

CALIFORNIA'S FIFTH
CLIMATE CHANGE
ASSESSMENT

San Francisco Bay Area 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

Authors and Contributors

Coordinating Lead Authors

Louise Bedsworth, *Center for Law, Energy & the Environment, University of California, Berkeley*
Shruti Sarode, *Center for Law, Energy & the Environment, University of California, Berkeley*

Engagement Leads

Casandra Esteve
Bay Area Climate Adaptation Network

Christina Oraftik
Bay Area Climate Adaptation Network

Michael McCormick
Bay Area Climate Adaptation Network

Authors

Alan Rhoades
Lawrence Berkeley National Laboratory

Daisy Ramirez Lopez
Pathways Climate Institute

Cory Copeland
San Francisco Bay Conservation and Development Commission

Benjamin Hatchett
Colorado State University

Emily Bercos-Hickey
Lawrence Berkeley National Laboratory

Rohini Haar
UC Berkeley, School of Public Health

Kris May
Pathways Climate Institute

Michael Wehner
Lawrence Berkeley National Laboratory

Yang Zhou
Lawrence Berkeley National Laboratory

Case Study Contributors

Alex Ghenis
Accessible Climate Strategies

Catalina Garzon
Communities United for Restorative Youth Justice

Chris Toledo
Suscol Intertribal Council

Cris Criollo
Marin Multicultural Center

Emily Yang
San Francisco Youth Commission

Jacy Bowles
Communities United for Restorative Youth Justice

Kamille Lang
Climate Resilient Communities

Matt Wolff
San Francisco Department of Public Health

Padma Balaji
Bay Area Youth Climate Summit

Rachel Hatch
Institute for the Future

Sadie Wilson
Greenbelt Alliance

Tadashi Fukami
Stanford University, Department of Biology

Associate Editor

Richard Matthew
University of California, Irvine

Acknowledgements

We extend our deep gratitude to the team at the Governor's Office of Land Use and Climate Innovation for their guidance throughout this process and for leading the statewide effort to produce California's Fifth Climate Change Assessment. We are especially thankful to community-based organizations, Tribal Nations, state agencies, and others who generously shared their time and perspectives. Their on-the-ground work advancing climate adaptation in the Bay Area was essential to shaping this report. We thank Rachel Clemsha for contributing data on fog in the Bay Area and Safeeq Khan for providing the projections of Sierra Nevada snowpack included in the report. We also want to recognize our climate data team, whose deep expertise, countless hours of analysis, and commitment to accuracy and clarity provided the backbone of this assessment.

The Fifth Assessment team acknowledges the many advisors, contributors, and community participants helped inform the research reflected in this report, including the Fifth Assessment Tribal Advisory Group for their review and guidance, which helped strengthen the report's discussion of Tribal priorities, Tribal expertise, and the climate impacts affecting California Native American communities.

Suggested Citation:

Bedsworth, L., Sarode, S., Rhoades, A., & Esteves, C. (2026). *San Francisco Bay Area Regional Report* (California's Fifth Climate Change Assessment). University of California, Berkeley. https://www.climateassessment.ca.gov/2805/

Disclaimer: The Fifth Assessment has been prepared as directed by Public Resources Code Sections 71340, et seq. and supported entirely by state funding allocated by the California Legislature in the Budget Act of 2021. The Assessment's reports summarize the best available information about potential climate futures, impacts, and adaptation approaches in California at the time of the Assessment's preparation. The authors of this report are solely responsible for their content and conclusions. The information presented here does not necessarily represent the views of the coordinating agencies of the State of California. Nothing in this Assessment establishes or modifies any binding rule, requirement, or legal obligation, nor is the Assessment an endorsement of any particular project, policy or response strategy. Specific response strategies will be developed by state, regional and local governments, and will likely involve policy trade-offs and funding considerations.

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 San Francisco Bay Area is made up of nine counties: Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma. The region has a vibrant economy, diverse and growing population, and varying landscapes and geographies. The Bay Area is home to many Indigenous Peoples that have stewarded the region's resources for millennia.

The Bay Area has a Mediterranean climate and is already experiencing measurable climate-related impacts that have worsened dramatically in recent years. These climate effects are rarely homogenous: they are almost always worse for low-income or more marginalized communities. This report provides an overview of the projected impacts of climate change on the region's climate, including projected changes in temperature and precipitation, sea level rise, groundwater, and wildfire. The report then examines the effects of these changes on the region's social, natural, and built systems. The report concludes with a discussion of regional governance and areas for future research.

This report builds on the Regional Summary Report prepared as part of the Fourth California Climate Change Assessment (Ackerly et al., 2018) and the robust foundation of climate change work already underway in the region. The author team developed the report in consultation with members of the Bay Area Climate Adaptation Network (BayCAN) and many other partners. Quotes and case studies from this engagement work are included throughout the report to provide local experience, knowledge, and perspectives on the region's changing climate as well as approaches to address current and future risk.

Key Findings

The region is already experiencing the effects of climate change and projections show more severe impacts in the coming century:

- Average annual temperature in the San Francisco Bay Area has increased by +1.5°F (0.8°C) compared to the base period (1981–2001).
- The number of days above 90°F (32.2°C) is projected to increase up to 30–50 days per year by the end of the century, with larger increases projected for the northern (e.g., Solano County) and eastern portions (e.g., Contra Costa County) of the SF Bay Area.
- A larger share of precipitation is expected to fall through large storms (i.e., atmospheric rivers) in the coming century, increasing from about one-third of the region's precipitation today to approximately half of the region's precipitation by the end of the century.
- Rising sea levels pose risks to infrastructure, communities, and economic centers of the Bay Area. Current projections also show further risk from rising groundwater levels associated with rising sea levels.
- Nearly two-thirds of the region's water supply comes from the Sierra Nevada snowpack, which is expected to experience significant declines in the share of precipitation that falls as snow.

Some important uncertainties remain about the future impacts of climate change on the region

- Fog, an important feature of the Bay Area's climate and ecology, is a very complex phenomenon to model and large uncertainties remain about how fog patterns could change in future climate conditions.
- Recent analysis of vertical land motion suggests that current projections of sea level rise likely underestimate these risks in the Bay Area due to the subsidence in the region.
- The Bay Area's precipitation patterns are highly variable. Current projections of future precipitation may not capture this variability.

Climate change is stressing the region's social, built, and natural systems and will increase the costs of future disasters.

- Wildfire risk and extreme heat pose the most significant risks to public health, with lower income and marginalized residents facing higher impacts.
- Climate change will exacerbate the costs of disasters in the region. Adaptation, including wildfire risk reduction and flood protection, can reduce these costs.
- The SF Bay Area faces an extreme shortage of accessible and affordable housing. The region is projected to add 1.4 million jobs and nearly as many households by 2050. Climate change poses significant risk to existing homes in the wildland–urban interface and in coastal areas. Approximately 64,000 planned housing units are in areas projected to face flood risk. Fragmented governance regimes (e.g., ownership, homeowners' associations) can complicate coordinated resilience efforts.
- Rising sea levels pose significant risks to housing and other infrastructure in the region. Over one-quarter of residents in Redwood City are projected to be in areas projected to flood within the next 25 years. Regional agencies estimate the cost to protect the region from sea level rise is between $81–147 billion.
- Rising groundwater levels threaten to mobilize contaminants from over 400 toxic sites by the end of the century, under a *high* sea level rise scenario.
- The region's water system is highly vulnerable to climate change. Wastewater treatment plants, traditionally located on the Bay shoreline, face inundation from rising sea levels and disruption from rising groundwater levels. Regional water agencies are pursuing water efficiency and recycling programs to reduce vulnerability to reductions in water supply.
- The region's electricity system faces increasing demands from data centers, increased electric vehicle use, and building electrification, compounding risks from climate change. Pacific Gas and Electric (PG&E) projects moderate to high risks to its electric system due to high heat, wildfire, heavy rain and flooding, and sea level rise.
- Critical transportation corridors—including roads, rail, ferry systems, and walking and biking infrastructure—face risks from coastal inundation and flooding. Even modest coastal disruptions can result in cascading delays farther inland.
- Agriculture in the Bay Area accounts for 1.2 million jobs and nearly $311 billion in annual sales and faces increasing risks from water volatility, increased temperatures, sea level rise and groundwater hazards, and wildfire.

The region has taken important steps to advance local and regional adaptation activities, including leadership by Indigenous groups, local organizations, and regional agencies.

- The Bay Area has been at the heart of the land back movement, enabling Indigenous stewardship and governance on the land. The Tamien Nation acquired 235 acres of ancestral homelands in 2025 and will undertake restoration on the land by reintroducing native species, teaching Tribal community members place-based practices, and increasing resilience through Indigenous fire stewardship.
- The Canal Alliance is part of a partnership to support resilience to sea level risk in this highly vulnerable neighborhood in San Rafael (Marin County). A resident-led Steering Committee has provided capacity-building and training for residents that has allowed them to take an active part in the adaptation planning, embed equity goals, and link the planning process to other local priorities, including housing, health, and emergency management.
- Several youth organizations, including Communities United for Restorative Youth Justice and Bay Area Youth Climate Summit, provide opportunities for Bay Area youth to actively participate and shape the region's climate actions.
- The San Francisco Bay Conservation and Development Commission developed the Regional Shoreline Adaptation Plan and is providing support for local governments to develop sea level rise adaptation plans. The Bay Adapt platform provides a regional vision and collaborative organization to support a regional approach to adapt to rising sea levels.
- Fewer examples exist for regional coordination on climate impacts other than sea level rise (e.g., extreme heat or wildfire). Focused efforts to identify priorities for regional collaboration on preparedness activities, including planning and project implementation, will be important for the region. Opportunities remain for the region to expand partnerships with Indigenous groups in existing and future coordination on adaptation and resilience.

Table of Contents

Executive Summary 8

Chapter 1. Introduction 13

1.1 Current Conditions 16

1.2 Interregional Connections 16

1.3 Approach to the Regional Report 17

Chapter 2. Climate Science: Historical & Projected Trends 18

2.1 Historical Context 21

2.2 Projected Changes in Temperature and Precipitation 21

2.3 Extreme Heat 24

2.4 Precipitation 25

2.4.1 Storms and Flooding 29

2.4.2 Drought 30

2.5 Snowpack 31

2.6 Fog 35

2.7 Wildfire 38

2.7.1 Bay Area Fire Activity 41

2.7.2 Bay Area Wildfire Seasonality 42

2.7.3 Bay Area Prescribed Fire Seasonality 43

2.8 Sea Level and Groundwater Rise 44

2.8.1 Sea Level Rise 44

2.8.3 Analysis and Mapping 47

2.9 Subregional Variation in Impacts 50

2.9.1 The San Francisco-San Joaquin Bay Delta 51

2.9.2 Heat and Wildfire—Alamo, Contra Costa County 51

2.9.3 Warmer Nights and Coastal Hazards—Half Moon Bay, San Mateo County 51

2.9.4 Heavy Precipitation and Flooding—Healdsburg, Sonoma County 52

2.9.5 Drought and Wildfire—Morgan Hill, Santa Clara County 52

2.9.6 Sea Level Rise and Flooding—Sausalito, Marin County 52

Chapter 3. Social Systems 53

3.1 Racial Equity and Climate Justice 54

3.2 Public Health 58

3.2.1 Key Climate Risks 59

3.2.2 Air Quality and Wildfires 59

3.2.3 Extreme Heat and Infrastructure Vulnerabilities 60

3.2.4 Vector-Borne Disease 60

3.3 Economics 62

3.4 Labor and Workforce 63

3.5 Communications 65

3.6 Human Displacement 66

3.7 Emergency Capacity 66

Chapter 4. Natural and Working Lands & Waters 68

4.1 Indigenous Knowledge 70

4.2 Biodiversity and Habitat 71

4.3 Water (Surface and Groundwater) 73

4.4 Coastal Issues 74

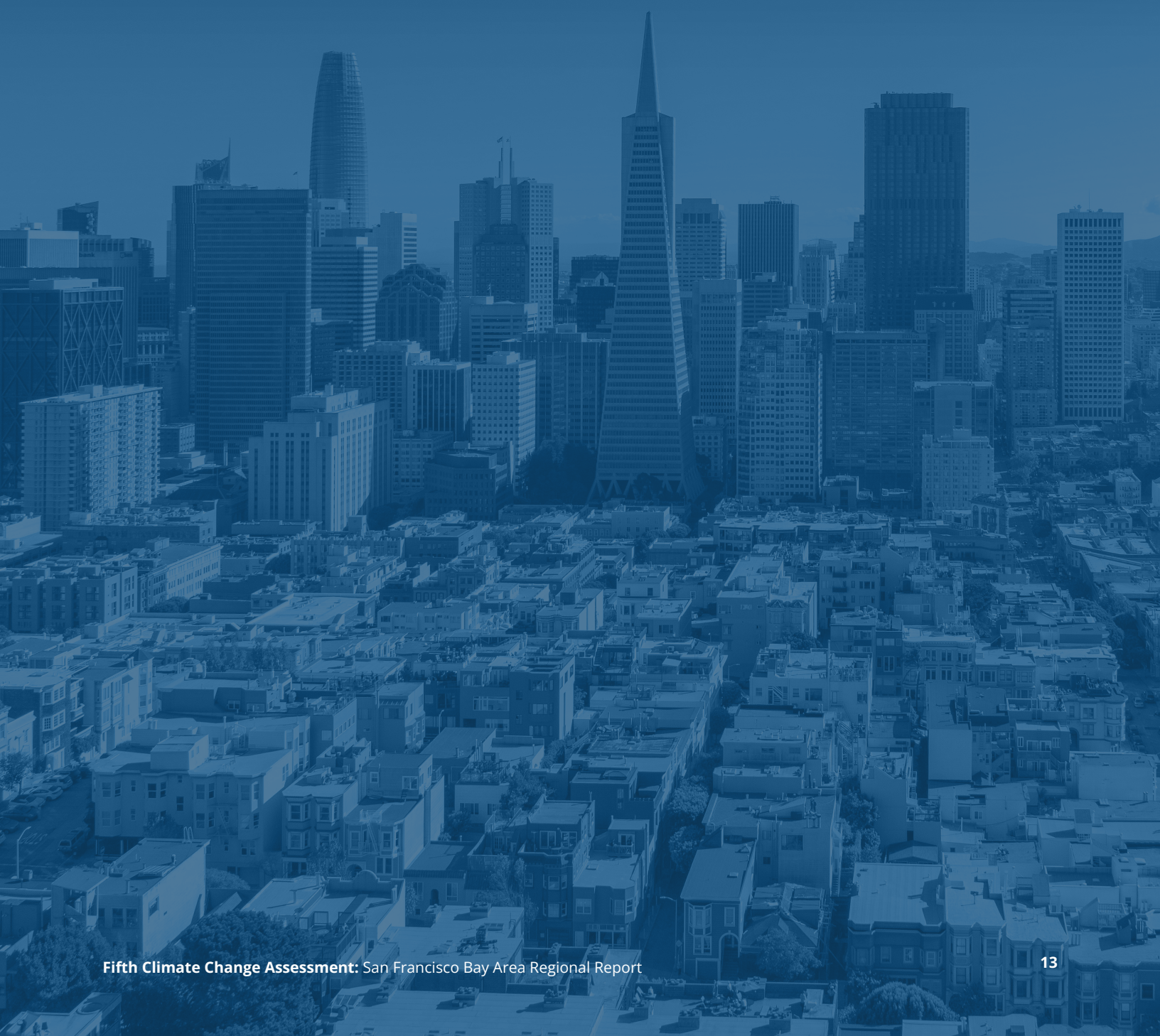


4.5 Agriculture 75
4.5.1 Key Climate Risks to Agriculture 75
4.5.2 Crop-Specific Risks 76
4.6 Land Use, Land Conversion, and Community Development 77
4.6.1 Key Climate Risks 78
4.6.2 Gaps and Needs 78
Chapter 5. 79
Built Systems 79
5.1 Sea Level Rise and Bay Area Infrastructure 80
5.2 Toxic Sites 82
5.3 Transportation 82
5.3.1 Key Climate Risks 84
5.3.2 Resources and Planning 84
5.3.3 Gaps and Needs 84
5.4 Power Grid / Energy Consumption & Distributed Generation 85
5.5 Buildings 85
5.5.1 Resources and Planning 86
5.6 Natural Infrastructure 86
5.6.1 Key Climate Risks 87
5.6.2 Gaps and Needs 87
5.7 Wastewater, Stormwater, and Water Systems 87
5.7.1 Threats to the Regional Water Supply 87
5.7.2 Infrastructure Vulnerability: Wastewater and Stormwater 89
5.8 Housing 90
5.8.1 Key Climate Risks 91
5.8.2 Jobs-to-Housing Imbalance 91
5.8.3 Gaps and Needs 91
5.9 Emergency Capacity & Mobility 92
Chapter 6. Regional Governance 94
6.1 Coordinating Across Jurisdictions and Impacts 95
6.1.1 Tribal Partnerships 95
6.1.2 Sea Level Rise 95
6.1.2 Heat and Air Quality 96
6.2 Coordinating and Collaborative Structures 97
6.2.1 Bay Area Climate Adaptation Network 97
6.2.2 Bay Area Regional Collaborative 97
6.2.3 TOGETHER Bay Area 97
6.2.4 Oakland-Alameda Adaptation Committee 97
6.3 Youth Organizing and Action 98
6.3.1 California Indian Museum and Cultural Center 98
6.3.2 Bay Area Youth Climate Summit 99
6.3.3 Communities United for Restorative Youth Justice (CURYJ) 99
Chapter 7. Conclusion 100
7.1 Areas for Future Research 101
7.1.1 Generation of Climate Model Data in Future California Climate Change Assessment Reports 101
7.1.2 Climate Impacts 102
7.1.3 Governance and Finance 103
References 104
Appendix A. Case Studies 113
Appendix B. Interviews 132
Appendix C. Additional Figures 148



Chapter 1.

Introduction



The San Francisco Bay Area is made up of nine counties: Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma. The region is a major global hub of innovation and culture with a diverse population, complex geography, and robust economy. Currently home to approximately 7.8 million people, the region's population is projected to grow to 9.3 million over the next 20 years (Metropolitan Transportation Commission & Association of Bay Area Governments, 2025).

