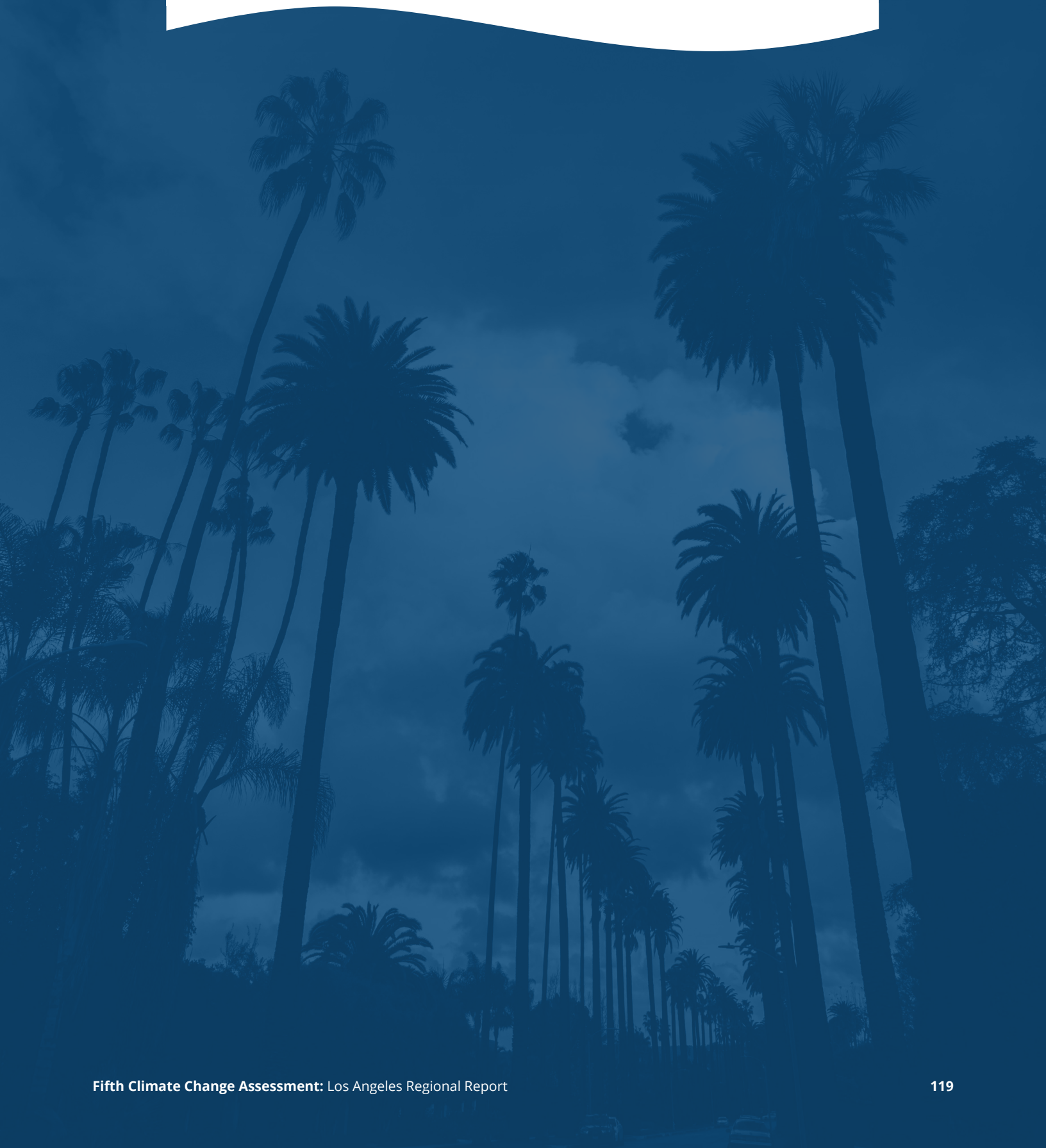


Table A1: Availability of downscaled climate projections, using LOCA2-Hybrid and WRF. *Summarizes availability of projections from 15 global climate models (GCMs) downscaled by LOCA-Hybrid and 4 GCMs downscaled by WRF. All figures use all available LOCA2-Hybrid projections for the given SSP, except where the given metric is unavailable, in which case the smaller set of WRF projections is used.*

Driving global climate model	Downscaling model	SSP2–4.5	SSP3–7.0	SSP5–8.5
ACCESS-CM2	LOCA2-Hybrid	Yes	Yes	Yes
CESM2-LENS	LOCA2-Hybrid	-	Yes	-
CNRM-ESM2-1	LOCA2-Hybrid	Yes	Yes	Yes
EC-Earth3	LOCA2-Hybrid	Yes	Yes	Yes
EC-Earth3-Veg	LOCA2-Hybrid	Yes	Yes	Yes
FGOALS-g3	LOCA2-Hybrid	Yes	Yes	Yes
GFDL-ESM4	LOCA2-Hybrid	Yes	Yes	Yes
HadGEM3-GC31-LL	LOCA2-Hybrid	Yes	-	Yes
INM-CM5-0	LOCA2-Hybrid	Yes	Yes	Yes
IPSL-CM6A-LR	LOCA2-Hybrid	Yes	Yes	Yes
KACE-1-0-G	LOCA2-Hybrid	Yes	Yes	Yes
MIROC6	LOCA2-Hybrid	Yes	Yes	Yes
MPI-ESM1-2-HR	LOCA2-Hybrid	Yes	Yes	Yes
MRI-ESM2-0	LOCA2-Hybrid	Yes	Yes	Yes
TaiESM1	LOCA2-Hybrid	Yes	Yes	-
EC-Earth3	WRF	-	Yes	-
MIROC6	WRF	-	Yes	-
MPI-ESM1-2-HR	WRF	-	Yes	-
TaiESM1	WRF	-	Yes	-

Table A2: *Warming statistics throughout the LA Region for coastal and near-coastal locations*

		Malibu	Santa Monica	Long Beach	Downtown LA	Irvine	Anaheim
Average daily max (°F)	Hist	69.6	67.1	71.3	75	74	76.7
	MC	72.3±0.5	68.7±0.3	73.8±0.4	78.4±0.6	76.9±0.5	80.1±0.5
	EC	74.4±1.0	70.0±0.8	75.5±0.9	80.7±1.2	78.8±1.0	82.2±1.1
Average increase of daily max (°F)	MC	2.6±0.6	1.6±0.5	2.5±0.5	3.4±0.8	2.9±0.6	3.4±0.7
	EC	4.7±1.1	2.8±0.9	4.2±1.0	5.7±1.3	4.8±1.1	5.5±1.1
Average daily min (°F)	Hist	51.2	55	53.8	56.5	54	54.3
	MC	54.2±0.7	56.9±0.5	56.9±0.7	59.9±0.7	57.0±0.6	57.8±0.6
	EC	56.6±1.2	58.5±1.0	59.0±1.2	62.4±1.3	59.3±1.1	60.1±1.2
Average increase of daily min (°F)	MC	2.9±0.8	1.8±0.6	3.1±0.8	3.4±0.8	3.0±0.7	3.5±0.7
	EC	5.4±1.3	3.5±1.1	5.3±1.3	5.9±1.4	5.2±1.3	5.8±1.3
Hottest day of year (daily max, °F)	Hist	95.6	88.3	98.3	99.2	98.9	102.4
	MC	99.7±1.0	91.0±0.8	102.3±1.0	103.8±1.1	102.4±1.1	106.7±1.1
	EC	102.0±1.6	92.4±1.6	105.0±1.8	106.9±1.9	105.0±1.7	109.8±1.8

		Malibu	Santa Monica	Long Beach	Downtown LA	Irvine	Anaheim
Warming on hottest day of year (°F)	MC	4.1±1.3	2.7±0.7	4.1±1.3	4.6±1.3	3.5±1.3	4.3±1.3
	EC	6.4±1.9	4.1±1.6	6.7±1.9	7.7±2.1	6.1±1.7	7.4±1.9
Number of days >95°F (35°C) per year	Hist	1.2	0	2.6	5	4	11
	MC	4.2±1.1	0.2±0.1	6.4±1.3	15.7±3.3	9.1±1.8	26.2±4.2
	EC	8.4±3.0	0.4±0.3	11.3±4.0	30.4±9.2	17.2±5.6	42.5±10.2
Number of nights >75°F (24°C) per year	Hist	0.7	1.1	2.6	3.4	2.7	2.9
	MC	3.4±1.9	3.3±2.1	10.3±5.2	14.7±5.2	8.5±3.7	11.7±4.5
	EC	9.8±4.8	7.0±3.9	21.6±9.7	33.4±12.8	19.3±8.4	25.5±10.2

Table A2 continued. Warming statistics throughout the LA Region for farther inland locations. *Hist: Historical; MC: Mid-Century; EC: End-of-Century. The statistics in each cell denote the mean plus or minus (±) standard deviation across 14 LOCA2-Hybrid downscaled models under SSP3–7.0 scenario. The statistics for each city are based on the closest grid cell on the 3-km LOCA2-Hybrid grid to the given city's central location.*

		Northridge	Santa Clarita	Pasadena	Riverside	San Bernardino	Big Bear Lake
Average daily max (°F)	Hist	80.4	79	78.6	80.5	81.8	60.4
	MC	85.0±0.8	83.8±0.8	82.6±0.7	84.9±0.7	86.4±0.8	65.4±0.8
	EC	87.8±1.3	86.7±1.3	85.2±1.3	87.5±1.3	89.2±1.4	67.3±1.2
Average increase of daily max (°F)	MC	4.6±0.9	4.8±1.0	4.0±0.8	4.4±0.9	4.6±0.9	4.9±0.9
	EC	7.5±1.3	7.7±1.3	6.6±1.4	7.0±1.4	7.4±1.4	6.9±1.2
Average daily min (°F)	Hist	53.1	51.2	53.8	51.9	52.8	31.8
	MC	57.5±0.9	55.7±0.9	57.8±0.7	55.8±0.6	56.9±0.7	36.6±0.6
	EC	60.3±1.4	58.7±1.4	60.4±1.4	58.6±1.3	59.9±1.3	39.3±1.1
Average increase of daily min (°F)	MC	4.4±1.0	4.5±0.9	3.9±0.8	3.9±0.7	4.1±0.7	4.8±0.7
	EC	7.2±1.5	7.5±1.5	6.6±1.4	6.6±1.3	7.1±1.4	7.5±1.1
Hottest day of year (daily max, °F)	Hist	109.4	108.7	104.5	108.2	110.5	88.4
	MC	114.4±1.2	113.4±1.3	109.7±1.1	113.7±1.2	116.0±1.3	92.9±1.2
	EC	117.2±1.8	116.4±1.9	112.9±2.0	116.8±2.0	118.8±2.0	94.8±1.7
Warming on hottest day of year (°F)	MC	5.1±1.3	4.7±1.3	5.2±1.2	5.5±1.3	5.4±1.3	4.5±1.1
	EC	7.8±1.9	7.7±2.0	8.4±2.2	8.5±2.1	8.3±2.0	6.4±1.6
Number of days >95°F (35°C) per year	Hist	60.9	59.6	26.4	61.8	81.5	0
	MC	98.3±7.6	96.8±7.5	59.1±7.6	101.7±7.7	120.2±7.7	0.5±0.3
	EC	123.1±12.7	120.7±12.9	84.1±14.3	124.6±13.1	142.4±12.7	1.3±0.9
Number of nights >75°F (24°C) per year	Hist	2.5	2.2	1.8	1.9	3.5	0
	MC	12.7±5.0	13.7±5.0	10.7±3.8	11.8±3.9	19.3±5.5	0.0±0.0
	EC	28.5±9.6	32.0±9.5	26.7±10.2	29.1±11.0	42.8±13.0	0.0±0.0