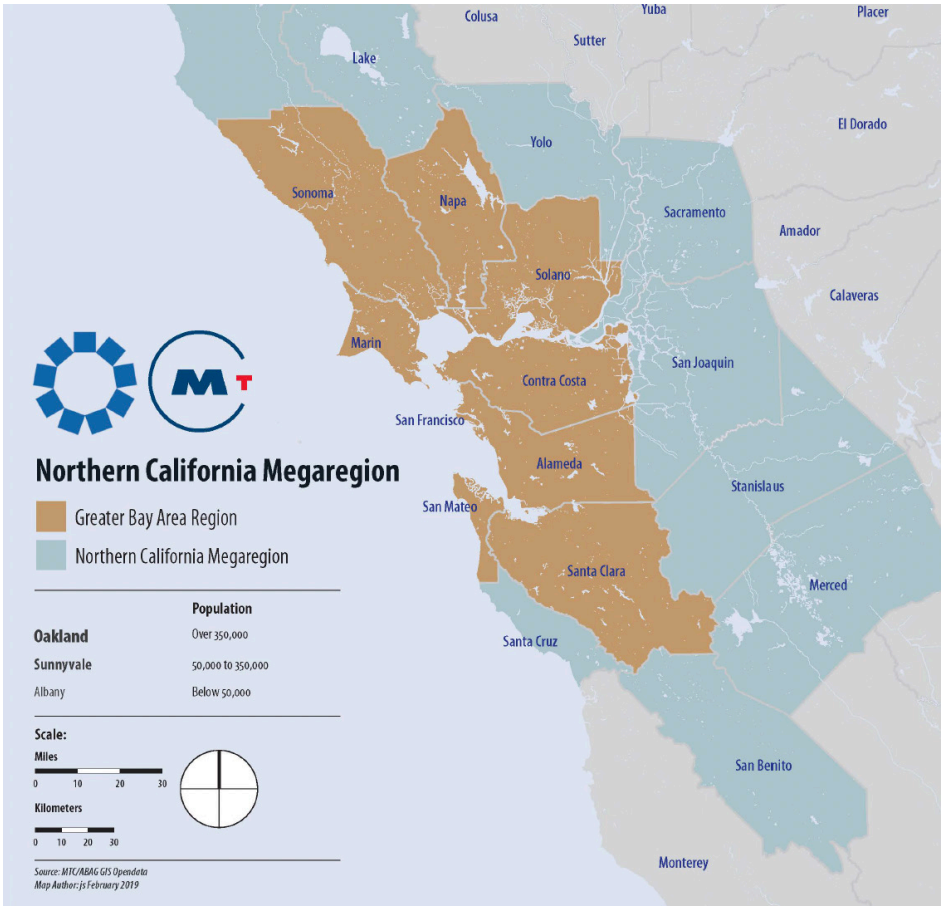


Figure 1: *Map of the San Francisco Bay Area.*

The SF Bay Area was originally inhabited by many Indigenous Groups (East Bay Regional Parks, 2019; Milliken, 2009). The Ohlone are the predominant Indigenous group of the Bay Area, including the Chochenyo and the Karkin in East Bay, the Ramaytush in San Francisco, the Yokuts in South Bay and Central Valley, and the Muwekma Tribe throughout the region. Other Indigenous groups in the nine-county region include the Graton Rancheria community (Coast Miwok and Southern Pomo), Kashaya, Patwin, and Mishewal Wappo in the North Bay, and the Bay Miwok in the East Bay (Bay Area Equity Atlas, n.d.)

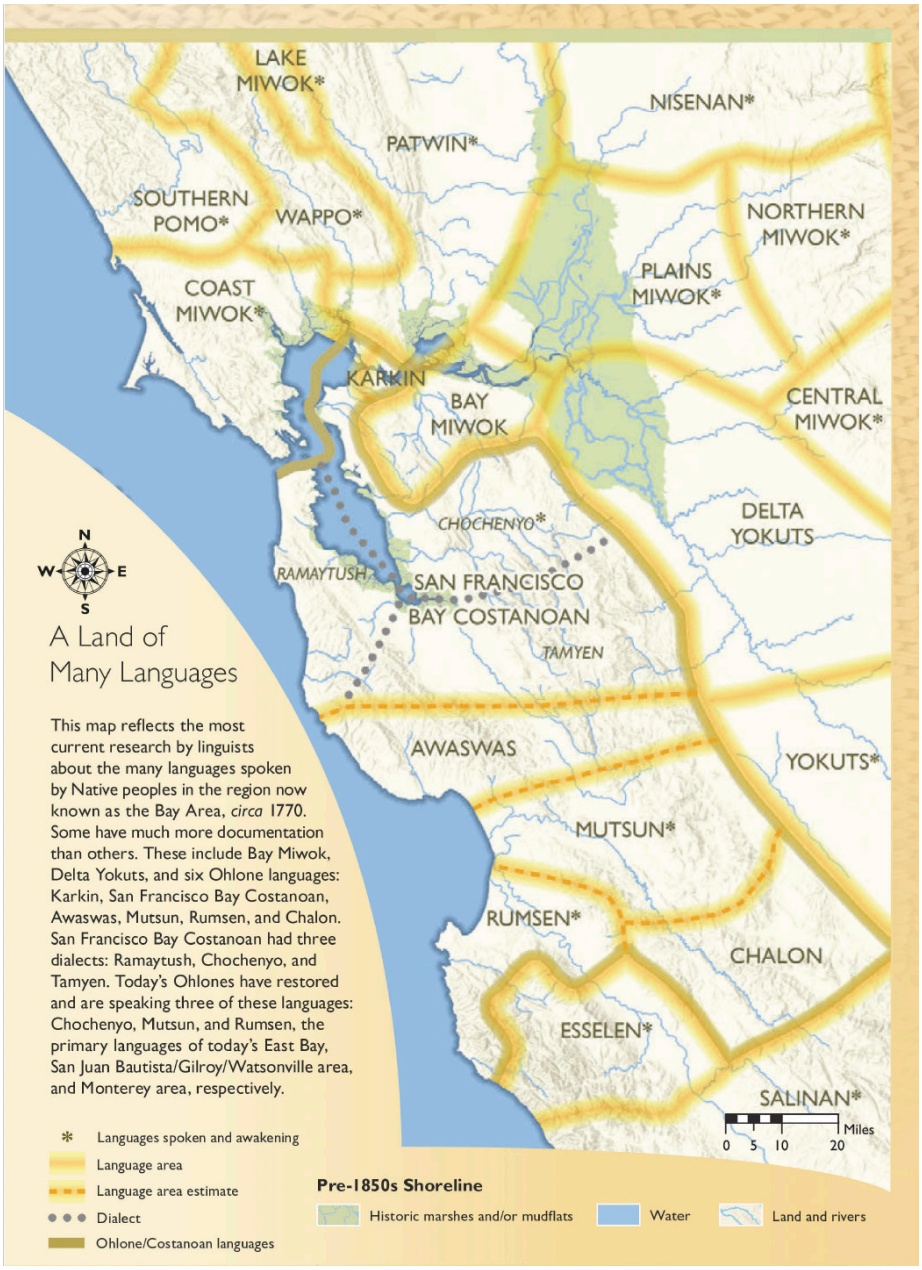


Figure 2: *Map of Tribal Homelands in the SF Bay Area, including language boundaries (East Bay Regional Parks, 2019).*

Geographically, the Bay Area is defined by the San Francisco Bay, a tidal estuary that is a critical ecological habitat and the central feature of the region's topography. The landscape is a mosaic of steep coastal mountains, redwood forests, rolling hills with oak woodlands and grasslands, salty and fresh wetlands, and expansive agricultural lands, particularly in the North Bay. The region's infrastructure is complex, featuring a dense multimodal transportation network of bridges, freeways, and public transit systems, all converging around the bay. This infrastructure is both a testament to the region's economic vitality and vulnerabilities to climate-related hazards.

The Bay Area has a strong regional economy, driven by technology, finance, healthcare, and tourism. This economic strength is interwoven with a rich cultural and demographic tapestry. The region is one of the most ethnically diverse in the nation, with a significant presence of Hispanic/Latino, Asian, African American, and Pacific Islander communities.

The Bay Area is also a historic hotspot for social change, particularly for Urban Indians. During the latter half of the 20th century, the region served as a primary site for the Indian Relocation Act. The US government displaced members of various Tribes, including those from the Southwest, Great Plains, and Eastern Woodlands, to the area with promises of training, housing, and jobs that it ultimately failed to deliver. Today, California is home to close to 200 Tribes, with only 109 of them recognized by the US federal government. The Bay Area holds one of the largest populations of Intertribal Indians in the country (Bay Area Equity Atlas, n.d.).

The San Francisco Bay Area's demographic patterns, coupled with a history of social and economic inequality, create varied levels of vulnerability to climate impacts, underscoring the importance of equitable climate solutions. The region's geographic, social, and cultural diversity also present opportunities for innovative approaches to build resilience that center Indigenous leadership and locally-designed solutions.

1.1 Current Conditions

The Bay Area is already experiencing measurable climate-related impacts that have worsened dramatically in recent years. Many of these climate effects are rarely homogenous: they are almost always worse for low-income or more marginalized communities. For example, during the expanding wildfire season in California and across the western United States, air quality in the region now regularly reaches hazardous levels, with fine particulate matter (PM2.5) concentrations exceeding the US Environmental Protection Agency (EPA) standards by 300–500% (Kramer et al., 2023). The Bay Area faces unique infrastructure vulnerabilities. For example, with its historically mild climate, San Francisco has the nation's lowest air conditioning ownership rate (45% [34% central air, 11% room units] versus 92% national average), with nearby cities like Oakland and Hayward ranking among the lowest—this makes residents particularly susceptible to health impacts when temperatures rise (Mauhay-Moore, 2023).

1.2 Interregional Connections

The Bay Area has important connections to other regions of the state. The region relies on the Sierra Nevada region to supply a significant share of the region's drinking water. It is important to note that the development of some of these systems came at the expense of Indigenous Tribes in the Sierra Nevada region. The creation of the Hetch Hetchy Project inundated the Hetch Hetchy Valley, the traditional summer homelands of the Ahwaneechee and Tuolumne Bands of Miwok Indians. The damming and flooding of the valley not only submerged these managed ecosystems and disrupted sacred waters, but also forcibly severed the Tribes' physical and spiritual connections to their homelands. The modern water infrastructure built upon this historical displacement now serves as the primary source of water for the Bay Area region.

The high cost of housing in the region has led some of the workforce to find homes in neighboring regions, including the San Joaquin Valley. Therefore, there are important transportation corridors

between these regions. The Bay Area is also impacted by natural disasters in other regions, especially smoke from regional wildfires but also flood or storm-related disruptions in commerce, water supply, and electricity.

1.3 Approach to the Regional Report

This report builds upon a robust foundation of climate change work already underway in the region. Because of this, the report was developed using an engagement-first model. The Bay Area Climate Adaptation Network (BayCAN) served as the engagement lead on the report. BayCAN is a regional collaborative that includes local and regional government, community-based organizations, and private sector members. BayCAN advances climate adaptation for all through regional and subregional convenings, connecting members to the resources and technical assistance they need to make their projects successful. BayCAN coordinates a bimonthly equity working group. We used BayCAN's broad network to conduct a series of listening sessions, focus groups, and interviews that informed the basis of this report.

A major takeaway from the outreach was the desire for a regional summary report that would be accessible and actionable. **Table 1** outlines major themes from the outreach and how they are addressed in this report.

Table 1: *Themes from Regional Report Outreach and Engagement and How They are Reflected in the Report*

Theme	Description	Reflection in Report
Narratives and Case Studies	Examples of specific actions being taken to address climate change that are replicable and provide information on how people and communities are already experiencing the effects of climate change	Report includes case studies and first person narratives through interviews
Governance	Because addressing climate change often requires coordination across sectors and jurisdictions, participants wanted a discussion of current governance models and gaps	Report includes section on regional governance
Finer Resolution Data	Information on local scale climate impacts that can be overlayed with demographic and other data to inform decision making	Report includes an explanation of the limitations of downscaled climate models (**Box 1**), and local data on vulnerability
Actionable	Information that can be accessed and used to support local planning, grant applications, and other activities	Included lists of tools and resources in most sections of the report
Accessibility	Clear communication using plain language and visuals to ensure information is accessible, easily understood, and actionable by diverse audiences.	The language used is clear and straightforward. We avoided jargon as much as possible.

This regional report integrates climate data, historical trends, and future projections with insights gathered through engagement with community-based organizations, Tribal Nations, State agencies, and local partners. Case studies and community voices are woven throughout the report, illustrating how climate change is reshaping daily life and how resilience efforts are emerging from the ground up. The report intersperses case studies and quotes from interviews conducted throughout the report development process. Each case study title links to a full case study included in **Appendix A**. Quotes from interviews link to the full interview in **Appendix B**. Anonymous quotes were provided by the Institute for the Future based on the research they conducted for the Fifth Assessment report "Building an Inclusive Future: A Participatory Approach to Transformative Climate Change Resilience" (see full report for more information)

Chapter 2.

Climate Science: Historical & Projected Trends



Key Messages

- Average annual temperature in the San Francisco Bay Area has increased by +1.5°F (0.8°C) compared to the base period (1981–2001).
- The number of days above 90°F (32.2°C) is projected to increase up to 30–50 days per year by the end of the century, with larger increases projected for the northern (e.g., Solano County) and eastern portions (e.g., Contra Costa County) of the SF Bay Area.
- Future warming does not appear to considerably affect the total amount of precipitation in the San Francisco Bay Area. However, the months in which precipitation occurs shift by both mid- and end-of-century, with more precipitation falling in the winter months than in spring or summer.
- Fog is an important feature of the Bay Area's climate and ecology; however, it is a very complex phenomenon to model. As a result, large uncertainties remain about how fog patterns could change in future climate conditions, making this an important area for future research.
- Rising sea levels pose risks to infrastructure, communities, and economic centers of the Bay Area. Current projections also show further risk from rising groundwater levels associated with rising sea levels. Recent analysis of vertical land motion suggests that current projections likely underestimate these risks in the Bay Area due to the subsidence in the region.

The San Francisco Bay Area's climate vulnerability is compounded by its unique geography, socioeconomic complexity, and the intersection of multiple hazards. While extreme heat, drought, wildfire, flooding, and sea level rise are the most apparent climate threats, the Bay Area also faces compounding risks from non-climatic hazards such as seismic events. A major local earthquake, or even a non-local seismic event capable of generating a tsunami, would exacerbate climate hazards by damaging critical infrastructure: electrical grids and natural gas pipelines could be disrupted and water conveyance systems could be compromised, limiting supplies during drought or slowing post-disaster recovery. Rising seas further heighten the risk that a tsunami or distant storm-driven swell could coincide with a local storm, creating cascading impacts across the region.

Box 1: *A Note on Using Downscaled Climate Scenarios to Understand Regional Impacts*

Participants in many of the outreach discussions convened to inform development of this report indicated a desire for finer resolution data on climate impacts. Specifically, some participants requested census tract or neighborhood scale data. This box provides a short description of limitations of currently available models to provide this information.

Understanding the interconnected risks posed by environmental hazards requires climate model simulations that can capture changes at different spatial scales. As represented in **Figure 3**, global climate models (GCMs) operate at grid spacings on the order of 62 miles (100 kilometers). These simulations are well suited for describing large-scale drivers like atmospheric and ocean circulations, but cannot capture the Bay Area's steep topography, complex coastlines, and localized weather patterns that create its many microclimates. Regional climate models (RCMs), such as the Weather Research and Forecasting (WRF) model and/or statistical downscaling algorithms such as the Localized Constructed Analogs version 2 (LOCA-2), which are both employed for California's Fifth Climate Change Assessment (Fifth Assessment), combined with GCMs can better capture the Bay Area's heterogeneity by reaching grid spacing of 0.6–6 miles (1–10 kilometers). These downscaling techniques provide more locally relevant information related to future climate hazards that are shaped by how temperature, precipitation, and other climate variables interact with topography and how they could change under different Shared Socioeconomic Pathways (SSPs). However, these downscaling techniques do not reach grid spacings that we would consider "reality" (3–300 feet or 1–90 meters), where features like individual smaller ridges, valleys, and/or urban blocks strongly influence the Bay Area's unique microclimates and future climate hazards.

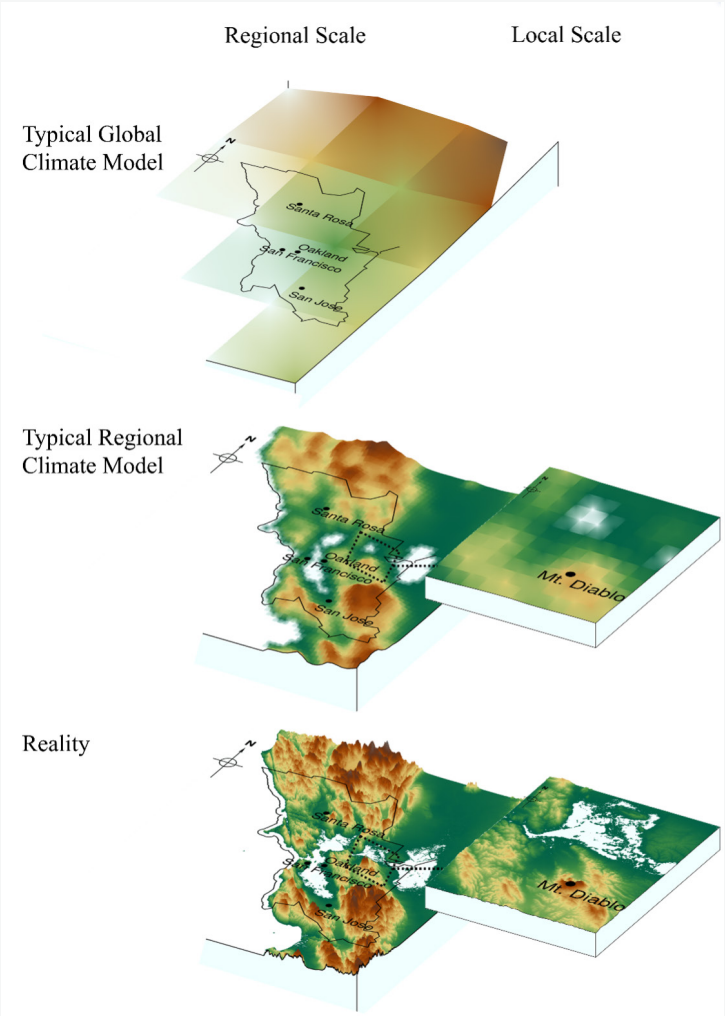
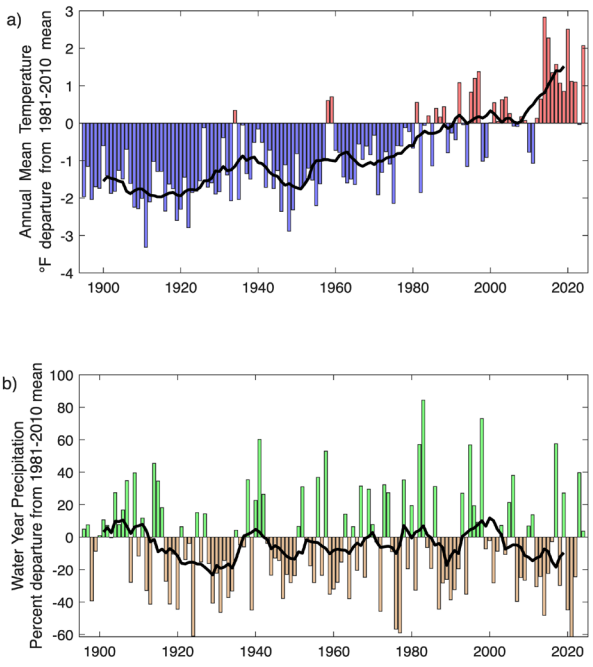


Figure 3: *Climate data is typically produced by global climate models, regional climate models, and/or statistical downscaling algorithms. Due to computational constraints, climate data can resolve processes at 62 miles to 6.2 miles (100 to 10 kilometers) grid spacing, which coarsens the reality of the Bay Area's heterogeneity and influences potential climatic hazards at the local scale where decisions are made.*

Downscaled climate data is useful for assessing vulnerabilities and designing adaptation strategies. They provide insights at neighborhood to regional scales, but we should also consider that all models have limits. The downscaled projections provided herein represent the best available science for the tasks of assessment, planning, and implementation.