Table A3. *Summary of previous studies on the impact of climate change on ozone concentrations in LA Region*

Source	Base Year	Future Year	Climate Scenario	Time Period	maximum 8-hourO3 change (ppb)	Note	Trend in maximum 8-hour (ppb/ year)	Air Quality Model
(Zhu et al., 2019)	2012	2035	RCP 4.5	Summer Only	13	Peak increase in SoCAB	0.57	CMAQ
(Zhao et al., 2025)	\	2050	RCP8.5 and RCP4.5	10 years	1.54	Difference between RCP8.5 and RCP4.5	/	UCD/ CIT
(Horne & Dabdub, 2017)	2023	2020–2050	All regions increase 1°C	August 27–29	1.5–3	Averaged over diverse cities in Southern California	0.125–0.25	UCI-CIT
(Horne & Dabdub, 2017)	2023	2070–2100	All regions increase 3°C	August 27–29	3.1–9.3	Averaged over diverse cities in Southern California	0.05–0.15	UCI-CIT
(Millstein & Harley, 2009)	2005	~2050	2×CO2 scenario, climate change including T, RH, BVOC	July 14–19	2.2–11.3	Averaged over diverse cities in Southern California	0.049–0.25	CMAQ
(Millstein & Harley, 2009)	2005	~2050	2×CO2 scenario, climate change only including temperature	July 14–19	1.3–3.3	Averaged over diverse cities in Southern California	0.029–0.073	CMAQ
(Kim et al., 2015)	2001–2004	2057–2059	RCP4.5	3 years	6.01–7.54	Los Angeles County average	0.11–0.14	CMAQ
(Kim et al., 2015)	2001–2004	2057–2059	RCP8.5	3 years	9.01–11.52	Los Angeles County average	0.16–0.21	CMAQ
(Moghani & Archer, 2020)	2016	2050	RCP8.5	3 years	1–5	Southern California average	0.029–0.147	CAMx
(Sun et al., 2015)	2002–2004	2057–2059	RCP8.5	3 years	5	Maximum change in Los Angeles	0.091	CMAQ

Table A4. *Summary of studies on the impact of climate change on PM2.5 concentrations in LA Region*

Source	Base Year	Future Year	Climate Scenario	Time Period	PM2.5 change (μg/m³)	Note	Trend in PM2.5 (μg/m³ /year)	Air Quality Model
(Horne & Dabdub, 2017)	2023	2020–2050	All regions increase 1°C	August 27-29	-0.5	Average change of Southern California	-0.0417	UCI-CIT
(Horne & Dabdub, 2017)	2023	2070–2100	All regions increase 3°C	August 27-29	-1.4	Average change of Southern California	-0.0226	UCI-CIT
(Mahmud et al., 2010)	2000–2006	2047–2053	Business-as-usual scenario	7 years	-1.1	Maximum decrease in Los Angeles	-0.0234	UDC-CIT
(Mahmud et al., 2012)	2000–2006	2047–2053	Business-as-usual scenario	7 years	-6–4	Los Angeles	-0.128–0.085	UDC-CIT
(Zhu, 2019)	2012	2035	RCP 4.5	Winter Only	2	Mean increase in SoCAB	0.087	CMAQ
(Sun et al., 2015)	2002–2004	2057–2059	RCP8.5	3 years	-2	Maximum change in Los Angeles	-0.091	CMAQ

Table A5. *Overview of assessed damages and liabilities from recent notable California wildfire, where electric utility infrastructure was found to be at fault for ignition.*

Fire Event(s)	Utility	Primary Settlement/ Liability Amount	Notable Impact	References
2017 & 2018 Fires (Camp, Tubbs, etc.)	PG&E	$13.5 Billion (Victim Trust)	Led PG&E to file for Chapter 11 bankruptcy in 2019.	PG&E Plan of Reorganization, 2020; Fire Victim Trust (FVT) Claims Data Book, 2024; PG&E Bankruptcy Court Filings (Case No. 19-30088), 2022
2017 & 2018 Fires (Insurance Claims)	PG&E	$11 Billion	Reimbursement paid to insurance companies by PG&E.	
2017 & 2018 Fires (Public Entities)	PG&E	$1 Billion	PG&E settled with cities and counties.	
2021 Dixie Fire	PG&E	$45 Million (Penalty)	PG&E required to pay for penalties and infrastructure upgrades.	Plumas County Superior Court / North State DAs Settlement, 2022
2017 Thomas / 2018 Woolsey	SCE	$4 Billion+	Ongoing litigation and settlements.	SCE 10-K Annual Report, 2024
2025 LA Wildfires (Eaton & Palisades)	Under Review	$35–$45 Billion (Insured)	Total economic loss estimated $250B+.	LAEDC Economic Impact Study, 2025; AccuWeather Economic Assessment, 2025

Table A6. Household Income, All Adults by Gender and Race/Ethnicity, LA Region, 2023. *Table A6 describes the household income distribution of adults in the Los Angeles region by gender and race/ethnicity. Race and ethnicity are categorized as mutually exclusive groups. Latinos can be of any race. Data on other races/ethnicities are excluded due to insufficient sample size. Income groups are based on quartiles calculated within the region at the household level. Data is restricted to households reporting incomes greater than $0, with top and bottom 1% of the income distribution excluded to minimize outliers. Low-income (25th percentile) includes household incomes up to $48,000; Lower-middle income (25th–50th percentile) includes incomes over $48,000 up to $93,000; Upper-middle income (50th–75th percentile) includes incomes over $93,000 up to $160,600, and High-income (75th–100th percentile) includes incomes over $160,600. Population counts may not sum to totals and rows may not sum to 100% due to rounding. Source: Authors' analysis of 2023 IPUMS American Community Survey.*

	Total	Low-income (Up to $48,000)	Lower-middle income ($48,001–$93,000)	Upper-middle income ($93,001–$160,000)	High-income (Over $160,600)
Los Angeles Climate Region	15,993,000	19%	24%	27%	30%
Women	8,047,000	20%	24%	27%	29%
Men	7,946,000	18%	23%	28%	31%
Asian/Pacific Islander (API)	2,430,000	17%	19%	26%	38%
Women	1,289,000	18%	20%	25%	37%
Men	1,141,000	16%	19%	26%	39%
Black	895,000	29%	23%	25%	23%
Women	465,000	32%	23%	25%	21%
Men	430,000	26%	24%	25%	25%
Latino	7,561,000	21%	28%	30%	21%
Women	3,773,000	22%	29%	29%	21%
Men	3,788,000	20%	28%	30%	22%
White	4,398,000	16%	19%	25%	40%
Women	2,168,000	17%	20%	25%	38%
Men	2,229,000	14%	19%	26%	42%

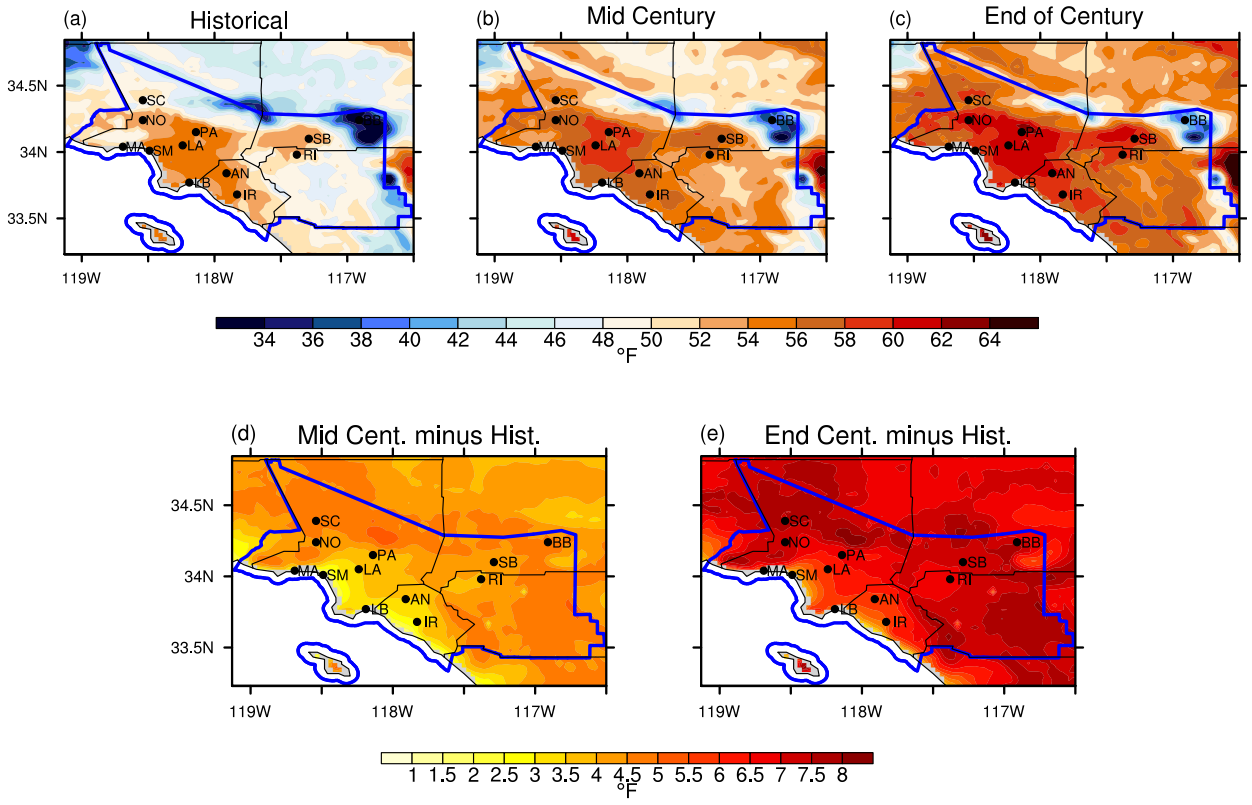


Figure A1: Daily-minimum temperature across the LA region during historical and future periods. *Top row: Daily-minimum temperature, averaged over the (a) historical (1981–2010), (b) mid-century (2041–2070), and (c) end-of-century (2071–2100) periods. Bottom row: Increase of the same metric in (d) mid-century and (e) end-of-century periods, relative to historical. All data are averaged over 14 LOCA2-Hybrid downscaled climate models under the SSP3–7.0 scenario. Cities are annotated as detailed in* ***Figure 1****.*