2.1 Historical Context

Average annual temperatures in the Bay Area are now 1.5°F (0.8° C) higher than the 1981–2010 baseline. Since 2000, nearly 80% of years (19 out of 24) have been warmer than that baseline, with only two years cooler by more than 1°F (0.6° C) than the 1981–2010 mean (**Figure 4**) (Durre et al., 2022). Like the rest of California, the Bay Area swings between wetter and drier years and sometimes stays that way for several years at a time. Precipitation in the Bay Area demonstrates substantial interannual (year-to-year) variability but also interdecadal variability with 5- to 10-year periods of generally persistent above-or-below 1981–2010 means (**Figure 4**). This year-to-year variability is largely dictated by a small number (approximately 3–7 annually) of storms, namely extratropical cyclones associated with moderate-to-extreme atmospheric rivers. These events are projected to increase their contribution to annual precipitation at the expense of smaller "run-of-the-mill" storms with less moisture transport and/or weaker dynamics. Looking at a historical climate product (nClimGrid) the percent changes in total amount of precipitation has not shown an appreciable change since the early 1900s (relative to a 1981–2010 climatology). Since 2000, the moving mean highlights a drying trend influenced by three notable drought episodes in 2007–2009, 2012–2016, and 2020–2022. For Bay Area hydroclimate, both past and future, the key story is variability, not gradual change.



Rising Temperatures and Highly Variable Precipitation in the Bay Area

Figure 4: *The top chart shows how average annual temperatures in the Bay Area have changed compared to the 1981–2010 average, based on NOAA's nClimGrid dataset (Vose et al., 2014; updated monthly). The bottom panel shows changes in total precipitation for each "water year" (October 1–September 30), expressed as percent differences from the 1981–2010 average. In both figures, the black line shows the 11-year moving average, highlighting longer-term trends. Figure by John Abatzoglou, UC Merced.*

2.2 Projected Changes in Temperature and Precipitation

To understand future climate change, the Fifth Assessment uses a set of downscaled climate models (see **Box 1**) that project future climate under a range of future emission scenarios. Shared Socioeconomic Pathways (SSPs) are projections of global socioeconomic scenarios that could occur over the 21st century. The Intergovernmental Panel on Climate Change (IPCC) defined the SSPs in their Sixth Assessment Report on climate change in 2021 (D. Chen et al., 2021). SSPs integrate information on demographic, socioeconomic, technological, and political factors that will affect future emissions, land use change, and other factors. SSPs project radiative forcings, or changes in the Earth's energy balance, that arise due to changes in greenhouse gases, aerosols,

and other natural and anthropogenic direct and indirect factors. For this report, all projections, unless otherwise noted, show future conditions under three SSPs:

- SSP2–4.5 (SSP245): *Medium* emission scenario
- SSP3–7.0 (SSP370): *High* emission scenario
- SSP5–8.5 (SSP585): *Very high* emission scenario

The LOCA-2-Hybrid projections show that, under the high emissions scenario, the Bay Area steadily warms through the century (**Figure 5**). Average monthly surface air temperatures are projected to rise by 2–4°F (1.1– 2.2°C) by mid-century and by 4–7°F (2.2–3.9°C) by the end of the century. The smallest increases are expected in January, while the largest are projected for October (**Figure 6**). Given October is the final month of the Bay Area's warm season, this pattern could increase heat impacts on people, energy demand, and wildland fire hazard. Higher average and extreme temperatures will also stress crops in the region. In contrast, projections of precipitation do not show significant change in average annual precipitation over the century (less than 10% increase through the 21st century), and there is little variation across the different scenarios and models (**Figure 5**).

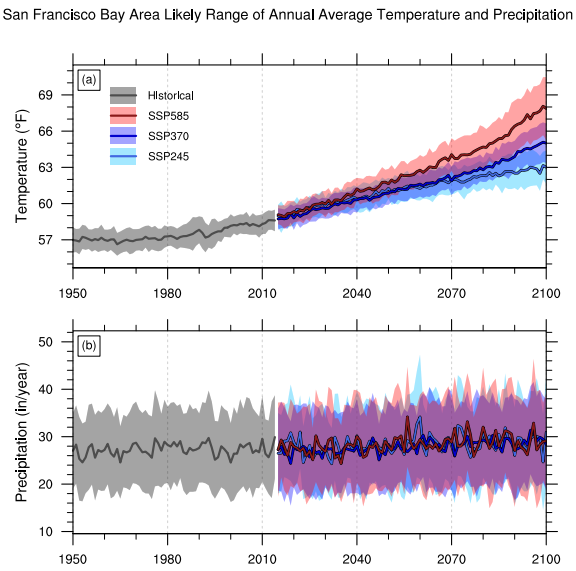


Figure 5: *Projected changes in the Bay Area's climate are shown here using LOCA-2-Hybrid data. The top panel shows the projections of annual average temperature, and the bottom shows annual precipitation. Gray represents the historical record, while the colored lines show three possible futures: Medium emissions (SSP245; light blue), High emissions (SSP370; dark blue), and Very high emissions (SSP585; red) scenarios. The bold lines represent the 11-year centered moving mean for each scenario. The shaded areas around each line represent the "likely" range across model projections Figure by Paul Ullrich, UC Davis.*

However, projections do indicate a shift in precipitation seasonality (**Figure 6**). In the Bay Area, like much of the state, a handful of big storms (nearly always associated with atmospheric rivers) contribute approximately 50% of the annual precipitation and account for over 80% of the interannual variability (see the Fifth Assessment report "The Impacts of Climate Change on Atmospheric River Storms and California's Water Resource Infrastructure" for more information).

Projections robustly indicate that atmospheric river-derived precipitation will increase, while precipitation contributed by weaker storms will decrease (**Figure 7**). It is also likely that total precipitation will accumulate through fewer, more intense, and potentially more clustered events. This means that even if total annual rainfall doesn't shift appreciably, the Bay Area will need to manage precipitation more often as a hazard rather than a resource.

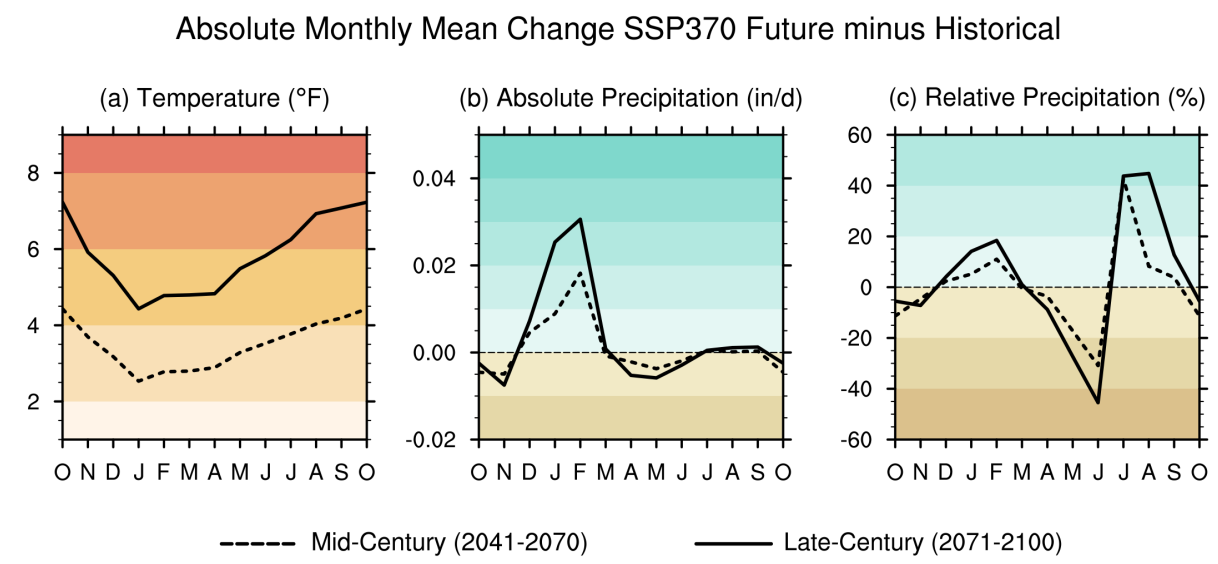


Figure 6: *LOCA-2-Hybrid SSP370 projections of the mid-century (dotted lines) and end-of-century (solid lines) monthly mean change in surface air temperature and precipitation (both absolute and relative) within the SF Bay Area. Figure by Paul Ullrich, UC Davis.*

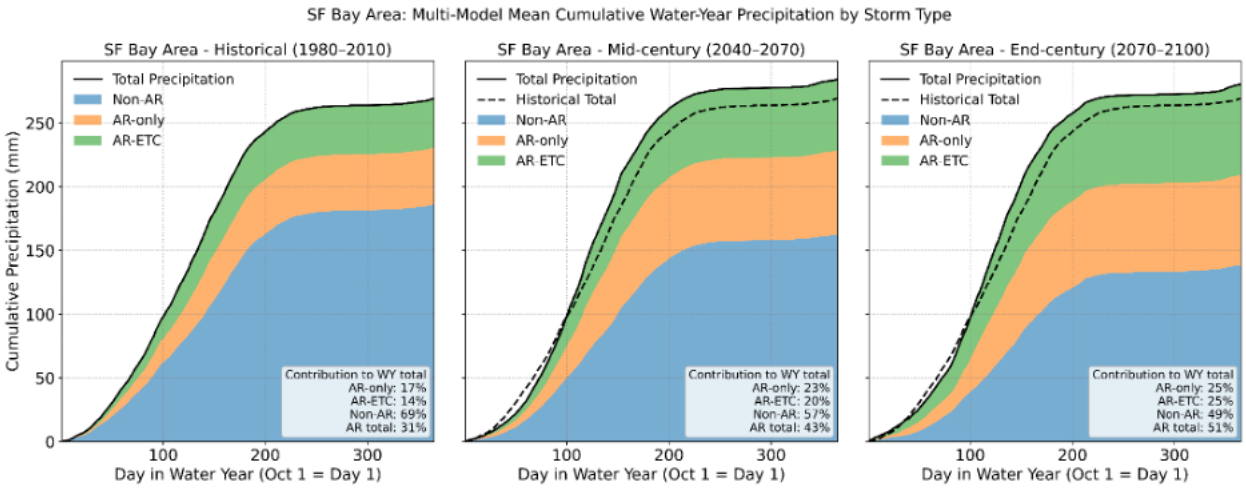
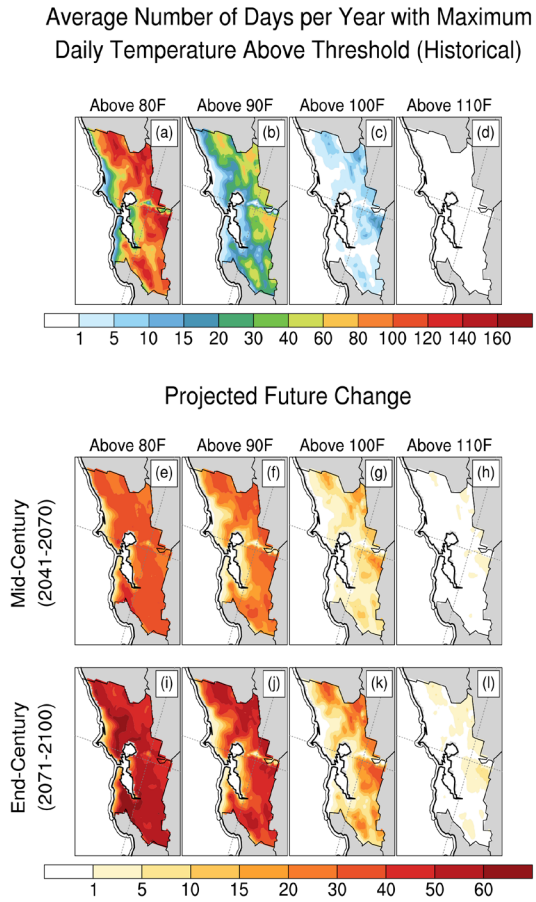


Figure 7: *Mean water year cumulative precipitation, shown by contributions from non-AR, AR-only, and AR-ETC events for the historical (left), mid-century (middle), and end-century (right) time periods under SSP585. The box located in the lower right of each subpanel plot shows the percentage contribution from each storm event type to the total precipitation.in surface air temperature and precipitation (both absolute and relative) within the SF Bay Area.*

2.3 Extreme Heat

Associated with these systematic increases in monthly mean temperatures at mid- to end-of-century (**Figure 6**), the number of days with maximum daily temperatures that exceed thresholds of concern also increase throughout the Bay Area (**Figure 8**). These thresholds range between 80–110°F (26.7–43.3°C). According to Vaidyanathan et al., 2019, important thresholds to consider for extreme heat include the following:

- 80–90°F (26.7–32.2°C) is the temperature range at which daily hospitalizations begin to appreciably increase for at-risk populations in California-Nevada (e.g., diabetics and fluid and electrolyte disorders); and
- 90–100°F (32.2–37.8°C) is the threshold at which the National Weather Service, in collaboration with the Center for Disease Control, begins to issue HeatRisk alerts.



Rising Heat: More Extremely Hot Days Ahead

Figure 8: *LOCA-2-Hybrid SSP370 projections show the average number of days per year when the daily high temperature exceeds thresholds of concern related to heat exposure in the Bay Area. The top row shows historical conditions, the middle row shows projected changes by mid-century, and the bottom row shows projected changes by end-of-century. Figure by Paul Ullrich, UC Davis.*

By the end of the century, some parts of the Bay Area, particularly in the northern (e.g., Napa and Solano counties) and eastern portions (e.g., Contra Costa and eastern Alameda counties), could see 30–50 more days per year above 90°F (32.2°C) (**Figure 8**). These two hot spot regions of the SF Bay Area also see an increase of 1–15 days per year for days above 100°F (37.8°C). Many regions that historically experienced fewer than 10 days above 100°F (37.8°C) per year are projected to see that number double or triple. These increases in heat days pose health concerns for vulnerable populations (i.e., those without adaptive capacities such as air conditioning, children and older adults, and the immunocompromised), workers exposed to heat (i.e., outdoor workers or those working in non-climate-controlled environments), agriculture, and natural ecosystems.

Not all areas in the region will be equally affected. Extreme temperature refugia, where projections for increases in the number of days above particular health-impacting thresholds are muted, occur in the westernmost coastal regions of the SF Bay Area (e.g., Half Moon Bay and Bodega Bay) and along the periphery of the San Francisco Bay itself. These regions are natural microclimates caused by their proximity to the relatively cool ocean (a product of coastal upwelling) that maintains the presence of fog and onshore breezes during the warm season.

Even though these refugia may not exceed traditional thresholds, the relative warming can still create serious risks. Communities and ecosystems adapted to cooler environments may struggle with even moderate temperature increases. For example, a top 2% heat extreme may be 80°F (26.7°C), but that could be 15°F (8.3°C) warmer than what these communities are used to and therefore could pose problems. (An example of this effect is shown for San Diego County in Figure 1 of VanderMolen et al. [2022].)

Box 2: *Limitations and Uncertainties in Temperature Projections*

Uncertainties in these LOCA2-based mean and extreme temperature projections include:

- Urban heat island effect: The Fifth Assessment projections don't capture fine-scale urbanization effects like heat retention from asphalt, buildings, and limited vegetation. This means actual extreme temperatures in cities, in general, and in specific neighborhoods, in particular, may be higher than what the projections suggest.
- Humidity: Wet bulb temperature (which accounts for humidity) better reflects heat risks, but was not explored with Fifth Assessment projections (partly due to long standing issues in GCMs in representing humidity feedbacks; [Simpson et al., 2024]).
- Climate adaptation and policy action: Future implementation of climate adaptation strategies (e.g., cool roofs, regreening cityscapes, etc.) and future policy and technology changes could reduce extreme temperatures at the regional-to-local scale relative to projected outcomes and affect vulnerability and exposure to extreme heat.
- Future urban growth, deforestation, or irrigation can alter regional-to-local temperatures but aren't fully included in Fifth Assessment climate projections.

2.4 Precipitation

California's largest (in terms of total precipitation) cool season storms are associated with atmospheric rivers (ARs). ARs are long, narrow plumes (hence "river") of strong water vapor transport (or integrated water vapor) that are found in the warm sector of the cyclone (storm) that produce heavy, consistent rainfall, especially in mountains (**Figure 9**). They can drop many inches of rain in just a few days (6–72 hours). This often causes river and urban flooding. The worst impacts come from prolonged wet spells characterized by multiple back-to-back storms over multiple weeks, particularly for the Sierra Nevada, coastal mountains in Marin and San Mateo counties, and the Russian River in Sonoma County (Gorman et al., 2023; Cassidy, 2023). Recent examples include January–February 2017, February 2019, and February–March 2023.

It is rare to have a nearly "average" (mean or median) precipitation year—often it's either a boom or a bust. Research shows that ~50% of precipitation comes from atmospheric rivers (AR), but over 80% of the year-to-year variability is due to these days (Dettinger, 2011). ARs are big contributors and the drivers of variability as too few storms lead to drought, while too many storms cause flooding. Between December 2022 and March 2023, California experienced more than a dozen ARs. These storms caused serious flooding and landslides, resulting in emergency declarations in 43 of 58 counties (Fawcett, 2023). Extremely wet years in the Bay Area occur roughly every decade or two, (2016/2017, 1997/1998, 1981/1982 and 1982/1983).

Traditional Gathering in the Era of Climate Change

> ***"Certain times of the year there are certain plants we gather and animals we hunt. Due to climate change, that timing is changing. We have to constantly monitor the biological resources, and sometimes we just don't know anymore."***

—Chairwoman Quirina Geary, Tamien Nation. See Case Study I: "Tamien Nation: Land Back, Cultural Stewardship, and Climate Resilience in the South Bay" in **Appendix A** *for more.*

The historically observed small mean change in water year total precipitation relative to the large year-to-year variability in the SF Bay Area is also reflected in model estimates. Climate models show that this large year-to-year variability will continue throughout the 21st century, with only small changes in the annual total amount of precipitation, regardless of SSP scenario.

Although the annual total amount of precipitation weakly responds to future warming, the months in which that precipitation occurs do shift at both mid- and end-of-century. According to the LOCA-2-Hybrid projections under the *high* emissions scenario (SSP370):

- More precipitation occurs within core winter season months (particularly January and February
- Less precipitation occurs in fall (October and November) and spring (March–May).
- Minimal precipitation occurs in summer (June–August), thus the small absolute projected increases that appear as large percentage increases (upwards of 40%) are negligible.

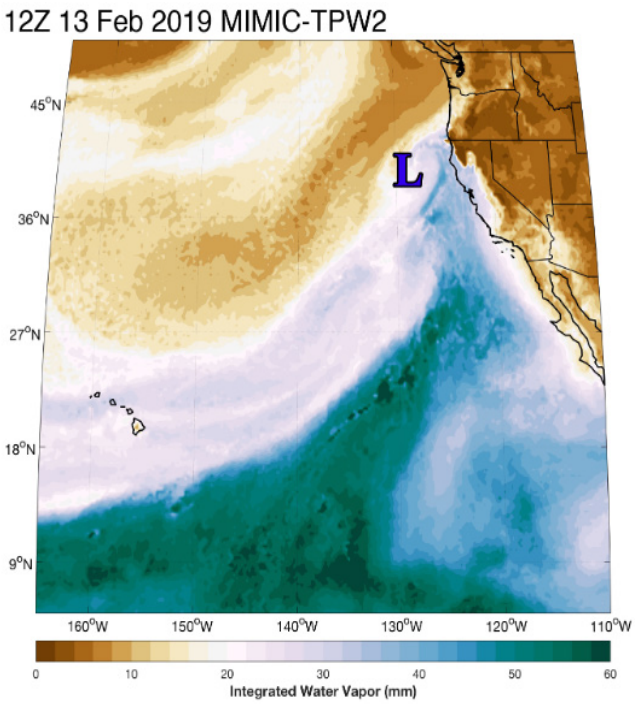


Figure 9: *Recreated image from Hatchett et al. (2020) of the February 2019 "Valentine's Day" atmospheric river using satellite-based estimates of integrated water vapor from the University of Wisconsin's MIMIC-TPW version 2 algorithm. The atmospheric river is labeled and the "L" denotes the location of the surface low pressure in the extratropical cyclone.*

In a warming climate, abrupt changes between dry and wet years (commonly called “whiplash” and technically known as “interannual variability”) are expected to become more common. Historically, the Bay Area experiences whiplash in 5–10% of years; projections suggest this will rise to 10–15% of years. Northern portions of the Bay Area are already starting to experience this shift and could continue to do so by mid-century, and the whole SF Bay Area could begin to experience this shift in “whiplash” by end-of-century (**Figure 10**).

In addition to an increase in interannual precipitation variability, other precipitation related changes projected for the Bay Area include:

- The wettest day of the year, often associated with an atmospheric river, could become 10–30% wetter by end-of-century with warming (**Figure 11**).
- Contra Costa and Santa Clara counties may see some of the largest relative increases, meaning larger impacts where such extremes were historically less common.

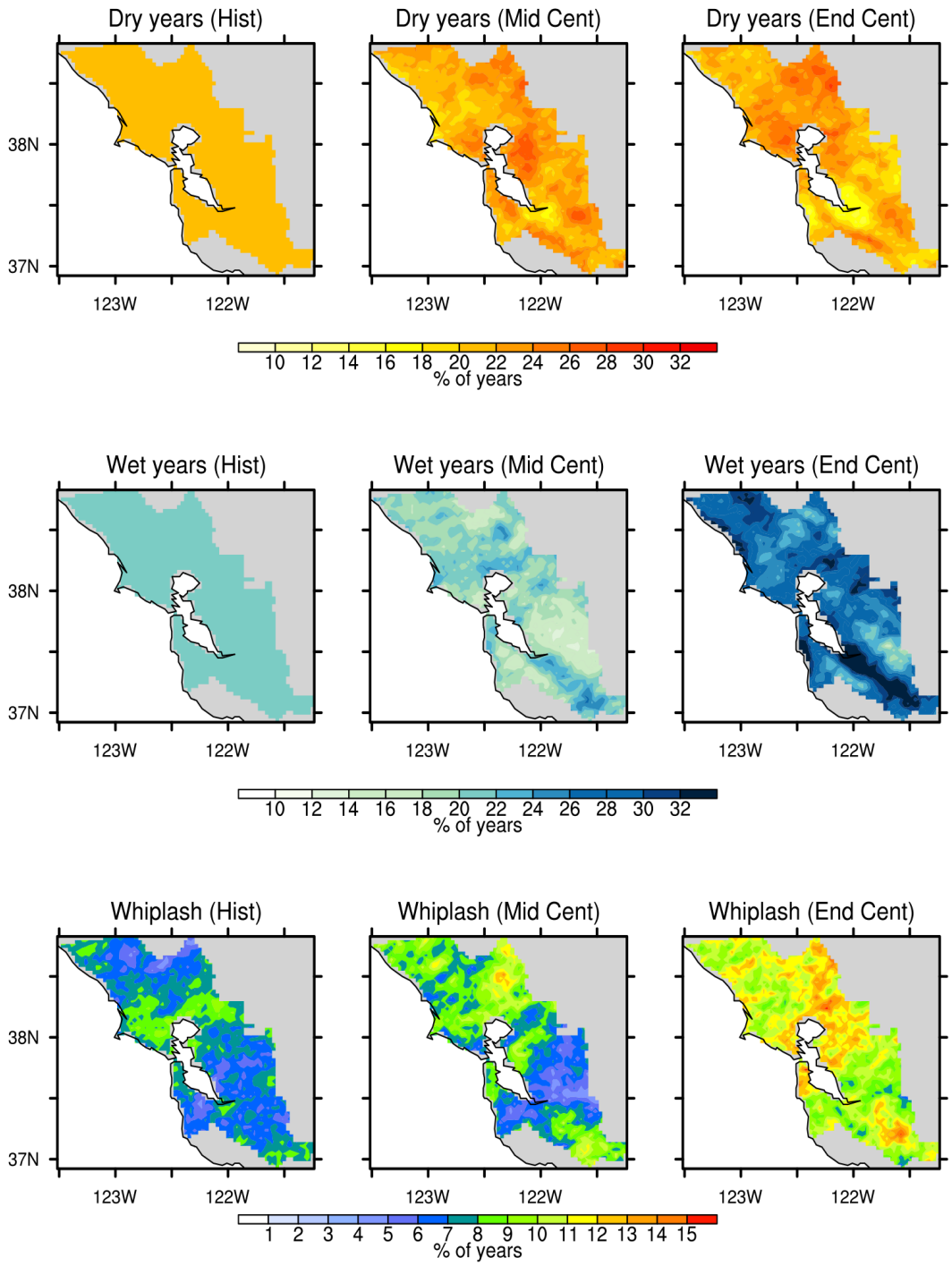


Figure 10: *LOCA-2-Hybrid SSP370 projections of the percentage of years in which the SF Bay Area experiences dry conditions (top row), wet conditions (middle row), and weather whiplash (bottom row) for the historical (Hist; 1981–2010), mid-century (Mid Cent; 2041–2070), and end-of-century (End Cent; 2071–2100) periods. Dry conditions are defined as the bottom 20th percentile of historic precipitation, wet conditions as the top 20th percentile of historic precipitation; and whiplash as consecutive wet and dry years. By definition, historical occurrence of wet and dry years is 20% everywhere. Figure by Jesse Norris, UCLA.*

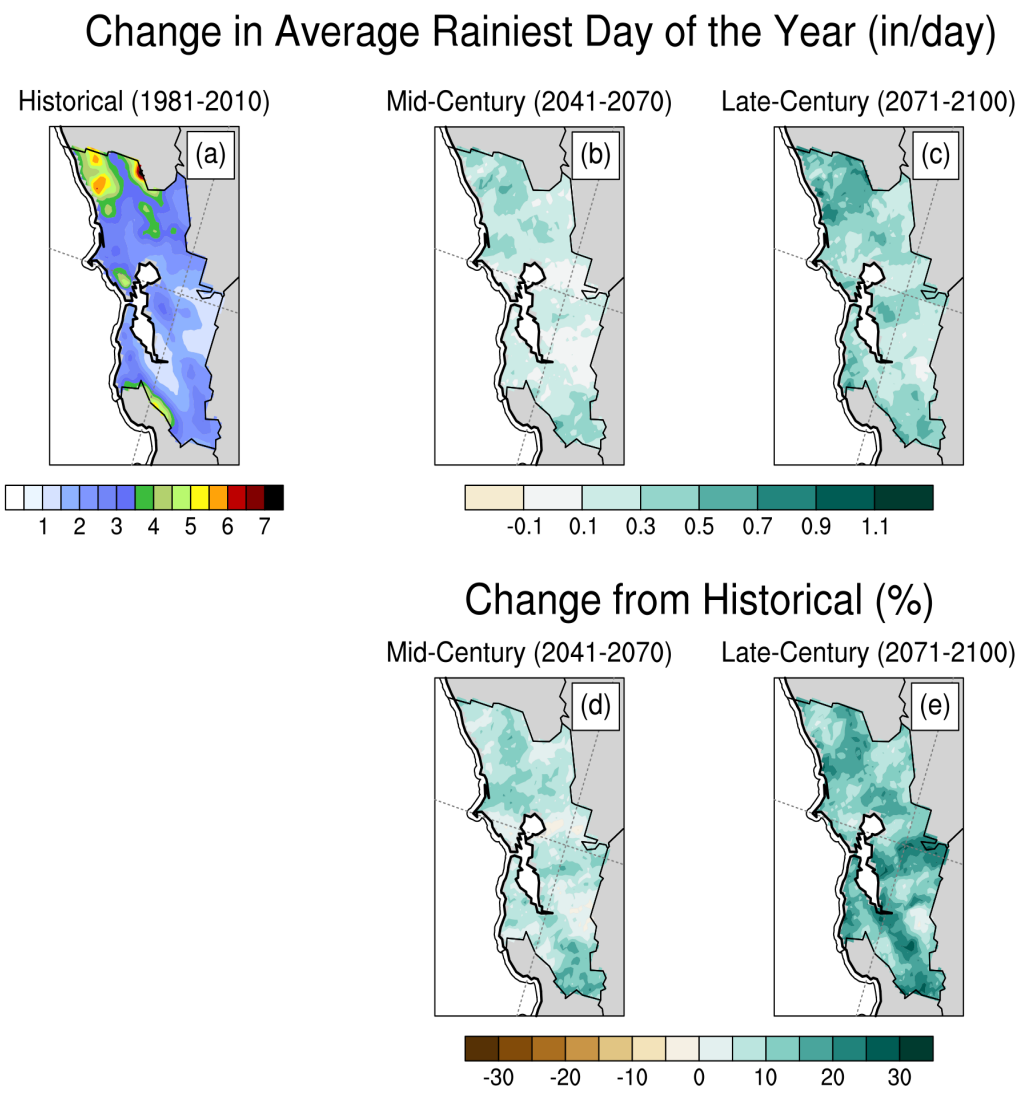


Figure 11: *LOCA-2-Hybrid SSP370 projections of the rainiest day of the year. Changes at mid-century and end-century are provided for absolute and relative changes in the top and bottom rows, respectively.*

The Interconnectedness of Ecological and Cultural Loss

> ***"Climate change affects every part of our lands, waters, cultural practices, and the well-being of our Tribal community. We are seeing the impacts all around us. We need to bring back cultural burning and other traditional practices because the fires in California are getting worse, and we are losing the land, plants, and animals that have always been part of our way of life. Our waterways have changed too. You can't just go to a stream and drink the water like our ancestors once could. Native fish are disappearing, and there are places where we can no longer fish or gather the way we once did. When we lose access to clean water, traditional foods, plants, fish, and animals, we are losing more than natural resources. These are things that are sacred to us and are part of who we are as Muwekma Ohlone people."***

—Bernadette Quiroz, Muwekma Ohlone Tribe of San Francisco Bay Area. See Case Study VI: "Cultural Burning and Indigenous Collaboration at 'Ootchimin 'Ooyakma" in **Appendix A** *for more.*

Key points for future precipitation in the SF Bay Area:

- A modest increase in total precipitation by mid-century and end-of-century is projected.
- Increased atmospheric river contributions to SF Bay Area precipitation (from 30% to 50%).
- The months in which precipitation mostly occurs historically (December–March) remain the same in future climates. However, those months could have a faster accumulation of precipitation (implying more intense precipitation per event, more clustered events, or both), which could stress historical assumptions in water management and flood planning.

Box 3: *Uncertainty and Limitations in Precipitation Projections*

- California has some of the highest year-to-year variability in precipitation in the country. This is also termed interannual climate variability in climate science. Arguably, interannual climate variability is not well sampled within the Fifth Assessment projections, which would require longer climate simulations (1000s rather than 100s of years of simulations) and/or more ensemble members.
- The rate at which precipitation changes with warming (or precipitation scaling) is an ongoing area of research, particularly in how precipitation scales across multiple days of a storm event versus at daily-to-subdaily timescales. Evidence shows that the precipitation scaling could occur at higher rates (>7% per 1.8°F [1°C] of warming) at subdaily timescales, which could have implications for engineering assumptions in how reservoirs are operated (e.g., flood pool space and rule curves) and design standards of flood mitigation infrastructure (e.g., culverts and drains).
- The Fifth Assessment projections may underrepresent precipitation scaling at shorter timescales, particularly during moderate-to-extreme storm events.

Sources: (Huang, Stevenson, et al., 2020; Huang, Swain, et al., 2020; Mak et al., 2023; Patricola et al., 2022; Rhoades et al., 2024)

2.4.1 Storms and Flooding

At the local scale, the Bay's 400-mile shoreline is subject to erosion, flooding, and storm damage. These risks are made worse by sea level rise, coastal development, the phasing of storms with high tides, strong winds, and long period waves (swell).

Cool season storms interact with the varied terrain of the Bay Area to enhance or suppress precipitation totals. Precipitation is enhanced on the windward side of topography, such as the western slopes of Mt. Tamalpais and Mt. Diablo, or in the coastal mountains of Sonoma County (e.g., Cazadero). Air flowing downward along the lee (away from the wind) slopes of the Coastal Ranges suppresses precipitation and yields the rain shadow effect, whereas locations in lower elevation valleys, such as San Jose,

Concord, or Napa, may observe 5–10 times less rainfall than the mountains to their west. When moderate-to-extreme atmospheric river conditions are present for long durations (12 hrs+), the aforementioned windward mountain-caused enhancement of rainfall can produce storm totals of 10–20 inches over 1–2 days, leading to widespread flooding, landslides, and erosion but also help terminate drought conditions. In addition, flash flooding and erosion may result from short duration (minutes-to-hour), high-intensity precipitation. These precipitation events typically occur as convection (thunderstorms) embedded within cool season (i.e., frontal) storms if atmospheric conditions align. These storms may or may not coincide with atmospheric rivers. Often, the passage of a cold front can be identified by a rapid but short-lived increase in precipitation rates. While the total precipitation from convective precipitation may not be as large as storm totals of long-duration events, the rapid rate of precipitation over a short duration can overwhelm drainage and conveyance systems leading to localized flooding, especially in urban areas. It can also have road impacts, cause localized flooding around streams and smaller floodplains, and contribute to erosion. Finally, warm season rainfall from summer thunderstorms is rare but not unheard of in the Bay Area. These storms are typically associated with moisture moving northward from eastern Pacific tropical storms between July–September and may or may not produce measurable rainfall. In the latter case, when cloud-to-ground lightning occurs, these so-called "dry thunderstorms" can produce widespread wildfire ignitions, which the region experienced in August 2020 (the LNU Complex Fire).

2.4.2 Drought

Future increases in temperature, regardless of whether total precipitation increases or decreases, will produce longer duration and more severe droughts. They will also lead to an increased potential for rapid-onset "flash" droughts that occur over weeks rather than years. This will yield problems for agricultural production, fire hazard, and ecosystems, as well as water supply reliability and water quality in the Bay Area. The Bay Area is also affected by prolonged drought in regions it depends on for its water, food, and energy production—most notably the Sierra Nevada and Central Valley, but also the Colorado River Basin (e.g., Colorado River Compact allocations to Southern California water authorities and districts).

The link between rising temperatures and more severe droughts can be explained by the Clausius-Clapeyron relationship (*Glossary of Meteorology, n.d.*), which describes the non-linear relationship that allows warmer air to hold increasingly larger amounts of water vapor. An increase in temperature by 1.8°F (1°C) results in a ~7% increase in the amount of water vapor that can exist in the atmosphere. This means that as the air warms, it is increasingly capable of extracting more water through transpiration (plants) and evaporation (soil and open water). With a projected increase in dry days (Polade et al., 2017), this implies more opportunities to evapotranspire more water, leading to faster onset, more frequent, and more severe droughts.

By the end of the century, inland counties like eastern Alameda and Contra Costa could see a marked increase in extreme multi-year drought, owing in large part to the higher evaporative demand of the atmosphere (**Figure 12**). All types of vegetation throughout the Bay Area, from wildland to agriculture to ornamental plants (e.g., urban landscaping) will be exposed to hotter, drier conditions in a warmer world, leading to increased plant stress. This will likely increase urban and agricultural water demand and may necessitate changes in crop types. Additionally, in

the areas adjacent to wildlands (wildland—urban interface; WUI), intermixed with wildlands (the wildland urban intermix), and even urban areas far from the WUI, urban landscaping, fences, and building materials will be more receptive to ignition from wildfire—an issue recently exemplified in the January 2025 Los Angeles fires and in recent Bay Area urban conflagrations such as the 2017 Tubbs Fire and 2020 Glass Fire. Maintaining defensible space and well-watered ornamental vegetation are important steps to reduce the chance of a wildland fire igniting a structure.