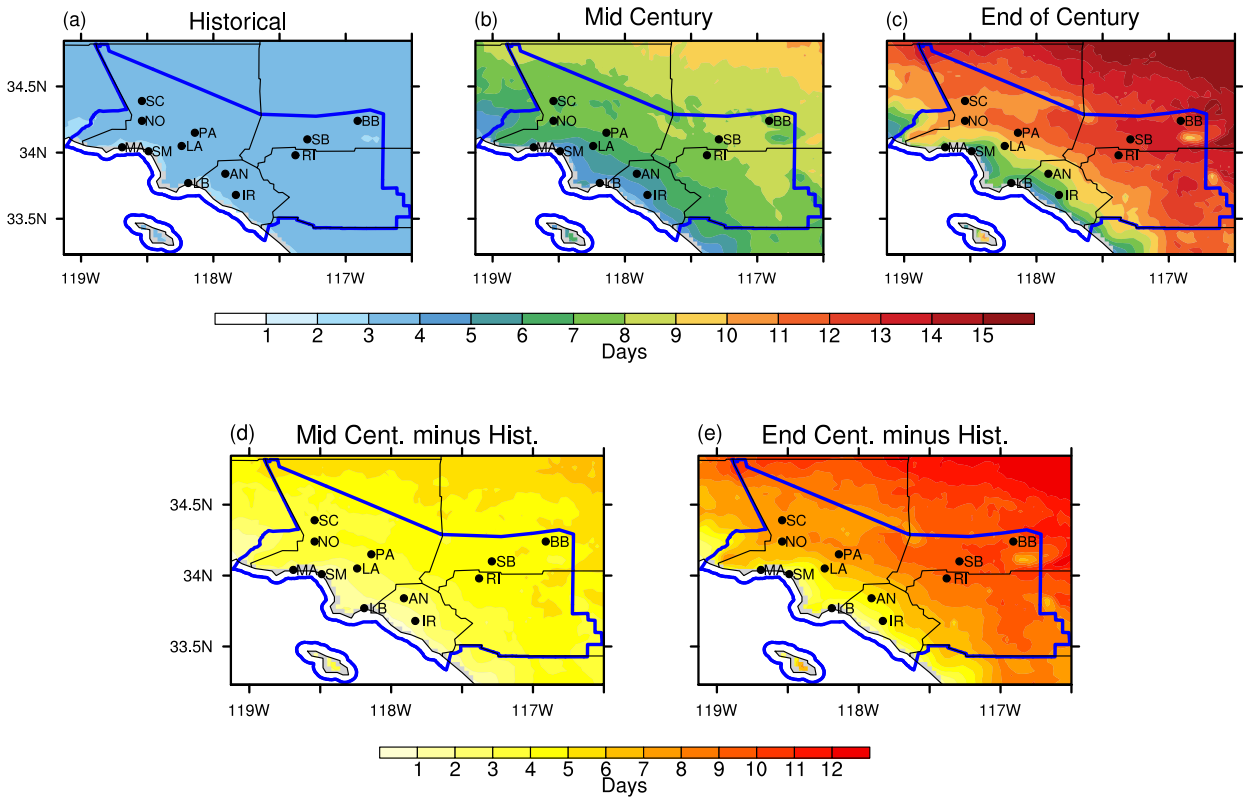


Figure A2: Heat wave duration across the LA region during historical and future periods. *Top row: The mean longest heat wave per year (defined as duration of consecutive days with temperature above 98th percentile of historical temperature distribution), averaged over the (a) historical (1981–2010), (b) mid-century (2041–2070), and (c) end-of-century (2071–2100) periods. Bottom row: Increase of the same metric in (d) mid-century and (e) end-of-century periods, relative to historical. All data are averaged over 14 LOCA2-Hybrid downscaled climate models under the SSP3–7.0 scenario. Cities are annotated as detailed in* ***Figure 1****.*

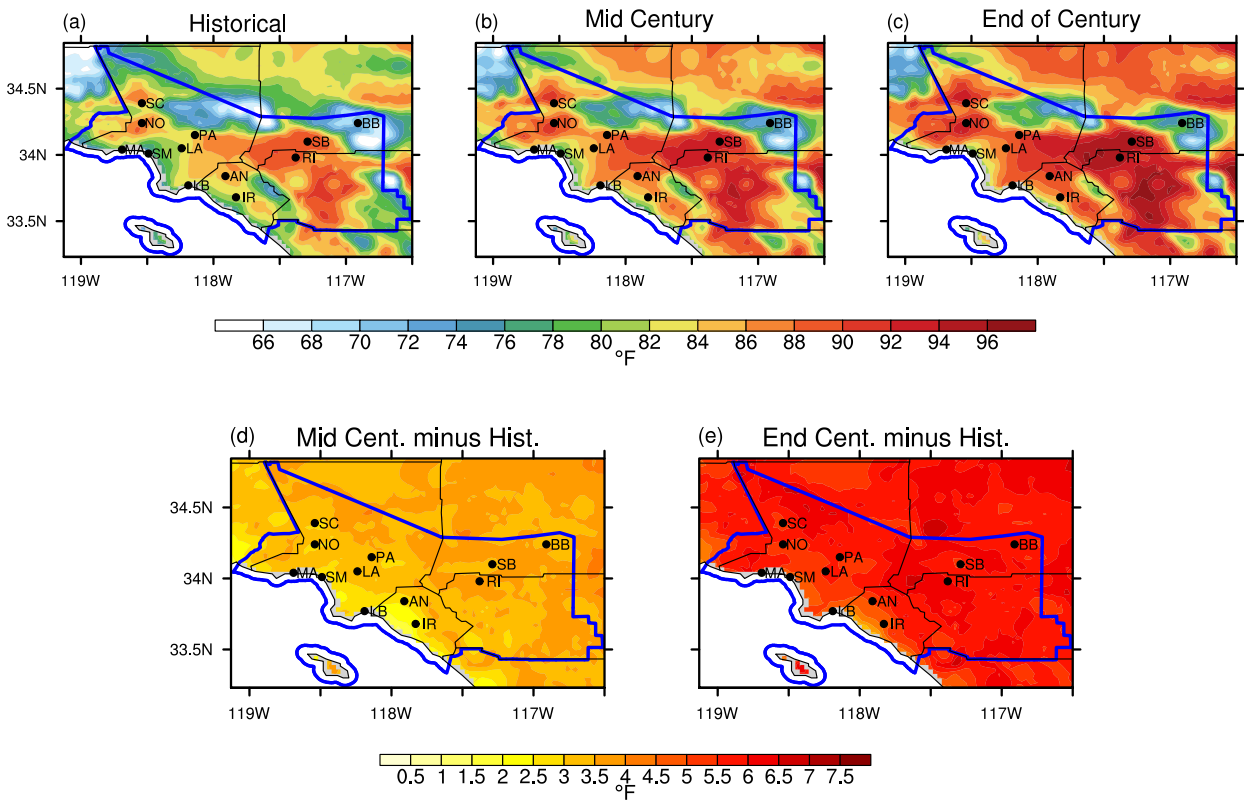


Figure A3: Annual-maximum wet-bulb temperature across the LA region during historical and future periods. *Top row: Annual-maximum daily-maximum wet-bulb temperature, averaged over the (a) historical (1981–2010), (b) mid-century (2041–2070), and (c) end-of-century (2071–2100) periods. Bottom row: Increase of the same metric in (d) mid-century and (e) end-of-century periods, relative to historical. All data are averaged over 12 LOCA2-Hybrid downscaled climate models (fewer than other figures because of relative humidity being unavailable for some) under the SSP3–7.0 scenario. Cities are annotated as detailed in* **Figure 1**.

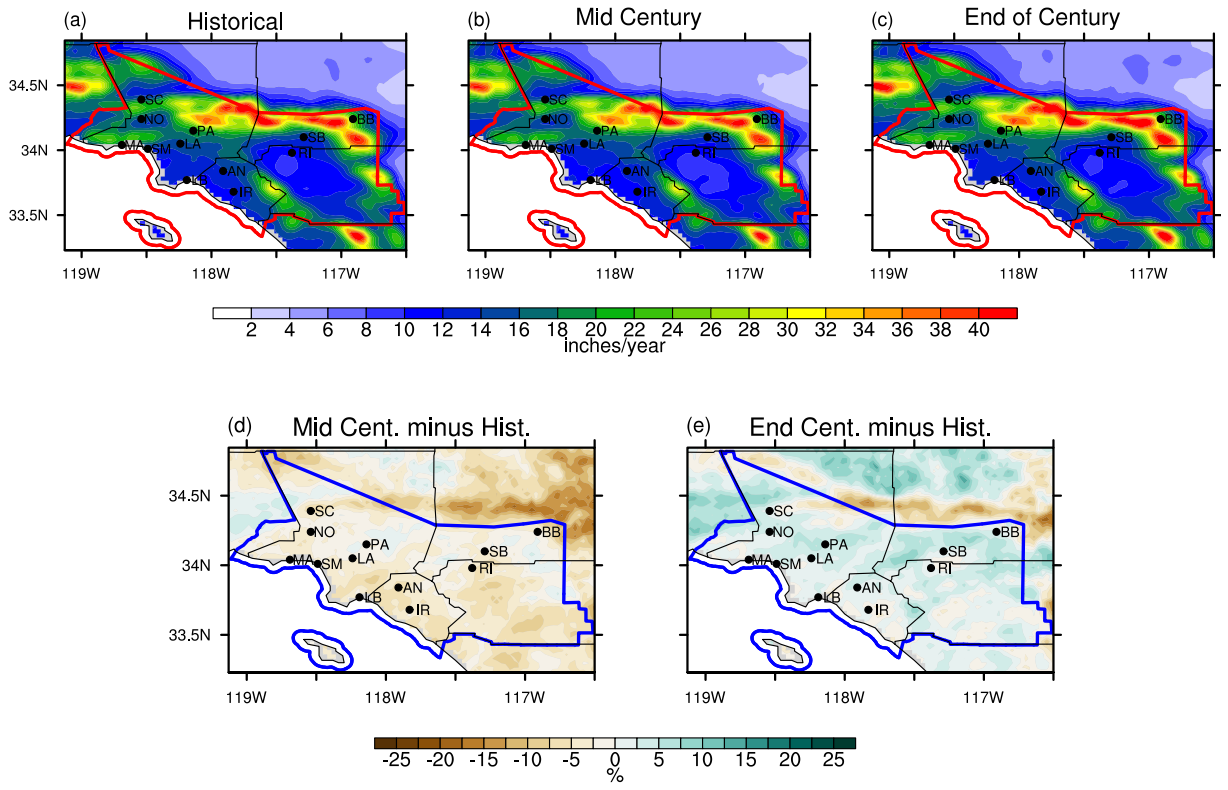


Figure A4: Annual precipitation across the LA region during historical and future periods. *Top row: Mean annual precipitation, averaged over the (a) historical (1981–2010), (b) mid-century (2041–2070), and (c) end-of-century (2071–2100) periods. Bottom row: Percentage increase of the same metric in (d) mid-century and (e) end-of-century periods, relative to historical. All data are averaged over 14 LOCA2-Hybrid downscaled climate models under the SSP3–7.0 scenario. Cities are annotated as detailed in* **Figure 1**.