A thirstier atmosphere suggests that even during wet years, drought recovery may be less effective. Drier soils absorb more rainfall and produce less runoff, meaning that rainfall following longer dry spells between rainfall events will be less efficient at refilling reservoirs and generating streamflow. Climate change is also expected to shift precipitation toward fewer but more intense storms. This means the Bay Area could have the same average annual rainfall but spread across fewer events with less efficient runoff, making it harder to meet human and ecosystem water demands.

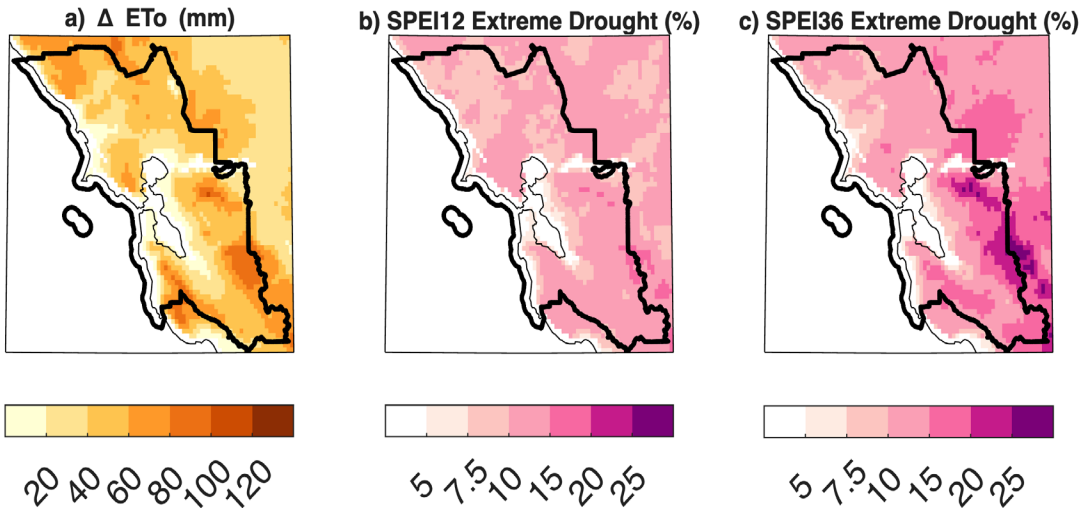


Figure 12: *LOCA-2-Hybrid SSP245 multi-model mean projections of the (a) change in annual evaporative demand (ETo), and the likelihood of extreme drought realized through (b) 12-month Standardized Precipitation-Evapotranspiration Index (SPEI) and (c) 36-month SPEI for mid-century under SSP245. Figure by John Abatzoglou, UC Merced.*

2.5 Snowpack

The Bay Area relies on snowpack in the Sierra Nevada for nearly two thirds of the region's water supply. Sonoma and Napa counties are the two exceptions in the region, relying instead on the rain-dominated Russian River and Napa River watersheds, respectively. Snowmelt-originating freshwater is routed from the Sierra Nevada to the Bay Area through both natural and man-made conveyance and storage mechanisms enabled by the State Water Project, the Hetch Hetchy System, and others.

Today, some municipalities rely nearly 100% on snow-derived water resources while others have a larger portfolio of supply (e.g., groundwater and direct potable reuse). In a warmer world, the natural storage mechanism for water in the Sierra Nevada, snowpack, is expected to peak at lower volumes, earlier in the year, and contribute meltwater less efficiently to streams and rivers.

These shifts from a snow-dominated to a more rain-dominated wet season undermine key assumptions in how the engineered water supply system has operated historically. There are additional implications for hydropower production reliability (important for baseloads, particularly in a more renewables-dominated portfolio) and agricultural productivity (e.g., water gaps) (Siirila-Woodburn et al., 2021). Therefore, projected changes in snowpack in the Sierra Nevada and corresponding shifts in runoff have implications for the region's water supply (see Chapter 5. Built Systems).

Snow water equivalent (SWE) measures the melt water content of a given snow depth. The snow-to-liquid ratio can range from approximately 6 inches of snow for 1 inch of melt water (wet snow) to 15 inches of snow for 1 inch of melt water (dry snow). Projections developed for a report for the Pacific Crest Trail Association show the projected decline in snowpack along the Pacific Crest Trail, which traverses the headwaters of major watersheds that supply water to the Bay Area, over the 21st century (**Figure 13**) (O'Brien & Marston, 2022). An assessment by Shulgina et al. (2023) indicates winter storms in the northern and central Sierra Nevada will undergo an approximately 1,600-foot increase in the snowline and an increase in precipitation from atmospheric rivers, which tend to have higher snowlines, at the expense of a decrease from non-atmospheric river events. The net effect will be similar precipitation totals but with 60% less snowfall (Shulgina et al., 2023), implying both less snowpack and more winter runoff.

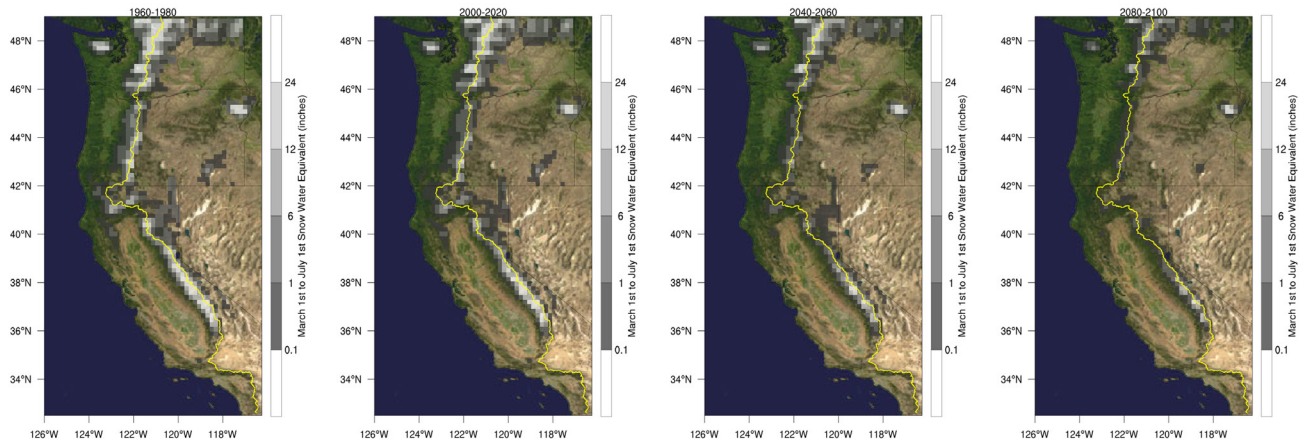


Figure 13: *Spring and early summer season (1 March–1 July) snow water equivalent along the Pacific Coast Trail. Estimates are derived from a ~20km (~12.5mi) grid spacing Earth system model (MRI-AGCM3-2) simulation under the SSP585 scenario. The yellow line represents the Pacific Crest Trail. Projections developed using details in Rhoades et al, 2022.*

The projections developed for the Pacific Coast Trail Association and Shulgina et al. (2023) are consistent with projections of SWE over the century developed for the Sierra Nevada Regional Report for the Fifth Assessment. These projections show that SWE will decline substantially, both in percent (**Figure 14**) and absolute (**Figure 15**) terms, across the Sierra Nevada over the century (Khan et al., 2026). The region includes Hetch Hetchy (water supply for San Francisco), the Mokelumne Watershed (water supply for the East Bay), and the State Water Project/Oroville (water supply for Contra Costa County and San Jose).

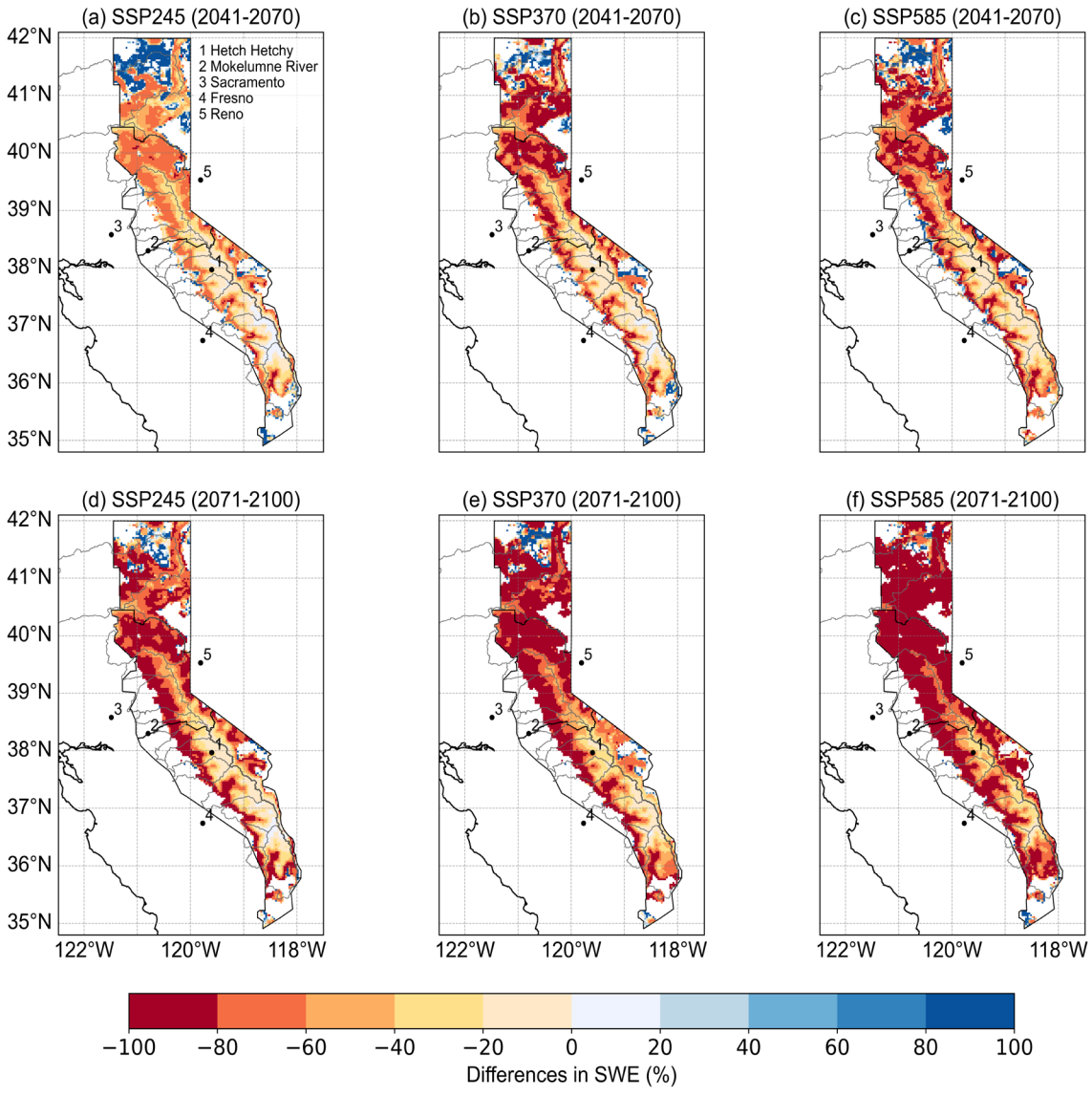


Figure 14: *Projected percent change in snow-water equivalent (SWE) for 2041–2070 (panels a, b, c) and 2071–2100 (panels d, e, f), under SSP245 (a, d), SSP370 (b, e) and SSP585 (c, f). The maps show SWE will decline in nearly all parts of the Sierra Nevada region. Source: Khan et al., 2026.*

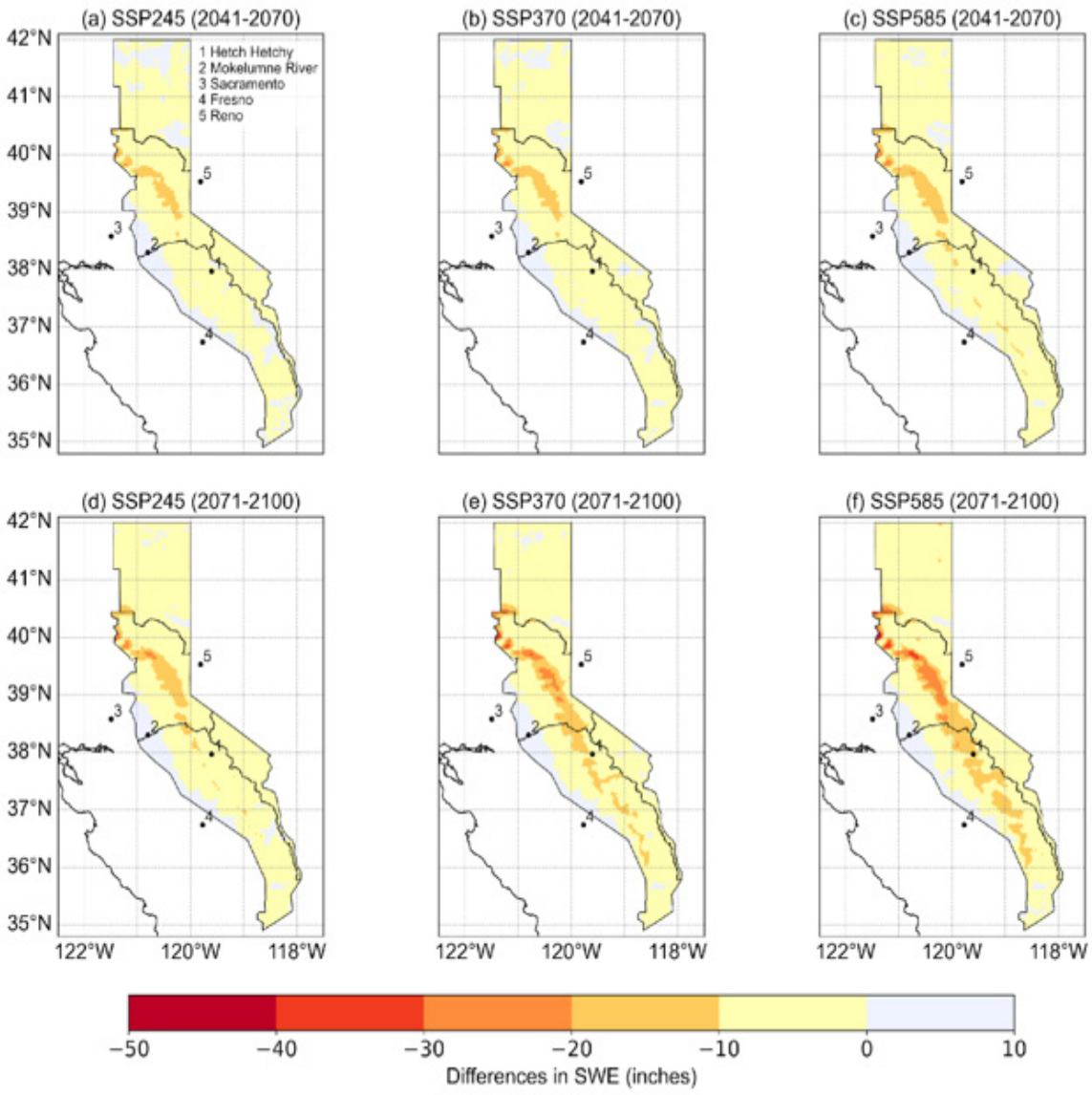


Figure 15: *Absolute Change in SWE in the Sierra Nevada region in 2041–2070 (panels a, b, c) and 2071–2100 (panels d, e, f), under SSP245 (a, d), SSP370 (b, e) and SSP585 (c, f). The maps show SWE will decline in nearly all parts of the Sierra Nevada region. Source: Khan et al., 2026.*

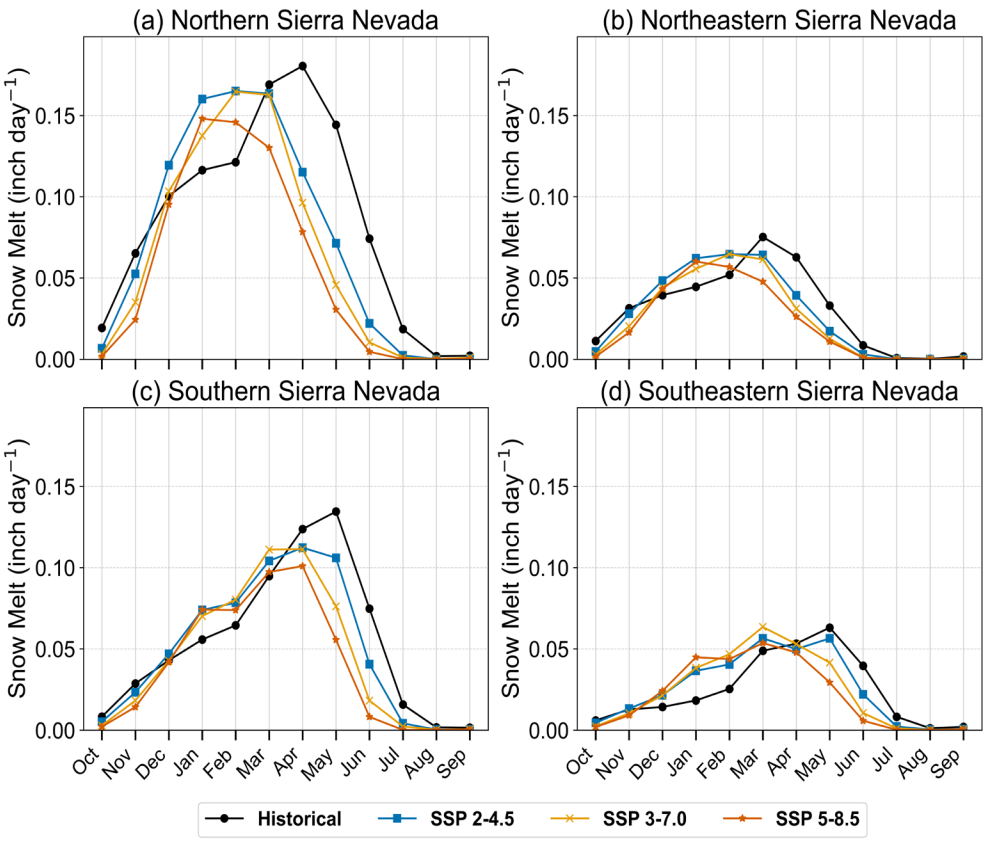


Figure 16: *Projections of runoff rate (mm/year) and timing (month) for four Sierra Nevada subregions. Snowmelt is an important source of water for the Bay Area. Source: Khan et al., 2026.*

Projections developed for the "Sierra Nevada Regional Report" also show that peak runoff will come earlier in the year for all parts of the Sierra (**Figure 16**). The combined effects of lower amounts of and less efficient snowmelt, combined with an earlier timing of when melt begins to occur, means that to ensure reliable water supply and maintain water quality, management will need to focus on capturing, storing, and conveying water more effectively, especially during back-to-back years of snow drought. Exploration of management approaches is necessary across scales, with a recommended focus on both identifying opportunities as well as potential unintended consequences.

2.6 Fog

Coastal fog is a distinct feature of the Bay Area's local climate and contributes to the region's weather and climate variability and microclimates. Fog plays an important role in maintaining the relatively cool coastal climate in the lower elevations of the Bay Area, especially in the summer months. Observations of low cloud cover in July and August at two Bay Area airports, San Francisco International (KSFO) and Oakland International (KOAK), since 1950 are relatively consistent, showing seasonal variability (**Figure 17**). A map of the Bay Area shows average summer low cloud cover over the region for the 1996–2014 period, illustrating the higher level of cloud cover on the coast and through the mouth of the bay (**Figure 18**).

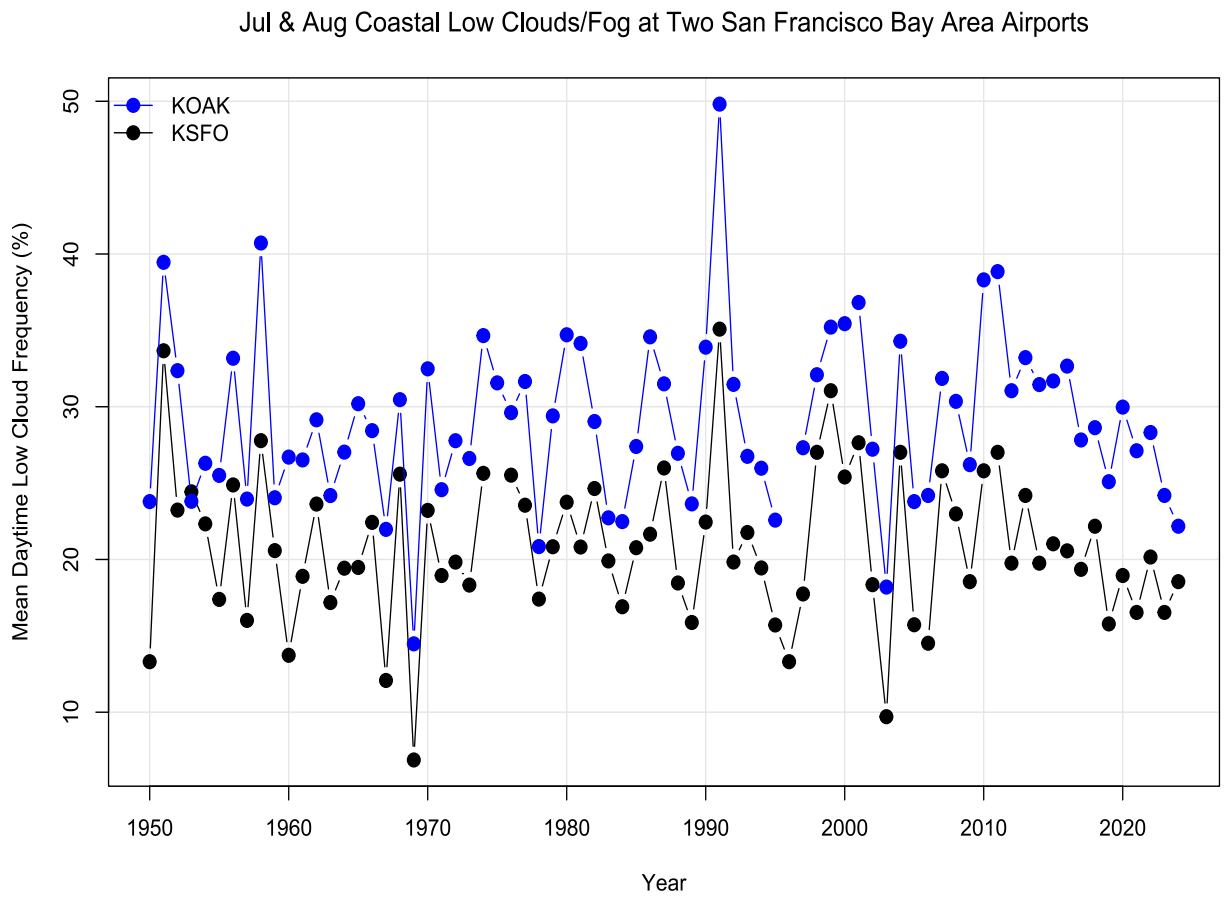


Figure 17: *Observed daytime (7, 10, 13, 16 PST) average July and August low cloud frequency at San Francisco International Airport (black) and Oakland International Airport (blue) 1950–2024. Low clouds are those with cloud bases less than 1000m above sea level. Cloud cover and height data at airports taken from Schwartz et al., 2014. Figure created by Rachel Clemesha, UC San Diego.*

How climate change will affect fog in the Bay Area remains an important area of research. While **Figure 17** shows a slight downward trend in low cloud cover at the two Bay Area airports, it is not outside the variability observed since 1950. The potential causes of this recent decline and implications of climate change are complicated because coastal fog formation is the result of a delicate balance between wind, heat, and humidity from three different sources: the ocean, atmosphere, and land (Oritz, 2025).

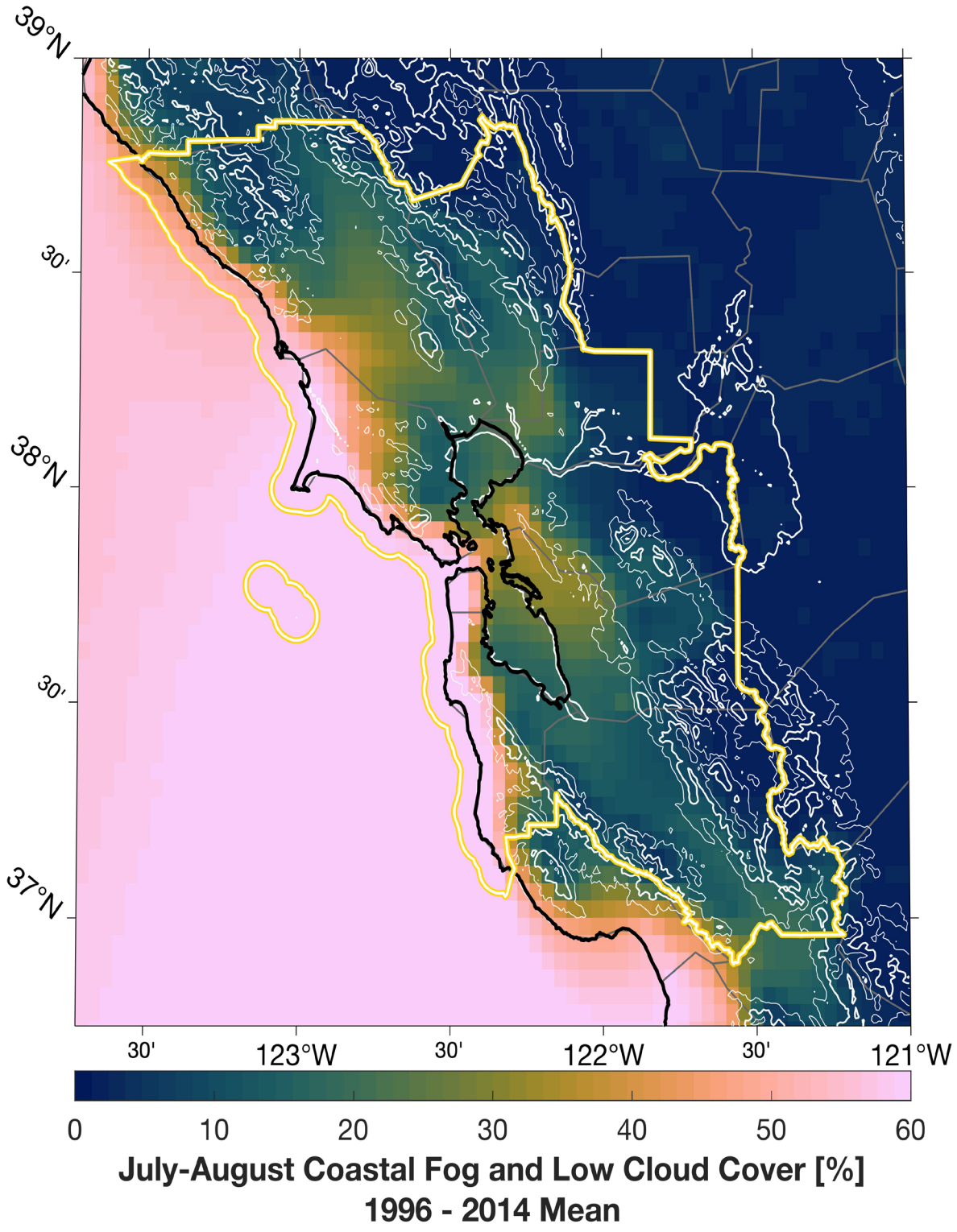


Figure 18: *Average July and August low cloud cover (colored shading) over the San Francisco Bay Area (yellow contour) and nearby coastal ocean. Topography is shown as white contours. The data is derived from the GOES-WEST satellite, as described by Clemesha et al. (2016) for 1996–2024. Figure by Rachel Clemesha, UC San Diego.*

The impacts of future climate change on coastal fog are not well understood. This is in large part because fog formation results from a complex mix of many factors, including ocean and atmosphere circulations and associated temperature structures (e.g., ocean upwelling, coastal winds, and the vertical profile of atmospheric temperature), aerosols (resulting from pollution and natural sources), and even the built environment. Research on the climate change impacts to fog formation continues to be a needed area of study, one that will help inform future planning for Bay Area climate conditions (Ackerly et al., 2018)

While projections for future fog conditions are uncertain, a decrease in coastal fog could increase energy demand for cooling, water demand for urban irrigation, and have impacts on agriculture, and increase wildfire hazard. Loss of fog will also have implications for iconic Bay Area species, including the coastal redwood (Johnstone & Dawson, 2010).

Weather Whiplash and Climate Anxiety

"It's either going to be drought and dry conditions, then as soon as the wind picks up, fires start, or it's going to be floods and storms. It seems like nowhere on the planet feels safe anymore."

—A Contra Costa County educator, who considers herself lucky to have the resources to relocate, has contemplated a wide range of destinations but has recently begun to feel like there is nowhere that is truly "safe".

2.7 Wildfire

Future wildfire activity in the Bay Area will be driven by changes in urban development and climate change. The Bay Area is composed of many fire-dependent ecosystems and experiences prolonged seasonal drought during the hot and dry summer and fall seasons. This creates an environment where an ignition can quickly grow into a problematic wildfire, especially if any wind is present. Today, wildfire is already an oft-present hazard for many months each year, and warming temperatures and continued fuel accumulation, combined with expansion of the wildland-urban interface, will increase wildfire risk in most of the Bay Area, (where risk is defined as both the probability and consequences of a wildfire occurring. Fire-informed land use planning, together with implementation of fire-safe building standards on new construction, hardening of existing structures, creation and maintenance of defensible space, and upscaling vegetation management through prescribed burning and other fuels reduction techniques can all reduce future fire hazard. When fire weather (typically hot, dry, and windy conditions) occurs with dry fuels, multiple protective measures such as burn bans, public safety power shutoffs, and public messaging via Red Flag Warnings can reduce the potential for ignitions. When fires do ignite, early detection from satellite and camera networks that leverage artificial intelligence technology to improve accuracy and timeliness enable rapid mobilization of fire suppression resources.

The Bay Area's landscapes and climate support many fire-dependent ecosystems, including coastal prairie, chaparral, redwood, tule marshes, and oak savannahs, among others. These landscapes depend on fire. For thousands of years, Indigenous Peoples used cultural burning to renew plant communities, enhance wildlife habitat, and reduce fuel loads, with naturally lighting fires reinforcing these cycles. Prior to European settlement, these landscapes experienced fire approximately every 2 to 50 years (LANDFIRE, 2016). Following European colonization, these carefully managed fire regimes were dramatically disturbed by various fire suppression policies,

such as The Act for the Government and Protection of Indians (Chapter 133, Cal. Stats., April 22, 1850), which criminalized Indigenous stewardship practices and accelerated the displacement of Tribal Peoples (see the Fifth Assessment's "Tribal and Indigenous Communities Statewide Topical Report"). As a result of fire suppression and fire exclusion, much of the Bay Area has not experienced wildland fire for over a century (**Figure 19**). While suppression has limited wildfire activity in the short term, it has also allowed fuels to accumulate over time. Given the annual recurrence of dry fuels and occasional juxtaposition with hot, dry, and windy weather in summer and fall, the relative lack of wildfire activity suggests fire suppression efforts have been extremely successful at achieving their goal. Conversely, the lack of wildfire also indicates ongoing fuel accumulation, which is increasing the potential for extreme fire behavior that is difficult or impossible to suppress and leads to widespread damage. This is called the "wildfire paradox" (Calkin et al., 2014), wherein most (~98%) of wildfires are suppressed under less extreme conditions leading to inevitable large, high-intensity, and high-severity fires that occur under extreme conditions. This extreme wildfire potential is starting to be realized (e.g., 2017, 2019, and 2020) with multiple large and damaging wildfires and several urban conflagrations causing widespread structure loss. Many regions of the SF Bay Area remain exposed to extreme wildfire hazard (e.g., the East Bay Hills, southern Marin County, communities along the periphery of the Santa Clara Valley, and the San Mateo hills).

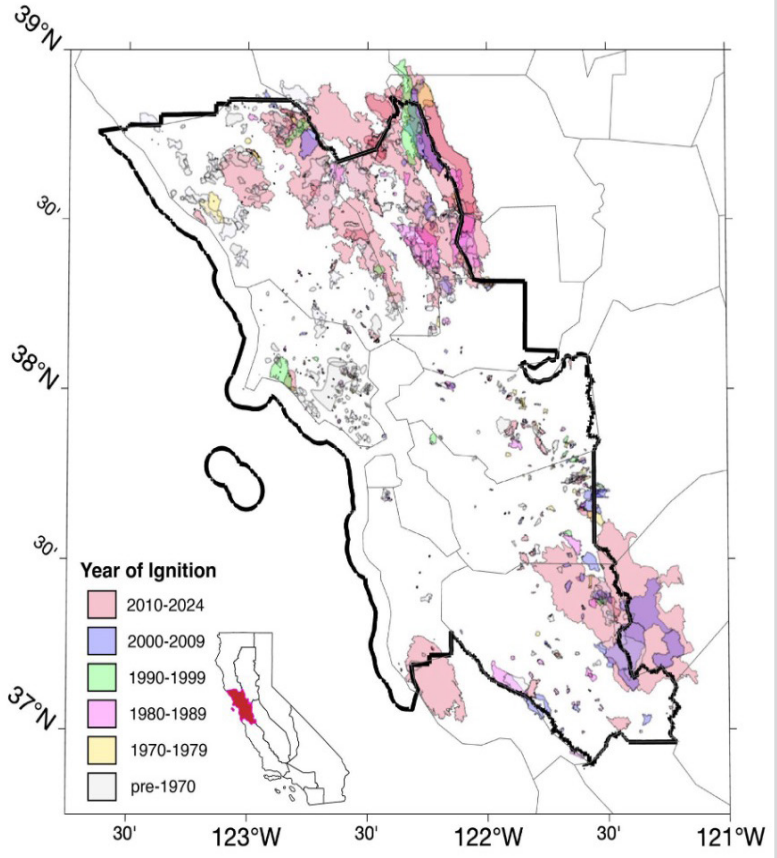


Figure 19: *Map showing SF Bay Area decadal fire history using fire perimeter data from CAL FIRE FRAP (2025).*

Given projections for a warmer, drier, and increasingly variable hydroclimate, wildfire resilience is becoming an increasingly important consideration for the Bay Area. Efforts to improve resilience may include reducing ignitions, mitigating hazardous fuels, and harden homes and infrastructure, while also embracing the use of beneficial fire to augment fuels reduction projects and to restore natural fire regimes to fire-dependent ecosystems. Partnerships with regional Tribal Nations to practice cultural burning and other Indigenous land management can enhance fuels-reduction projects, improve ecosystem health, and strengthen long-term landscape resilience. Examples of such partnerships throughout the Bay Area include efforts involving and co-led by the Tamien Nation, Wappo, Coast Miwok, and Southern Pomo. These stewardship efforts not only protect

life and property but also improve ecological outcomes by decreasing the future likelihood of widespread high-severity fire and helping to re-establish native species. A myriad of opportunities exist across the Bay Area to implement multi-benefit treatments, from strategic fuel breaks at landscape scales (e.g., parks) to neighborhood scales (e.g., open space, greenways, utility rights-of-way) to the parcel-level and even the patch level (10s of square feet). Achieving this vision requires strong community engagement and involvement at every stage–planning, implementation, monitoring, and retreatment–along with cross-agency and broad public partnerships needing to be built, maintained, and improved.

Box 4: *Case Study I: Tamien Nation: Land Back, Cultural Stewardship, and Climate Resilience in the South Bay*

The Tamien Nation is redefining regional climate action through a historic return to ancestral land ownership in the South Bay. In 2025, the Nation secured 235 acres in East San José—the first land returned to full Tribal control in the South Bay in over 200 years. By grounding modern workforce development in Traditional Ecological Knowledge (TEK), such as their Indigenous wildland firefighting crew, the Nation is restoring wildlife corridors and revitalizing fire-adapted ecosystems. This model demonstrates how sovereign land stewardship by non-federally recognized Tribes creates scalable, equitable climate solutions for the entire San Francisco Bay Area. See the full case study in **Appendix A**.