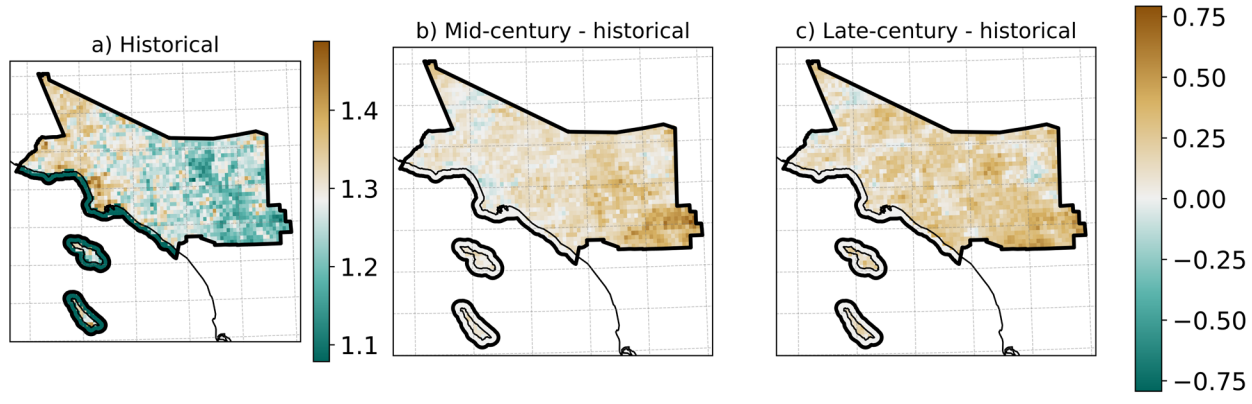


Figure A5: Drought duration across the LA region during historical and future periods. *The duration of the longest drought in the given period. Shown for (a) historical period; (b) mid-century minus historical; (c) end-of-century minus historical. All data are averaged over 14 LOCA2-Hybrid downscaled climate models under the SSP3–7.0 scenario. Drought is defined as water year (Oct–Sep) precipitation below the 10th percentile of the historical distribution.*

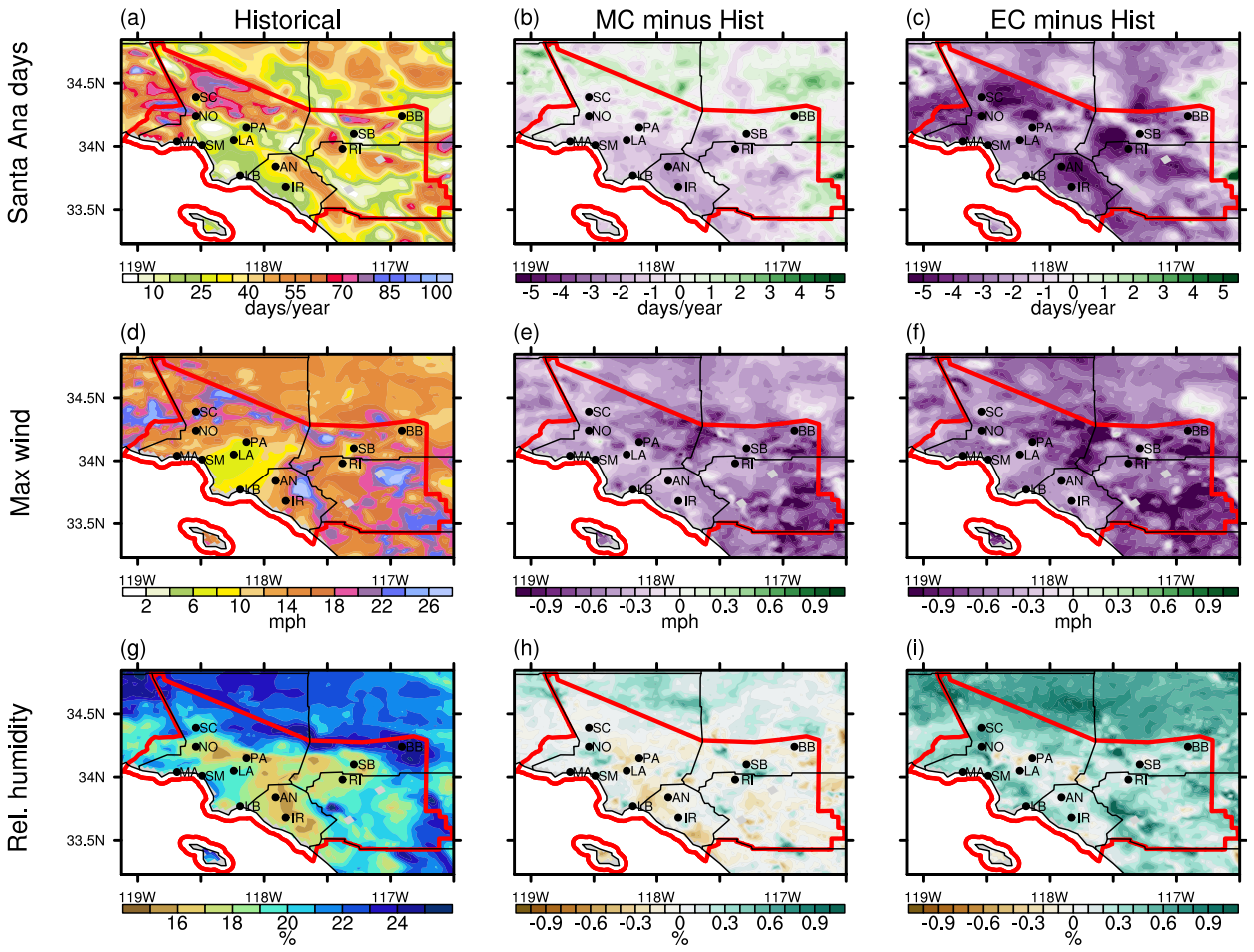


Figure A6: 21st century projections of Santa Ana winds across the LA region. *Shown for (left column) historical (1981–2010), (middle column) mid-century (2041–2070), and (right column) end-of-century (2071–2100) climates. Santa Ana wind days are defined as average wind direction between 0° and 90° (northerly to easterly) and average relative humidity below 35%. The top row shows the number of Santa Ana wind days per year; the middle row shows daily-maximum wind speed on Santa Ana wind days; and the bottom row shows average relative humidity on Santa Ana wind days. Taken from the average of WRF downscaled climate models under SSP3–7.0 scenario. Cities are annotated as detailed in* **Figure 1**.

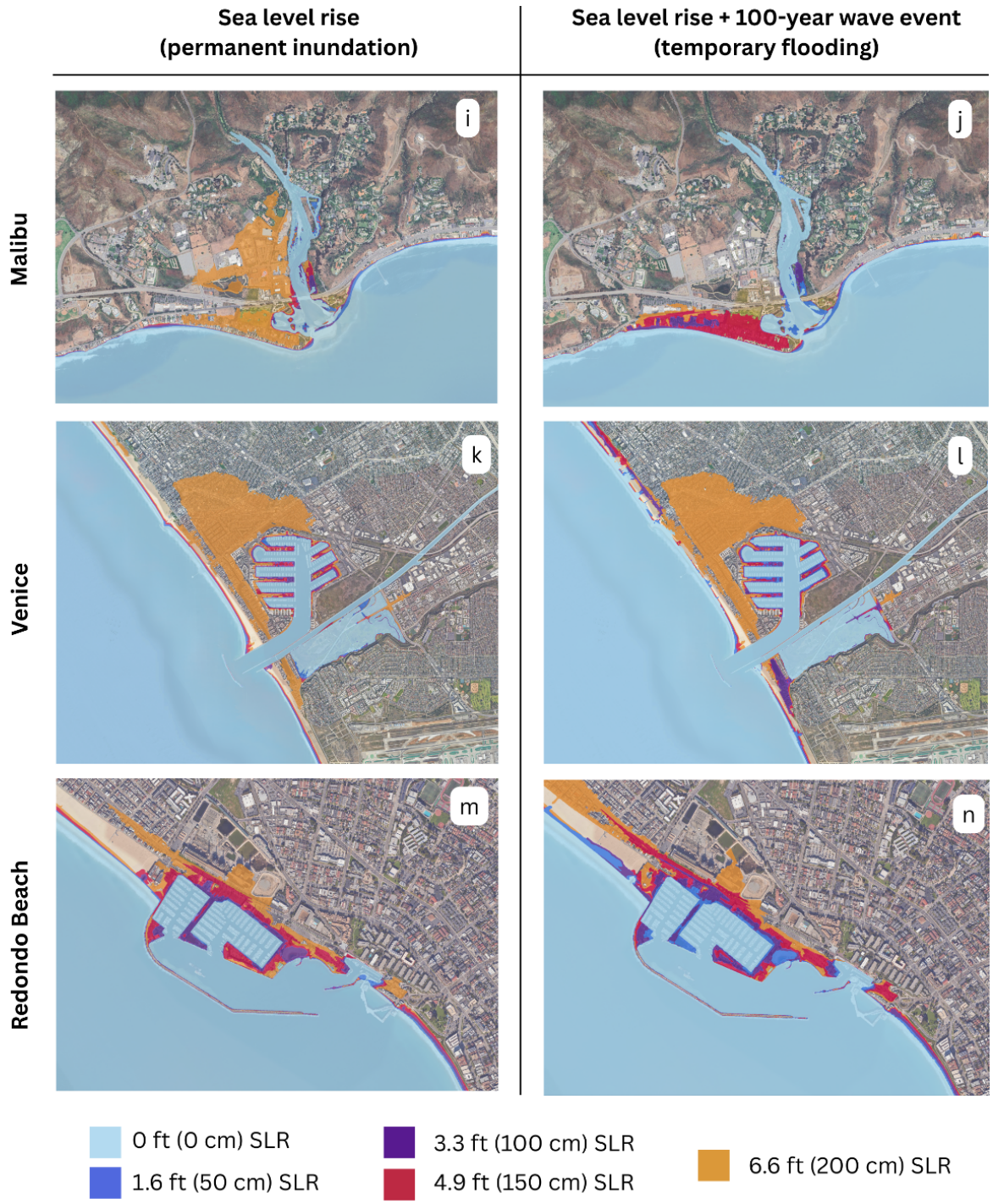


Figure A7: 21st century projections of flood hazard under various levels of sea level rise across the LA region's coastline, including when the 100-year event occurs. *Flood hazard projections corresponding to 1.6 ft (50 cm), 3.3 ft (100 cm), 4.9 ft (150 cm) and 6.6 ft (200 cm) of sea level rise as projected by the US Geological Survey's Coastal Storm Modeling System (or CoSMoS). These sea level rise values provide a range of future water levels, with 1.6 ft (50 cm) expected by 2060 and 3.3 ft (100 cm) expected by 2110, under the* ***intermediate-high*** *sea level rise projections (OPC Sea Level Rise Guidance, 2024). The figure highlights flooding hotspots from Southern Ventura to Orange County. Left panels: sea level rise (SLR), indicating the increase in the average. Right panels: sea level rise plus 100-year wave event, indicating the most extreme wave-driven flooding projected for the 21st century. (i,j) Malibu; (k,l) Venice; (m,n) Redondo Beach.*

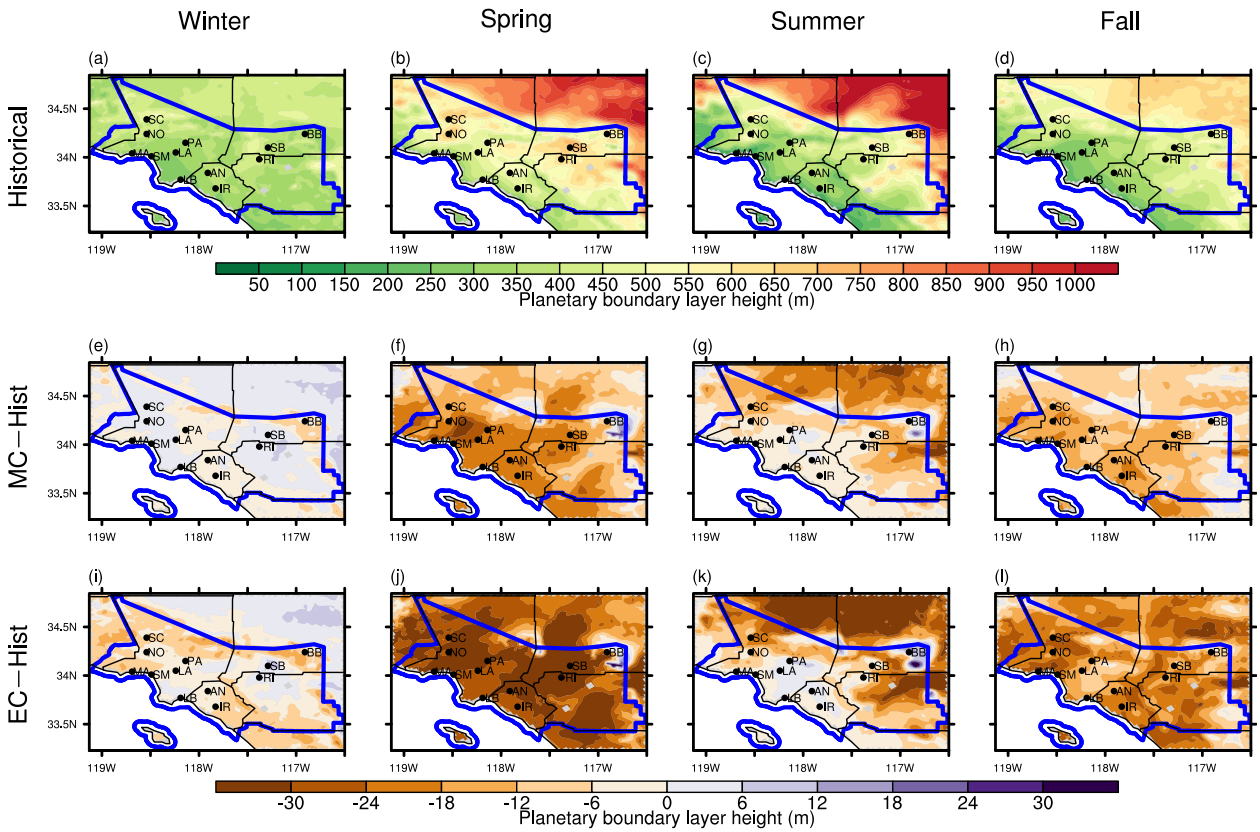


Figure A8: 21st century projections of planetary boundary layer height (PBLH), the height in the atmosphere below which pollution is typically trapped. *Shown for each individual season under (top row) historical (1981–2010), (middle row) mid-century (2041–2070) minus historical, and (bottom row) end-of-century (2071–2100) minus historical climates. Winter refers to December–February(left-most column); spring: March–May (left-middle column); summer: June–August (right-middle column); fall: September–November (right-most column). Taken from the average of four WRF downscaled climate models under SSP3–7.0 scenario. Cities are annotated as detailed in* **Figure 1**.

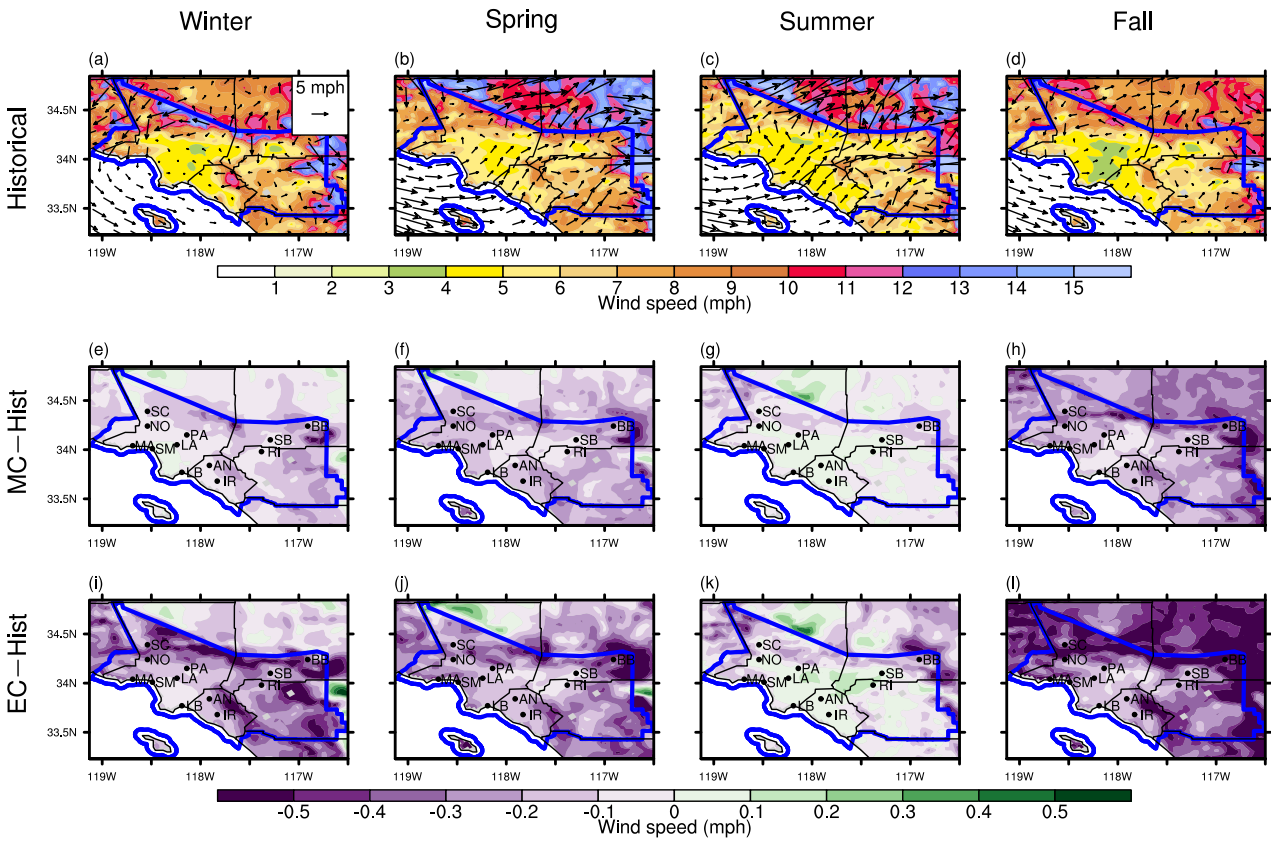


Figure A9: 21st century projections of wind speed and direction. *Shown for each individual season under (top row) historical (1981–2010), (middle row) mid-century (2041–2070) minus historical, and (bottom row) end-of-century (2071–2100) minus historical climates. Wind vectors are overlaid in top panels to show direction of winds in historical climate. Winter refers to December–February (left-most column); spring: March–May (left-middle column); summer: June–August (right-middle column); fall: September–November (right-most column). Taken from the average of four WRF downscaled climate models under SSP3–7.0 scenario. Cities are annotated as detailed in* **Figure 1**.