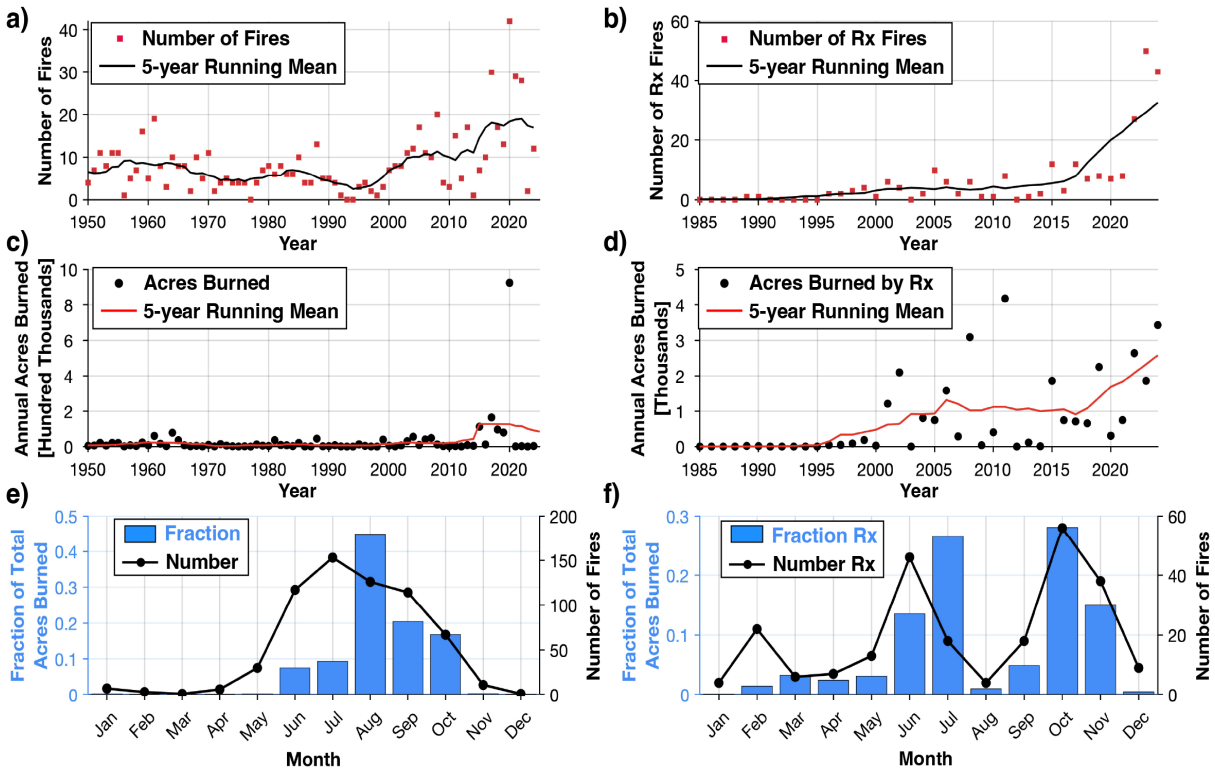


Figure 20: *a) Annual number of wildfires (red squares) between 1950–2024; the black line is a 5-year running mean. b) As in a) but for prescribed fires spanning 1985–2024. c) Annual wildfire acres burned (black circles) between 1950–2024; the red line is a 5-year running mean. d) As in c) but for prescribed fires spanning 1985–2024. e) Monthly fraction of total acres burned by wildfire (bars; left y-axis) and monthly number of wildfires (black dots and black line; right y-axis; calculated from 1950–2024). f) As in e) but for prescribed fires (calculated from 1985–2024).*

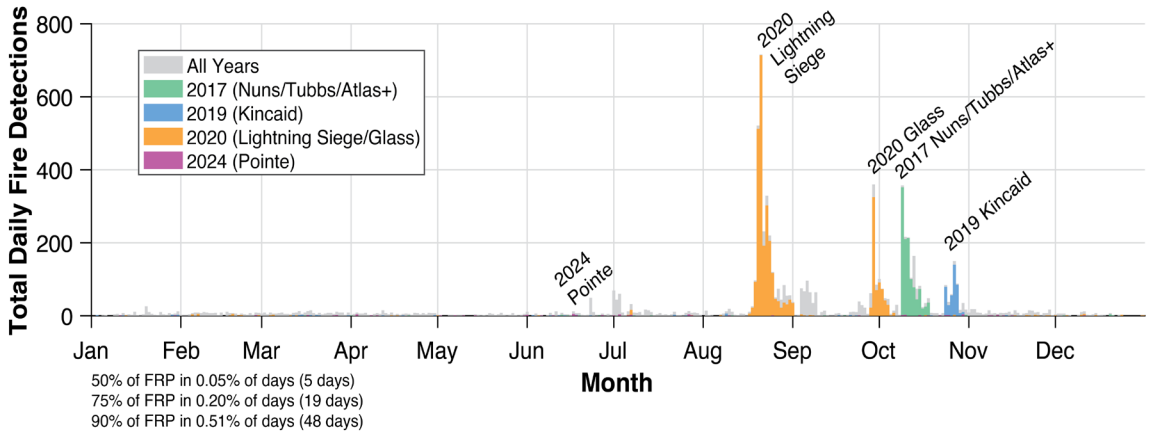


Figure 21: *A pyroclimograph (Hatchett, 2026) shows satellite-based fire history of daily fire detections (left y-axis) and daily cumulative fire radiative power summed over all years (right y-axis) for the SF Bay Area region. Notable recent fire years (and fires themselves) mentioned in the text are colored in, and the number of days contributing various percentages of fire radiative power (a metric of fire intensity) are shown along the bottom for reference.*

2.7.1 Bay Area Fire Activity

Following decades of relatively low wildfire activity between 1950–2000, the Bay Area has experienced increased fires over the past 25 years, with 2017 and 2020–2022 demonstrating notable increases before counts declined in 2023–2024 (**Figure 20a**). The large, burned areas in Sonoma and Napa counties as well as San Mateo and Alameda (**Figure 19**) reflect recent fire outbreaks such as in 2017, 2019, and 2020. Satellite records of fire detections for the past 25 years (2001–2025), called pyroclimographs (Hatchett, 2026) showcase these periods of active fire and the general late summer-mid-fall peak in seasonality of Bay Area wildland fires (**Figure 21**).

Although the Bay Area fire environment is frequently conducive to wildland fire ignition (i.e., warm-to-hot temperatures and low relative humidity) and spread due to its persistent winds, the most impactful fires have occurred on a small number of days. This highlights the aforementioned wildfire paradox: suppression efforts have been largely successful, but rare catastrophic fires are inevitable. The observation that 50% of the total fire radiative power (an imperfect but often-used proxy for fire intensity) comes from 5 days of the 9,131 days in the satellite record supports the idea that very intense fire days are rare. In terms of immediate catastrophic loss of life and property, the often wind-driven nature of Bay Area wildland fires allows rapid transitions from wildland fuels into urban fuels (structure fires). This transition can lead to urban conflagrations when multiple structure fires become involved and extreme fire behavior presents imminent threats to firefighter and public safety. Two recent examples of such conflagrations include the Tubbs Fire in 2017 and the Glass Fire in 2020. Prior to these, the 1991 Oakland Hills Fire was the most famous Bay Area urban conflagration. All three fires occurred during downslope, offshore Diablo Wind events.

In the Bay Area, wildland fires can occur throughout much of the year (**Figure 20**), though the most problematic wildfires begin to occur in mid-to-late summer (July–August) and can persist into the late fall (November). June may also bring dangerous fire conditions, as seen during the 2024 Point Fire in northern Sonoma County. Despite strong winds and rapid fire spread, losses were limited to three residences and seven outbuildings. This success stems from a sequence of activities starting with a

2018 CAL FIRE grant-funded vegetation management project. This project created roadside clearance via shaded fuel breaks and a proactive community that created defensible space and—with the help of various agency and community partners— implemented four 10- to 15-acre prescribed burns in 2020 via Sonoma County funding for prescribed fire. During the Point Fire, suppression efforts utilized pre-existing suppression infrastructure (dozer lines) from the 2020 Walbridge Fire to establish containment and eventual control of the fire.

CAL FIRE records indicate the number of Bay Area wildfires generally declined from 1950 to a minimum in the mid-1990s, then began to rise, peaking between 2016–2021 (**Figure 19a**). Prescribed fire frequency has rapidly increased since 2022 (**Figure 20b**). Despite increases in acres burned in the 1960s, 1980s, and 2000s, annual wildfire area typically stayed below 100,000 acres burned annually until the mid-2010s (**Figure 20c**). That changed in 2015 and again between 2017–2020, when several large high-impact wildfires increased burned acreage (**Figure 19c**). In 2020 alone, more than 900,000 acres burned after two years of drought left fuels extremely dry and susceptible to ignition. Fires started from both natural and human causes in remote locations often with excessive fuel loading and drought stress. The August 2020 "Fire Siege"—which included large fires such as the CZU Complex in San Mateo County, the SCU Complex in Alameda County, and LNU Complex in Napa and Sonoma counties plus many others along the west coast—was driven largely by widespread dry lightning strikes following hot and dry conditions and combined with limited firefighting resources due to a busy fire season nationwide.

From 2021–2024, less than 3,100 acres burned annually in the SF Bay Area. Consistent with increasing prescribed fire frequency over the past 20 years, acreage burned during prescribed fires increased steadily from the early 2000s with a more rapid increase in the past five years (**Figure 19b**). Since 2021, more area in the Bay Area has burned via prescribed fire than wildfire.

2.7.2 Bay Area Wildfire Seasonality

Both wildfire (**Figure 20e**) and prescribed fire (**Figure 20f**) display strong seasonality in the Bay Area. During the extended cool season, which starts with the onset of fall precipitation (typically by November) and lasting through mid-late spring (May), wildfire activity is minimal in terms of frequency and the fraction of total acres burned due to lower temperatures, higher moisture, and shorter days. As conditions dry and warm with longer days, fire season begins in June and July, with "peak" wildfire season occurring in August–October.

The large area burned during fires associated with the 2020 Fire Siege, which accounts for more than 40% of burned acreage in the record, strongly influences seasonal statistics. Still, it indicates the potential for widespread wildfire in the Bay Area under the right circumstances. It should be emphasized that a hot and dry summer is sufficient to produce receptive fuelscapes (a representation of the characteristics of live and dead fuel [vegetation] across a landscape in terms of fuel loading, sizes, arrangement, continuity, and moisture). Even after wet winters, wildfire risk can remain high. The 2017 Wine Country Fires and the 2019 Kincaid Fire both followed wetter-than-average winters, which encouraged growth of invasive annual grasses. These fine fuels spread fire quickly across the landscape and ignite heavier fuels that will propagate fire spread through ember generation and heat transfer. Drought conditions also matter: the extended 2012–2016 drought and associated

disturbances of pests and disease likely increased the dead and downed fuels, contributing to severe fires in 2017, 2019, and 2020.

Looking ahead, continued warming, more variable precipitation with longer dry spells between precipitation events, and increased fuel buildup will make these risks even greater. This further highlights the importance of fuels treatments that involve mechanical thinning followed by prescribed burning in strategic locations, but also home and structure hardening efforts in the wildland–urban interface and intermix areas. Improved emergency response communications and preparations will be critical to making evacuations more efficient; these improvements will require partnerships between communities and emergency managers to share information and build trust. Similarly, continued improvement of early warning systems and observations of wildfire smoke-related air quality will be paramount to reduce the negative effects on human health and the economy given expectations for continued, and likely expanding, wildfire activity across western North America.

2.7.3 Bay Area Prescribed Fire Seasonality

Prescribed fires also follow seasonal patterns. Most burns occur in early summer (June and July) and fall (October–November), though they occur throughout the year (**Figure 20f**) and likely account for much of the cool season fire history as detected by satellite (**Figure 21**). The two peak seasons, fall and early summer, are when over two-thirds of the acreage is burned. The multiple peaks in seasonality and year-round implementation highlights the myriad goals and objectives of prescribed fires. Because they are a necessary component of integrated land management, prescribed fires can be used primarily for fuels reduction efforts where maximum consumption is desired. Prescribed fires intending to reduce invasive species or for other ecocultural benefits occur at particular times of year to target species of interest. Grassland burns can serve purposes for both wildfire hazard reduction, by reducing fuel continuity across large areas, and ecological benefits. These burns must occur after grasses have cured, typically by early summer but before heavier fuels become receptive. Similarly, burning in woodlands requires fuel moistures to be sufficiently low to achieve objectives. In fall, once sufficient rainfall and recovery of fuel moistures lowers wildfire hazard, prescribed fire activity increases until winter conditions make fuels too wet. Pile burns and agricultural burning (both not included in the CAL FIRE records) are most common in the winter season. They produce sufficient heat for combustion under cold and rainy conditions but can't be done near receptive fuels due to more efficient ember production and radiant heat release, which can start spot fires or fire that creeps away from piles and becomes established in adjacent fuels. Mitigating potential smoke impacts on local and regional communities through improved emissions estimation, smoke forecasting, and communication will be a critical step to enhancing the potential to implement beneficial fire on the landscape.

2.8 Sea Level and Groundwater Rise

As sea levels rise and extreme storms become more intense, low-lying coastal communities and infrastructure face increasing flood risks. Nearshore areas are at risk of compound flooding— when the joint occurrence of heavy precipitation, elevated ocean and estuary water levels, and elevated groundwater levels exacerbate flood risks (C. May, 2020). Many communities are preparing for the threat of coastal floodwaters overtopping the shoreline with sea level rise (SLR), as well as the threat of increased stormwater and riverine flooding as extreme storms increase in frequency and intensity. Although coastal communities are increasingly aware that the shallow groundwater table is rising, most are not prepared for this slow but chronic threat.

The longest running tide gauge in North America, located near the Golden Gate Bridge (active since 1855), recorded about 8 inches (203.2 mm) of SLR between 1900–2000 (Ackerly et al., 2018). The San Francisco Bay Area faces SLR risk both along the SF Bay shoreline and the Pacific Coast, with several counties in the region needing to plan for both.

2.8.1 Sea Level Rise

The San Francisco Bay is arguably the keystone geographic feature of the region, with each of the region's 9 counties sharing a portion of Bay's Shoreline. Satellite data, collected over the last three decades, show that the rate of SLR, globally, has doubled over that period (Hamlington et al., 2024).

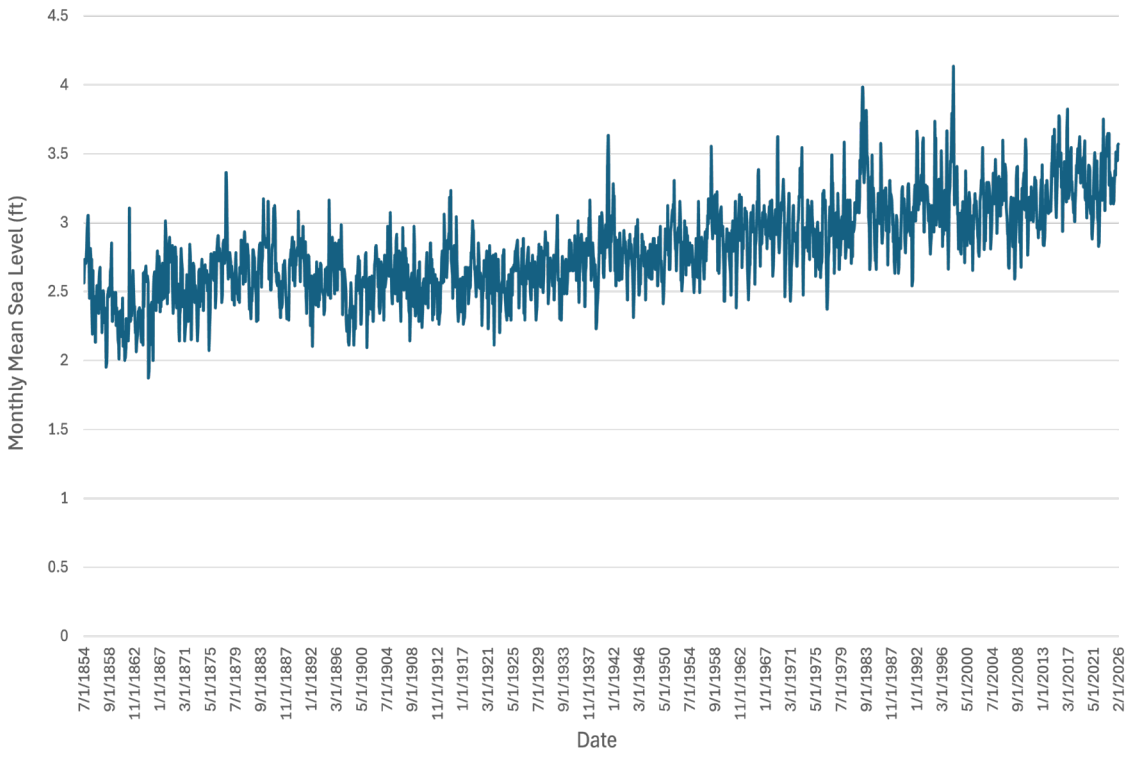


Figure 22: *Monthly average of hourly mean sea level rise measured at the San Francisco Tide Gauge located at the Golden Gate (July 1854 to February 2026).*

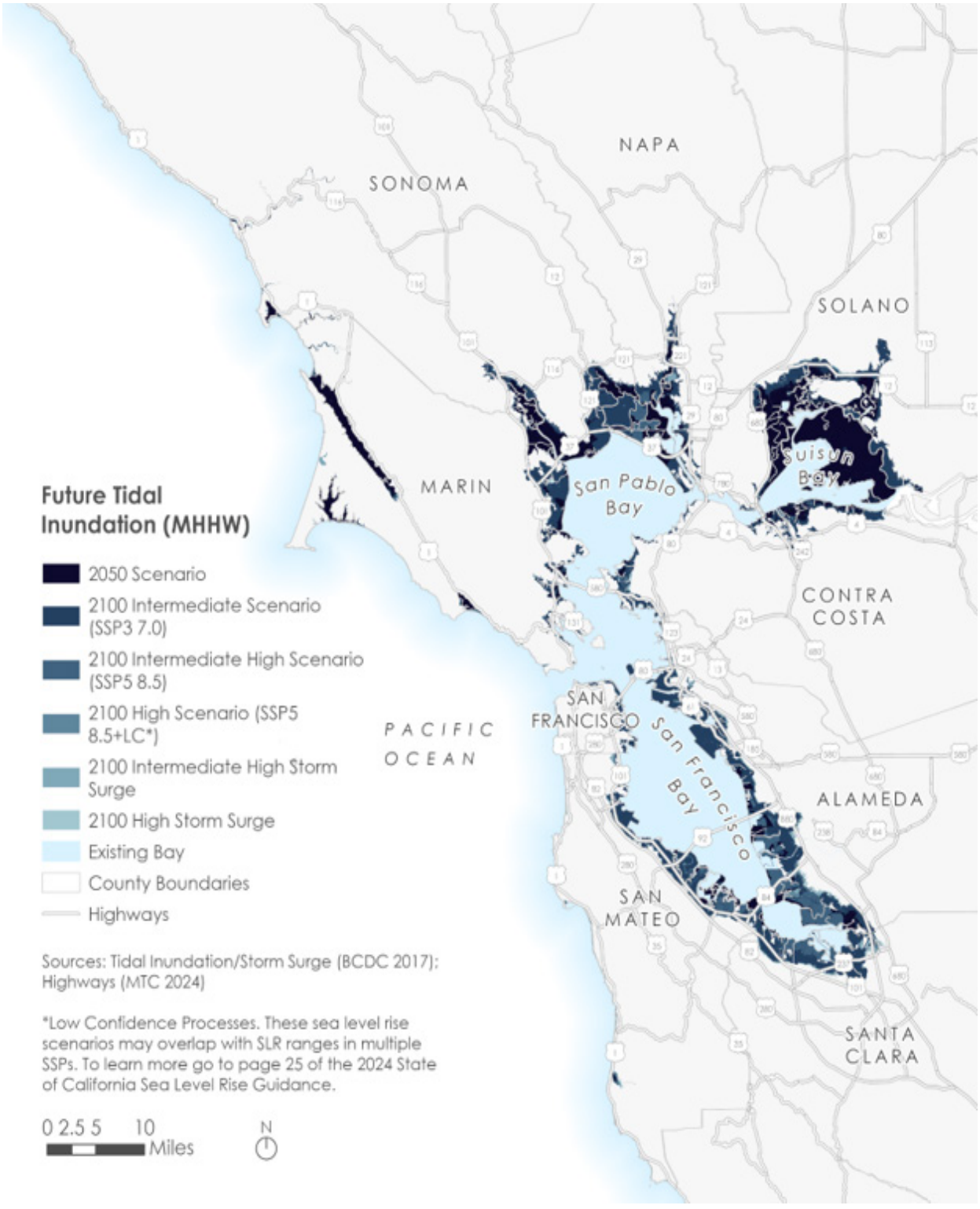


Figure 23: *Future tidal inundation in the Bay Area for 2050 and 2100 for intermediate (a plausible SSP370 scenario) and high emission scenario (a plausible SSP585 scenario). Shown with a historical storm surge that is based on the 100-year extreme tidal event.*

Satellite data also shows an increase in SLR rates off the California coast (Hamlington et al., 2016). Tidal gauges in the Bay Area show significant acceleration since 2011, suggesting some degree of increase in the rate of SLR in the Bay Area (**Figure 22**). This rate increase is likely subject to shift based on patterns of shorter and longer climate variability that drive circulation patterns in the region.