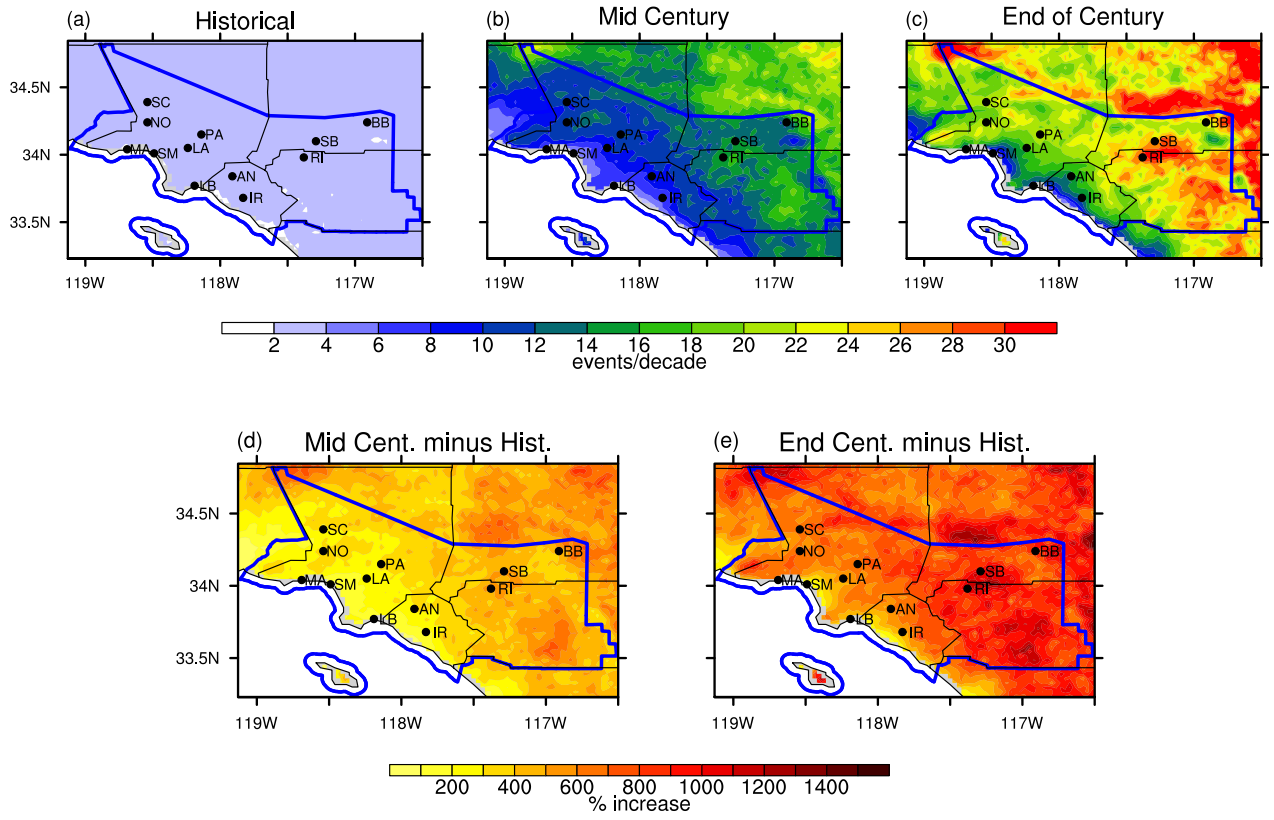


Figure A10: 21st century projections of concurrent drought and heat wave. *Top row: Frequency of a heat wave (at least 3 consecutive days above the local 98th percentile of temperature) occurring during a drought year (below the 20th percentile of local annual precipitation), averaged over the (a) historical (1981–2010), (b) mid-century (2041–2070), and (c) end-of-century (2071–2100) periods. Bottom row: Increase of the same metric in (d) mid-century and (e) end-of-century periods, relative to historical. For each period the drought and heatwave thresholds are based on the historical climate. All data are averaged over 14 LOCA2-Hybrid downscaled climate models under the SSP3–7.0 scenario. Cities are annotated as detailed in* **Figure 1**.

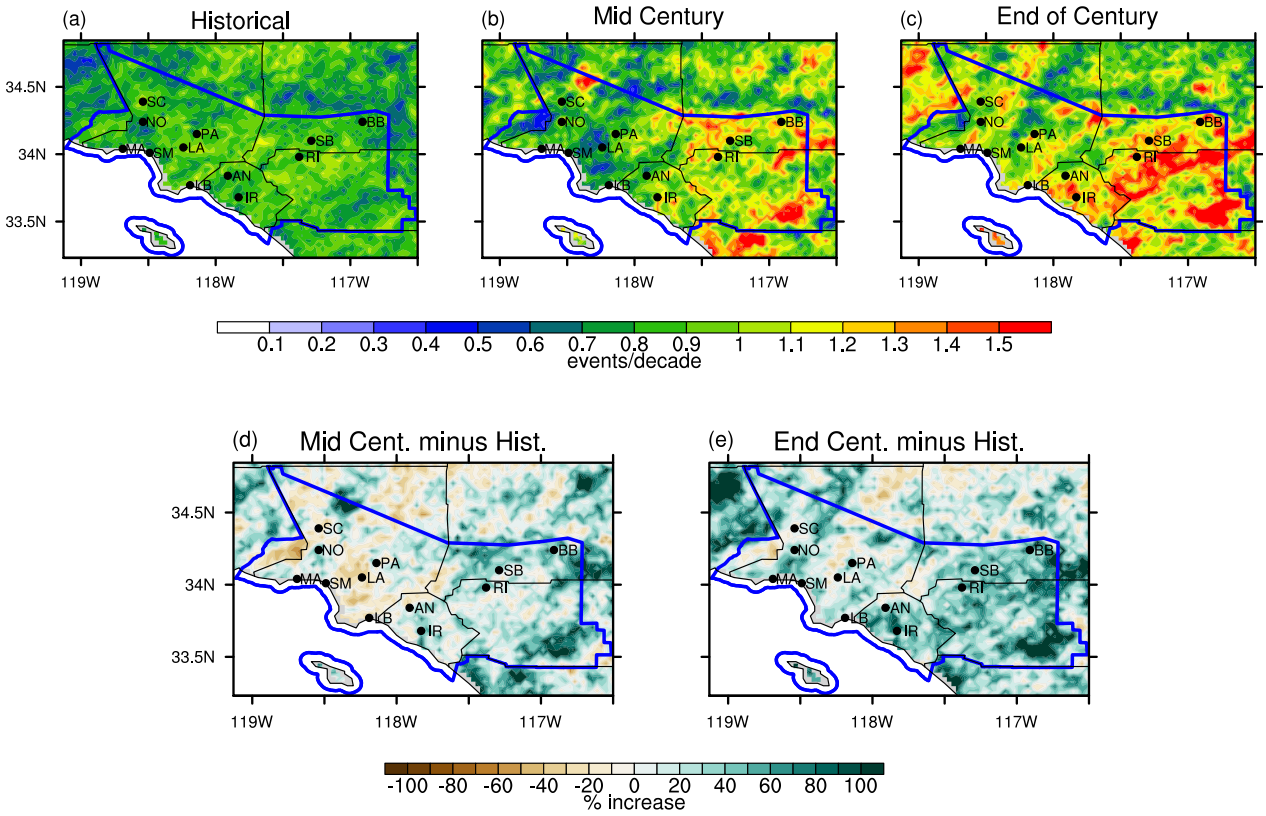


Figure A11: 21st century projections of drought followed by heavy rain. *Top row: Frequency of an intense precipitation event (above the 99.9th percentile of local daily precipitation) occurring during the year after a drought year (below the 20th percentile of local annual precipitation), averaged over the (a) historical (1981–2010), (b) mid-century (2041–2070), and (c) end-of-century (2071–2100) periods. Bottom row: Increase of the same metric in (d) mid-century and (e) end-of-century periods, relative to historical. For each period the drought and heavy rain thresholds are based on the historical climate. All data are averaged over 14 LOCA2-Hybrid downscaled climate models under the SSP3–7.0 scenario. Cities are annotated as detailed in* **Figure 1**.

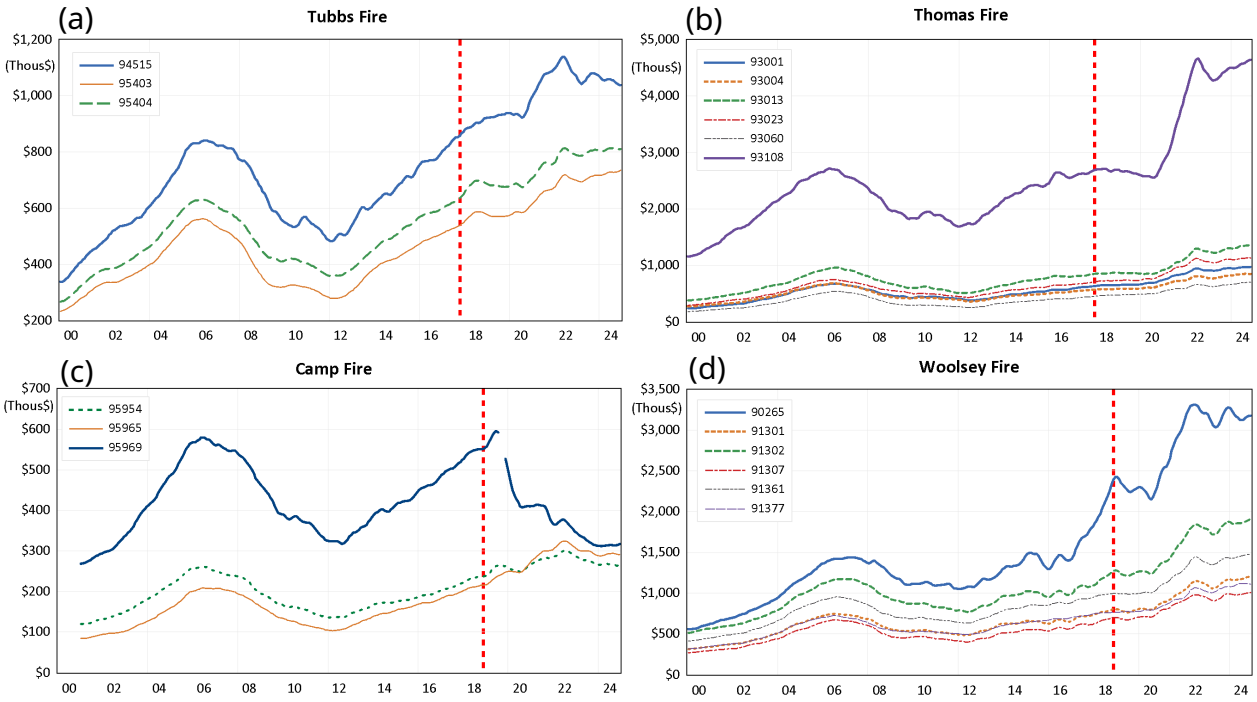


Figure A12: Median home prices in California zip codes affected by destructive wildfires. *Time series of home prices in individual zip codes affected by Tubbs, Thomas, Camp, and Woolsey Fires. In each case the time of the fire is indicated, after which most zip codes show prices leveling off, before continuing to rise two years or so later. The Camp Fire is an exception, in which prices in the 95969 zip code plummeted and remain slightly more than half what they were before the fire. Source: Zillow*



Figure A13: *Based on this 2023 Research Needs Assessment, the California State Water Resources Control Board funded research and public outreach events, administered by both Sea Grant programs in the state, in collaboration with the Sacred Places Institute for Indigenous Peoples, Heal the Bay, and the Southern California Coastal Ocean Observing System (SCOOS).*

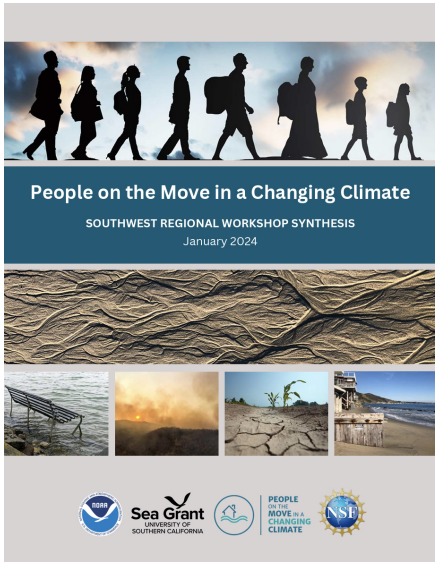


Figure A14: *Funded primarily by the National Science Foundation, the project, titled "People on the Move in a Changing Climate" (PEMOCC), held six regional workshops, and the Southwest Regional Workshop in 2022 was centered in Los Angeles.*

Text A1. Listening to Leaders Survey

TreePeople's *Listening to Leaders Survey* was designed to determine whom the public trusts for decision-making around climate and what attributes make someone a trusted figure in climate leadership. The survey asked the following questions:

1. In your community, whom do you **trust, rely on, and listen to** for information on and decision-making around climate priorities?
2. Why do you **trust, listen to, and rely on** them?
3. What is their position in the community as you understand it?

TreePeople conducted a power mapping exercise to identify Climate Leaders in the following categories: leaders in the community-based organization (CBO) and nonprofit space, leaders in academia, government leaders, prominent activists and community organizers, and Tribal leaders. Surveys were distributed to over three hundred individuals in the LA region, with 25 Climate Leaders being selected.

Text A2. Cascading Hazards

The chain of events leading to the 2025 fires likely began with the extremely wet winters of 2022-23 and 2023–24. In between these two winters, Hurricane Hilary in August 2023 led to an exceptional amount of summer rainfall (multiple inches, depending on the location), which likely prevented any major fire activity in the 2023 season. Subsequently, 2024 saw the third hottest summer on record in LA, which caused the unusual amount of vegetation to become particularly desiccated. Then, the 2024-25 wet season failed to materialize prior to January 7th, 2025, being

the second driest on record up to that date, so that the vegetation did not receive the moisture that it normally would by that point of the wet season. Finally, hurricane-force Santa Ana winds formed on January 7th and 8th, among the strongest ever recorded in the LA region. The combination of these winds and the exceptionally arid vegetation allowed the fires to spread so rapidly and deeper into the urban landscape than was previously thought possible. Three of the factors involved in this cascading sequence of events (wet years, dry years, and hotter conditions) are projected to intensify in the LA region. Other recent events in the region and nearby, such as the Thomas Fire and consequent Montecito mudslides in 2017-18, have been attributed to similar cascading hazards (AghaKouchak et al., 2020). Thus, although extremely challenging to model due to the long sequence of events and causal links, cascading hazards are likely to be at increased risk in the LA region through the 21st century.

Text A3. Oil Spills

Although not caused by climate change, there were notable impacts to water quality in the LA region that should be considered in combination with the additional climate impacts on water quality. On October 1, 2021, an underwater oil pipeline (P00547) connected to Platform Elly ruptured about 4.5 miles offshore of Long Beach. The spill released approximately 25,000 gallons of crude oil into the ocean, impacting a wide expanse of coastline, including popular beaches and state-protected wetlands and marshes. Federal and state agencies acted swiftly to shut down the pipeline and implement cleanup operations, while shoreline closures were enacted to protect public health and wildlife.

The environmental impact was substantial: oil covered over 8,000 acres of ocean surface and reached 127 acres of marshland and affected multiple habitats, including rocky intertidal zones, subtidal areas, and sandy beaches. There were significant wildlife casualties, with at least 116 birds (including threatened species) and several marine mammals. There were also effects on many fish, invertebrates, and aquatic plant communities. Rescue crews cleaned and rehabilitated live animals, and volunteers, along with professional crews, worked extensively to recover oil, collect tarballs, and monitor the environmental consequences over the following months.

The spill caused notable disruptions to the local community and economy. Beach closures affected major public events, such as canceling the final day of the Pacific Airshow, and fishery closures halted commercial and recreational fishing along much of the Orange County and San Diego coastlines. Businesses reliant on tourism, fishing, and recreation suffered financial losses, while local seafood markets faced public apprehension even after being deemed safe. Rapid environmental sampling, monitoring, and eventual cleanup operations allowed for the reopening of beaches and fisheries by November 2021. Promising research is ongoing on changes to the microbial community in the oil-affected wetlands, intending to isolate and culture oil-degrading bacteria to assist in future oil-spill recovery efforts (Gammon, 2024).

Text A4. DDT

Another notable water quality issue that might be considered in combination with other climate change-induced water quality issues in the LA region is the recent discovery of much more extensive deep water DDT (Dichlorodiphenyltrichloroethane) contamination than previously

known. The largest US DDT (a widely used insecticide) producer, the Montrose Chemical Corporation, operated in Torrance, California, and discharged waste products from the 1930s through the early 1970s. Various government agencies permitted the ocean disposal of industrial, domestic, and military waste via the LA County wastewater treatment plant to the Palos Verdes Shelf. The US Environmental Protection Agency eventually designated this area off the Palos Verdes Shelf in the 1990s as a Superfund Site.

It was not until 2020 that policy-makers and the public became aware of the greater extent of the waste beyond the Superfund Site. Researchers discovered, and the LA Times did a feature on the fact that, in addition to discharging waste onto the shelf, DDT was also dumped en route to several legal offshore dumpsites off the LA coastline. These deep-water sites off Southern California include what is now called Ocean Disposal Sites #1 and #2 in the San Pedro Channel. The types of waste deposited ranged from oil refinery byproducts and chemical waste to garbage and even military explosives. However, the specific history, volume, and composition of materials dumped remain poorly documented due to the sites' depth and remoteness (Almada, 2024).

Recent scientific interest and media attention brought deep ocean DDT contamination in the San Pedro and Santa Monica Basins back into focus, highlighting a pressing need to address new findings that reveal over 45 toxic DDT-related compounds ("DDT+") present in these productive marine ecosystems. Due to significant unknowns about the distribution, environmental fate, and impacts of DDT+, communities, researchers, and legislators at both the state and federal levels have called for major research investments. In response, the University of Southern California and California Sea Grant Programs created a comprehensive DDT+ Research Needs Assessment in 2022, gathering scientists, community members, and Tribal representatives to identify and prioritize research needs across site characterization, ecological and environmental health, and human health and well-being (**Appendix, Figure A13**). Based on this assessment, the California State Water Resources Control Board funded a research program and public outreach events, administered by both Sea Grant programs, in collaboration with the Sacred Places Institute, Heal the Bay, and SCOOS, the last of which occurred in January 2026 (Sea Grant, n.d).

Researchers have mapped the location of the deep-sea contamination, analyzed the extent of various contaminants, investigated the mobility and degradation of the DDT+, and explored the impacts on sealife. Early results suggest that, while much remains unknown about the deep-ocean site, the risk to public health is low for those following state fish advisories, but potential impacts to wildlife (such as marine mammals and birds) require further study (Kivenson et al., 2019; Merrifield et al., 2023; Stack et al., 2024; Neira et al., 2024; Turner et al., 2024; Schmidt et al., 2024). The collaborating agencies have committed to continued data collection, risk analysis, and transparency while developing possible remediation or risk-reduction strategies depending on the emergence of new evidence about threats posed by the site's historical contamination.

Text A5. Climate-Induced Human Mobility

One area of research that has grown since the Fourth Assessment is the study of climate induced human mobility, its socioeconomic consequences, and how to build resilience and adaptive capacity to prepare for the impacts of climate change in the US coastal and Great Lakes regions. Funded primarily by the National Science Foundation, this project, titled "People on the Move in a Changing Climate" (PEMOCC), held six regional workshops, and the Southwest Regional

Workshop in 2022 was centered in Los Angeles and facilitated by USC Sea Grant (Alvarez et al., 2024; **Appendix, Figure A14**). The main climate-induced drivers of human mobility and foci of discussion in the 2022 workshop were rising tides, groundwater intrusion, increased flooding, drought, and wildfire. Participants of the workshop included researchers, city officials, practitioners, community members, journalists, and Tribal members.

The 2022 workshop featured the current state of knowledge on climate-induced human mobility, explored local, regional, and international case studies, and determined the unique needs of the underserved and underrepresented coastal communities within the southwest. Specifically, the 2022 workshop summarized the research, policy, communication, and coalition and relationship building needs identified by participants in the workshop with the goal of using these lists as a tool to guide future research, funding, partnerships, and policy-making. To date, all PEMOCC workshops, including the 2022 workshop, have culminated in publicly available summary reports (PEMOCC, n.d.)

Text A6: Socioeconomic Profile of the LA Region

A significant portion of the LA region consists of socially disadvantaged and environmentally burdened communities, as defined by the State of California's Office of Environmental Health Hazard Assessment, who are likely to be particularly vulnerable to climate change societal and health impacts.

A number of indicators illustrate the struggles of many of its residents to achieve economic security. Despite the region's wealth, the region's median household income is significantly below the state's. There are significant income disparities by race and ethnicity (**Appendix, Table A6**). The median annual income of Black, Latino, and Native American households is lower than that of white and Asian and Pacific Islander (API) households. Likewise, there are significant gender disparities in income, most of which intersect with racial and ethnic disparities. Overall, women and girls are more likely to live in households with the lowest incomes. Gender gaps in income are evident within all racial and ethnic groups, with white and Black women and girls experiencing the widest gaps in relation to their male counterparts.

All told, 3 million people in the region live in households earning less than $48,000, a level below a living wage for a family of two working adults and one child (Glasmeier, 2026). About three in ten Black and Native American residents and two in ten Latino residents live in these lower-income households (**Appendix, Table A6**).

Income inequality in the LA region has a striking geographic dimension. High-income families are clustered on the coast, in Irvine and its surroundings, and in parts of the Northwest San Fernando Valley (**Figure 27a**). Those living in the top 5% of income are concentrated in a handful of neighborhoods: Newport Beach, Aliso Viejo, and Laguna Woods in Orange County; Marina del Rey, Westchester, and Culver City in LA County; and Malibu, Beverly Hills, and the Pacific Palisades and Brentwood neighborhoods of the City of LA (**Figure 27b**).

Lower income families are concentrated in the Inland Empire and in the urban core of LA (**Figure 27a**). One in nine people in the region live in households with income below the federal poverty line ($24,860 for a family of three) (US Department of Health and Human Services, 2023). Poverty

rates are significantly higher among women than men; they are highest among Black women and girls, with nearly one in five living below the federal poverty line. Nearly one in seven Latina women and girls also live below the federal poverty line. Overall, compared to white and API people, Black and Latino people disproportionately lack sufficient financial resources. People living in households in poverty are concentrated in Downtown and South LA and the Inland Empire (**Figure 27c**).

Housing constitutes one of the largest expenses for most adults, and millions in the LA region struggle to afford it. One sign of the affordability crisis is the region's low rate of homeownership relative to the state average. Within the region, Latino and Black adults are the least likely to be homeowners. Just 44% of Black adults and about half of Latino adults live in owned homes, compared to roughly two thirds of API and white adults.

Text A7. US Census Bureau's American Community Survey (ACS)

The ACS is the largest ongoing survey administered by the Census Bureau and includes detailed information on individuals and households covering more than 40 topics, including demographics, income, housing, and transportation. Respondents self-report their race and ethnicity. To avoid double-counting and in accord with research standards used by federal and state agencies, race/ethnicity groups are limited to those who report a single race. Latinos may be of any race, and people reporting multiple races are categorized as multiracial. The US Census Bureau collects data in accordance with Office of Management and Budget (OMB) standards, which in 2023 included five minimum racial categories: white, Black or African American, American Indian or Alaska Native, Asian, and Native Hawaiian or Other Pacific Islander. Hispanic or Latino ethnicity is reported separately. Survey respondents can mark as many racial or ethnic groups as correspond with their personal identity. Statistical significance is assessed at the 95% confidence level. Sample sizes too small for reliable analysis are omitted from publication. Data accessed via IPUMS. (Ruggles et al, 2025).

Text A8. Gender Definition in ACS

The public data used for this analysis, the US Census Bureau's American Community Survey (ACS), includes one question on sex. It asks a person's sex and instructs the respondent to mark a single choice: male or female. The ACS, as well as most generalizable population-based surveys, does not collect information on a broader spectrum of gender, such as gender expression or gender identity. Therefore, it is not possible to identify within the ACS data those for whom sex assigned at birth and gender differ, or to determine how these individuals respond to the question asking their sex. Due to the lack of data on gender identity, demographic analysis is based on self-identification in the ACS. All people who self-identify in the ACS as female are reported as women or girls, and all who self-identify as male are reported as men or boys. For example, a transgender woman who responds "female" is included in all analyses of women; one who responds with her sex assigned at birth, or "male," is included in all analyses of men. This may lead to some mismeasurement if people indicate a sex that does not align with their gender, but because the ACS is self-reported it is equally possible that people report sex as a reflection of their gender identity rather than sex assigned at birth. This limitation in the data prevents analysis of the experiences of people across a broader spectrum of gender identities, but the overall effects on

the published results are likely small. (An estimated 1% of California's adult population identify as transgender men, transgender women, or transgender nonbinary adults, according to a survey by the Williams Institute.) For the ACS question on gender/sex, see "American Community Survey Questionnaire," available at https://www2.census.gov/programs-surveys/acs/methodology/questionnaires/2023/quest23.pdf. For a discussion of gender and sex and recommendations for better data collection to accurately capture gender diversity, see "Measuring Sex, Gender Identity, and Sexual Orientation" National Academies of Sciences, Engineering, and Medicine, available at https://www.nationalacademies.org/publications/26424 (National Academies of Sciences, Engineering, and Medicine, 2022b). For data on transgender Californians, see "How Many Adults and Youth Identify as Transgender in the United States?" The Williams Institute, UCLA School of Law, available at https://williamsinstitute.law.ucla.edu/wp-content/uploads/Trans-Pop-Update-Aug-2025.pdf.

Text A9. Native American Definition in ACS

It is common to report data on race/ethnicity by limiting racial groups to a single race alone, and to categorize Latinos of any race as an additional and mutually exclusive group. This is the approach typically taken by the US Census Bureau for analysis of race and ethnicity in many of their research products. Creating mutually exclusive racial and ethnic categories prevents double-counting of individuals, allows percentages to sum to 100, and reduces the need to make assumptions about people's identities. However, doing so for people who identify as AIAN dramatically reduces the population identified as Native American and does so far more than for any other group.

The OMB racial standards define AIAN as "a person having origins in any of the original peoples of North and South America (including Central America) and who maintains Tribal affiliation or community attachment." (The question in the ACS includes space for respondents who select AIAN to write in the name of their enrolled or principal Tribe, though this is not a requirement.) Compared to the other major groups in the ACS, there are notable differences in the racial and ethnic identification of Native peoples. They are by far the most likely to also identify as Latino. Likewise, AIAN people (along with Native Hawaiian and Pacific Islanders) are also the most likely to identify as multiracial (US Census Bureau, 2019)

Text A10. Climate Story: Solar Watts

MONEIK JOHNSON is a longtime and active member of the Watts community, where she has owned her home for more than two decades. With fewer green spaces than other parts of the region, Watts is a disproportionately hot community—and it's only getting hotter due to climate change.

Johnson has experienced this heat firsthand. Despite the heat, she has never had air conditioning in her home. She has struggled to pay her electricity bills, even without the major expense of cooling her home to a comfortable level. But this is changing. After having solar panels installed on her home for free through Watts Rising's home solar program, she is already experiencing major benefits.

Once the panels were turned on, she immediately began seeing a difference in her electricity bill. "I was really happy. It came down tremendously… This last bill was the best bill. I've never seen a bill like that since I've been a DWP customer," Johnson said. Before having solar installed, Johnson was

making monthly payments to pay off her electricity bill debt. Now, she can pay the bill in full. "I'm able to just pay it all at once as opposed to making payments on it. It's always been a thing that I'm making payments, and to be able to pay it o feels good."

Lower electricity bills mean that Johnson can now afford to keep her home cooler and more comfortable. She plans to get air conditioning in the winter, when she might be able to take advantage of sales. "I know that now it'd be affordable for me to get air conditioning. I've been wanting it because it's so hot."

Johnson first heard about the Solar Watts program through a local family roofing business, where she has worked as an office manager for over 20 years. The company was working with GRID Alternatives, so Johnson knew she could trust the organization. When the solar program launched, she was one of the first in line to have GRID Alternatives install solar panels on her home. "The company I work for does a lot of work for GRID Alternatives, so I saw that Solar Watts was a real program. I knew they weren't making homeowners pay."

Johnson has been sharing her positive experience with installing solar to encourage others in her community to sign up for the program. "I've been telling all my neighbors that I know. It's a good thing to have."

Text A11. Climate Story: Community Resilience to Extreme Heat

I'm a climate resilience leader in the Southeast Los Angeles County region, also known as the "Gateway Cities." I grew up in Long Beach, California, a city of almost 500,000 people and a core hub of goods movement, air quality issues, and climate adaptation. Long Beach is adjacent to the largest port complex in the US carrying almost 20 million containers of materials a year. It's a location where shipped goods from the rest of the world crisscross neighborhoods via diesel trucks and trains.

With extreme heat being one of the highest impacts in the Southeast Los Angeles County Region (Climate data story by USC Neighborhood Data for Social Change), communities that already deal with a burden of air pollution will have effects exacerbated. My mom was a kindergarten teacher in west and north Long Beach for 19 years, where elementary schools and homes were in close proximity to high-traffic roads and refineries. The communities are predominantly made up of low-income households that suffer from air contamination, and consequently health issues like asthma. Over the years, parents, teachers, and local governments have collaborated for solutions like air filters and ventilation in classrooms, adding vegetation barriers near roadways, and school gardens.

I also have a large Latino family of outdoor workers, who are disproportionately affected by extreme heat. For example, my husband, a sanitation worker, was spotlighted in the Los Angeles Times for his attempts to stay cool during the hottest, longest heat wave in California in 2022 (article). Outdoor workers like him have limited access to shade and air conditioning during extensive physical labor hours. I frequently share extreme heat cooling tips to my family from ListosCalifornia.org, the State's website on emergency preparedness for climate events.

Because of climate experiences with community and family, I participate in climate change solutions every day. I have worked with non-profit organizations like Climate Resolve to advocate for more trees, shade canopies, bus shelters, cool pavement, and hydration stations. Now I work with the Gateway Cities Regional Climate Collaborative, which is identifying climate projects and plans,

uplifting community-informed research, and increasing resources for equitable, sustainable change. The Collaborative was founded by the Gateway Cities Council of Governments, TreePeople, SELA Collaborative, Grid Alternatives, and the Los Angeles Chief Sustainability Office.

I'm sharing my story to shed more light on climate change impacts and collective hope for solutions.

Text A12. Climate Story: Native Landscaping

I grew up in Park La Brea Los Angeles, and although most of my long-term concerns are about water conservation, drought, increasing temperatures, and public transit, what I want to talk about today is community resilience through urban agriculture.

I didn't grow up knowing where my food came from or how it was grown, and it wasn't until high school that I first learned about composting and organic farming.

In 2019, my parents had the privilege to be able to move up to Altadena, and it was the first time we lived in a place where we had soil that we could grow from. We started tearing up as much of the lawn as we could by ourselves to start growing three sisters blends like corn, beans, and squash, as well as greens, strawberries, tomatoes, potatoes, and other plants.

We began shifting our diets towards ones that were more local and organic, and it was a great experience to not only tear up useless lawn that was wasting water, but also to start planting native plants and turning the lawn into a green space and a natural space.

The wildfires directly impacted our soil, and now we're no longer able to grow and eat out of our soil safely. An idea that's been on my mind a lot recently is a community program that helps people remediate their lawns with plants, using things like corn and sunflowers over the course of a few seasons to heal their soil, which was done to LA State Historic Park in Chinatown by Metabolic Studio.

I'd love to see opportunities for communities to get together to learn about this process and to potentially convert a lot of what were once invasive green grass lawns into wild spaces with native plants after they've been rehabilitated. That's something I'm very passionate about and would love to learn more about and see if that's something that has been done before, and if so, how I can get involved.

Text A13. Climate Story: LA Compost

I'm a proud South Central LA native with deep roots in both art and land stewardship. I serve as LA Compost's South LA Regional Coordinator, overseeing food scrap collection and compost processing across the greater South Central region.

My passion for composting and environmental work comes from wanting to see my community thrive. Growing up surrounded by concrete, I watched my family turn our small front yard into a thriving garden, where we grew food and shared it with our neighbors. That experience taught me early on how powerful nature can be—not just in nourishing the body, but in bringing people together.

As I got older, I saw the deeper issues at play—parks left neglected, air pollution that made it harder to breathe, trash piling up in empty lots. I started asking, "Why does my community look like this?" The answer was a long history of disinvestment and environmental injustice. Volunteering at Carver Middle

School was a turning point for me. That's where I learned about composting, not just as a way to reduce waste, but as a tool for healing land and building community power. Now, through LA Compost, I get to do this work every day, making sure people in South Central have access to sustainable solutions that actually work for us.

The need for this kind of grassroots work is real. South Central LA faces serious environmental challenges, and inadequate waste management is one of the biggest. Overflowing trash bins, illegal dumping, and lack of proper waste services don't just make our streets look neglected—they create health risks and deepen existing inequalities. Climate change only makes it worse, with extreme heat, worsening air pollution, and rising food costs making it harder for families to access fresh, affordable food. These aren't abstract problems; they're things we deal with every day.

To help address this, LA Compost provides resources and support for residents in South Central. Through farmers' market food scrap drop-offs, composting workshops, and volunteer opportunities, we're giving folks real ways to be part of the solution.

One of my favorite success stories is of a high school student who volunteers at Carver Middle School Garden. He not only brings his family's food scraps every week, but he's gotten his mom and siblings involved too. He's passionate about environmental work and dreams of a future in sustainability. Seeing young leaders like him step up reminds me why it's so important to create opportunities for the next generation—opportunities I didn't have growing up. I'm grateful to work alongside LA Compost's South LA team, a small but mighty group of BIPOC femmes who bring so much wisdom and love to what we do. Looking ahead, I want to expand our soil education programs in schools, making sure more young people get hands-on experience with composting and land stewardship. For me, composting isn't just about keeping food waste out of landfills—it's about proving that we have the power to create the healthy, thriving neighborhoods we deserve.

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