The State of California Sea Level Rise Guidance estimates that there will be about 10 inches (0.8 feet) of additional SLR by 2050 (California Sea Level Rise Science Task Force et al., 2024; Sweet et al., 2022), representing a doubling of the rate of SLR since last century. The Ocean Protection Council (OPC) (2024) presents five SLR projections that range from low to high. The low scenario estimates 1 foot (304.8 mm) of SLR by 2100, a projection that is only possible if we rapidly de-carbonize our society. The highest scenario estimates 6.6 feet (201 cm) of SLR by 2100. This scenario assumes ice sheet melting and marine ice disintegration would occur this century, although this remains a source of uncertainty.

For most purposes, OPC (2024) recommends considering an intermediate scenario of 3.1 feet (94 cm) and a high scenario of 6.6 feet (201 cm) of SLR by 2100. The San Francisco Bay Conservation and Development Commission (BCDC) completed a SLR and extreme tide analysis that shows the extent of inundation the counties could experience along their Bay shorelines (**Figure 23**). The 1%-annual-chance extreme tide in the region is estimated to be about 3.5 feet (107 cm) above mean higher high water (average height of highest daily tide), although regional variations along the shoreline will occur (Mak et al., 2016). The Bay's shoreline and low-lying areas are highly vulnerable to SLR, and the region will require significant adaptation effort with an estimated cost over $110 billion through 2050 (**Figure 23**) (MTC/ABAG & BCDC, 2023).

Similar analyses are available for California's Pacific coast, including the Pacific shorelines of San Mateo, Marin, and Sonoma counties. The United States Geological Survey's Our Coast Our Future portal provides analysis and mapping of sea level rise, coastal storm surge, and wave hazards (Barnard et al., 2019).

Subsidence, or downward vertical land motion, can increase the relative rate of SLR. For example, if the ground subsides by 0.08 inches/year (2 mm/year) and sea level rises by 0.13 inches/year (3.4 mm/year), the relative rate of local SLR would be 0.21 inches/year (5.4 mm/year). Land subsidence in the Bay Area could result in larger SLR impacts than current projections suggest in areas with high subsidence rates (Govorcin et al., 2025). However, past subsidence rates are not reasonable predictors of future subsidence rates. It is challenging to predict future rates of subsidence, and this is an important area for future research.

The Compounding Threats of Subsidence and Sea Level Rise

> ***"Sea level rise is always front and center (for the Canal Neighborhood in Marin County), because the canal is shaped like a bowl and built on bay fill and is sinking at the quickest rate in the entire Bay much of the land is high tide and it is being held back by a hodge podge of public and private solutions ranging from levees (none which are FEMA certified) to plywood pieces in between walkways."***

—Aaron Burnett, Canal Alliance (See full interview in **Appendix B**).

2.8.2 Groundwater Rise

Groundwater is defined as water that exists below the ground surface in the void spaces of soils and rocks. The shallow, unconfined groundwater table sits at the intersection of unsaturated soils above and saturated soils below. This groundwater table may be located at the ground surface (i.e., the ground is fully saturated) or many feet below the ground surface. The elevation of the groundwater table fluctuates seasonally in response to rainfall. During a rainfall event, a portion of the rainfall infiltrates and seeps into the ground, causing the groundwater table to rise, and a portion of the rainfall flows overland (i.e., rainfall runoff) into channels, tributaries, and stormwater conveyance systems. The greater the distance is between the ground surface and the groundwater tables (i.e., the depth to water), the greater the capacity of the underground soils to soak up rainfall like a sponge, reducing the timing and severity of rainfall-runoff.

As sea levels rise, the salty groundwater connected to the ocean and estuaries migrates inland, pushing the fresher inland groundwater upward (Befus et al., 2020a; Habel et al., 2017; Plane et al., 2019). As the shallow groundwater table rises, the distance between the groundwater table and the ground surface decreases, reducing the capacity of soil to absorb additional water. This can increase rainfall runoff and the risk of urban flooding during storm events (Nuttle & Portnoy, 1992). Groundwater rise can also contribute to inland flooding in low-lying coastal areas with impacts often occurring earlier, and farther inland, than sea level rise-driven coastal flooding from overtopping the shoreline (Befus et al., 2020a; Bosserelle, 2022; Rahimi et al., 2020).

Rising groundwater tables also impact the built environment. When the groundwater table elevation exceeds infrastructure design criteria, underground infrastructure and roadways will degrade faster (X. Chen & Wang, 2023; Habel et al., 2020; Knott et al., 2017), infiltration rates into sewer systems will increase (Habel et al., 2017; Su et al., 2020), and the risk of mobilizing contaminants will increase (Habel et al., 2024; Hill et al., 2023). If the groundwater table exceeds the ground surface, emergent groundwater will cause localized flooding and act as an urban flood hazard (Befus et al., 2020a; Plane et al., 2019). These flooding conditions become more favorable during high tide events and atmospheric river events.

2.8.3 Analysis and Mapping

The United States Geological Survey (USGS) modeled and mapped the response of the shallow groundwater table to SLR along the entire California coast (Befus et al., 2020). USGS evaluated existing conditions and five SLR scenarios to capture the range of the long-term equilibrium groundwater table elevation, or the groundwater table elevation in the absence of rainfall-driven fluctuations. In the San Francisco Bay Area, Pathways Climate Institute and the San Francisco Estuary Institute (SFEI) led a regional study that analyzed and mapped the highest annual groundwater table elevation (C. L. May et al., 2022). The highest annual groundwater table is commonly used in design, representing the elevation of the groundwater table during or after a winter season with above-average rainfall. The analysis was limited to the low-lying areas near the shoreline where the influence of Bay water levels is most pronounced.

Both studies depict similar existing depth to water conditions along the shoreline, with the depth to water in most of the nearshore areas within the moderate (6.6–16.5 feet or 2–5 m below the ground

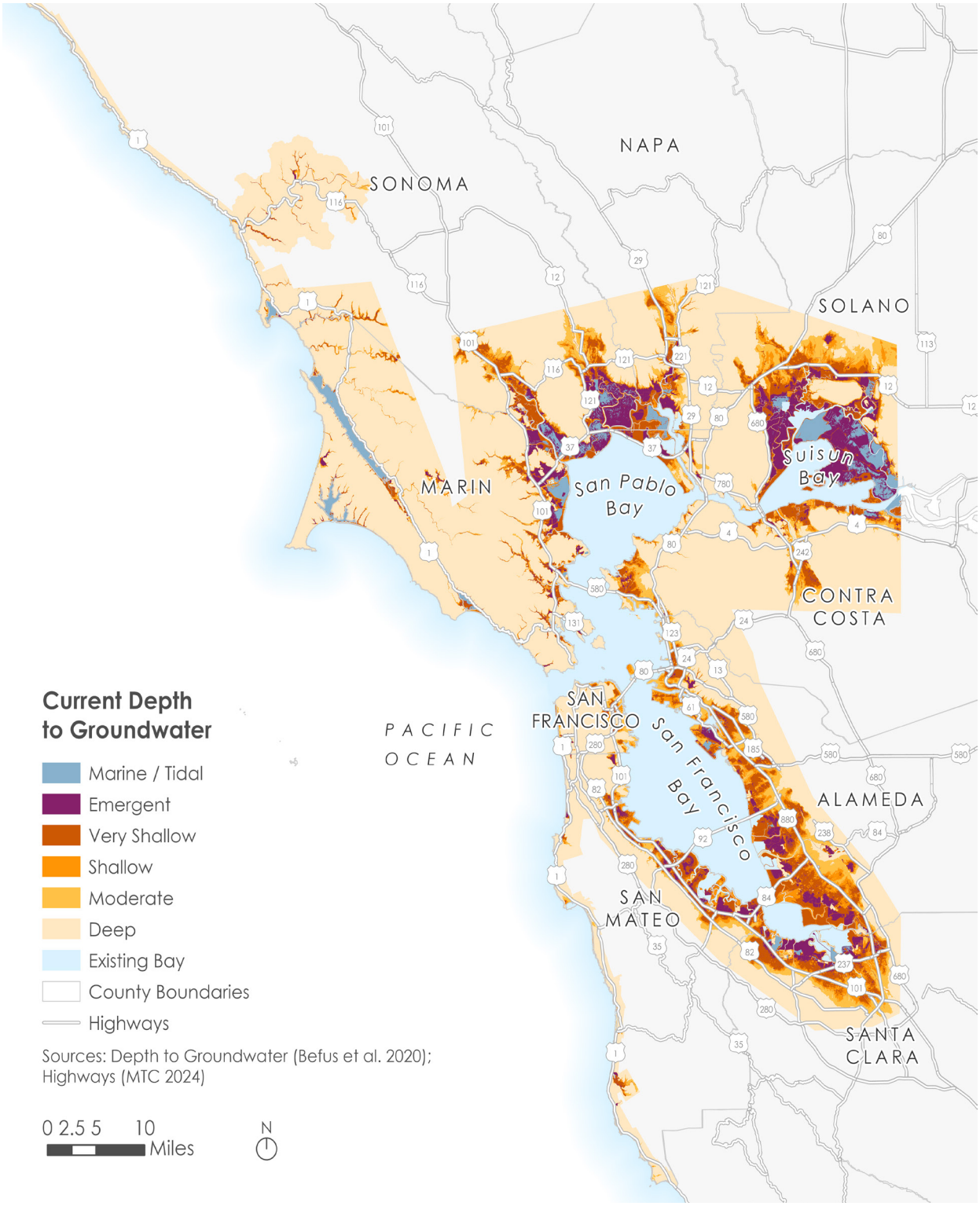


Figure 24: *Current Depth to Groundwater (Befus et al. 2020).*

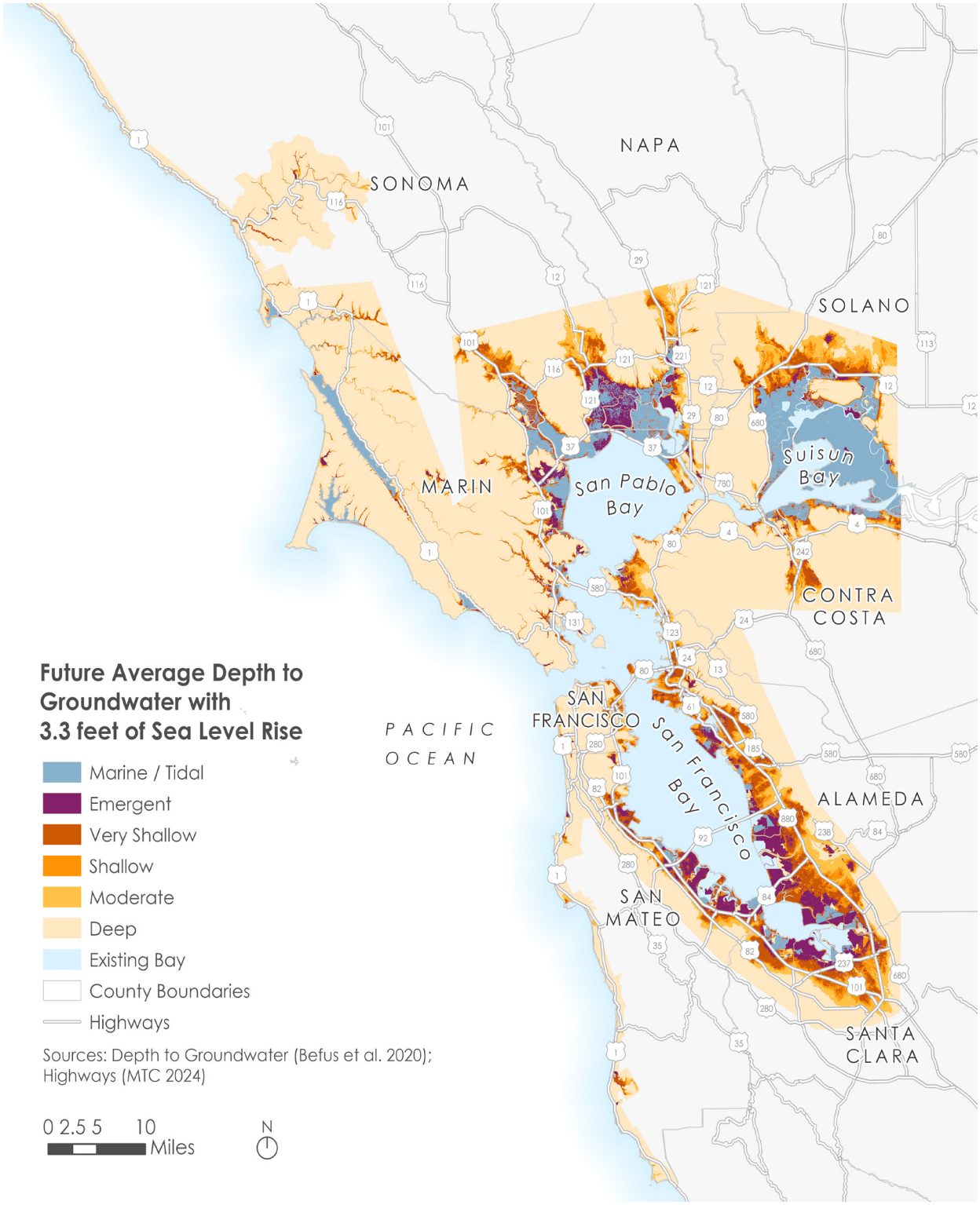


Figure 25: *Future Average Depth to Groundwater with 3.3 feet of Sea Level Rise (Befus et al. 2020).*

surface), shallow (3.3–6.6 feet or 1–2 m), and very shallow (0–3.3 feet or 0–1 m) zones (**Figure 24**; **Appendix C Figure A4**). **Figure 25** presents the projected future average depth to groundwater with about 3.3 feet (1 m) of SLR (see also **Appendix C Figure A5**), while SLR of 6.6 feet (2 m) leads to further expansion of marine/tidal areas (**Appendix C Figures A6; A7**). Existing below ground infrastructure in the moderate, shallow, and very shallow zones is likely to be impacted by a rising groundwater table.

Although both studies provide useful information for SLR adaptation and help raise awareness of the rising groundwater table, neither study can replace detailed local knowledge. Underground geology, hydrology, soil conditions, and groundwater flow are extremely complex and large-scale regional studies should be considered approximate in nature. Santa Clara Valley Water District applied their extensive knowledge of the local geology and groundwater basins in Santa Clara County in a local study that evaluated sea level rise-related groundwater rise (Gurdak, 2025). With low-lying, developed areas below SLR, a refined understanding of this risk was a priority for Valley Water.

TOOLS AND RESOURCES

Groundwater rise data are publicly available and downloadable in Geographic Information System (GIS) format. Additional resources such as StoryMaps, reports, case studies, and white papers are available, as noted below.

Data

- Projected responses of the coastal water table for California using present-day and future sea-level rise scenarios
- Our Coast Our Future, Hazard Map
- SFEI, Shallow Groundwater Response to Sea Level Rise
- SFEI, Shallow Groundwater Mapping
- The Shallow Groundwater Layer and Sea Level Rise: Description of Approaches
- SPUR, Groundwater rise impacts on East Palo Alto — A case study for equitable adaptation

StoryMaps

- Story Map: Shallow Groundwater and Sea-Level Rise
- Story Map: Aguas subterráneas y aumento del nivel del mar

2.9 Subregional Variation in Impacts

Because of the Bay Area's diverse microclimates, climate impacts may vary from location to location. Effective climate planning will need to address these nuances to see positive and equitable outcomes for communities. Here, we provide brief snapshots of expected impacts in specific locations in the Bay Area, chosen to reflect examples of the diversity and similarity of climate impacts across varied Bay Area regions.

2.9.1 The San Francisco-San Joaquin Bay Delta

The San Francisco-San Joaquin Bay Delta, where the Sacramento and San Joaquin Rivers converge before flowing into San Francisco Bay, is simultaneously central to statewide water supply and acutely vulnerable to climate hazards. The Bay–Delta is flood-prone and highly exposed to climate change stressors like SLR. Intense atmospheric river events can generate storm surge and compound flooding, straining both natural and built defenses (Gershunov et al., 2025). SLR further heightens the likelihood of levee overtopping or failure, with the potential to disrupt water conveyance for millions of Californians. Salinity intrusion into the Delta is another growing concern. As sea levels rise and freshwater flows vary under climate change, saltwater can push farther inland, degrading water quality for municipal and agricultural users (Rittelmeyer et al., 2025).

The following snapshots were developed for the Strategic Plan for the Community Economic Resilience Fund (Payne et al., 2023) to inform the regional economic development plan. Each snapshot characterizes changes in five Bay Area Jurisdictions in 2050 under a high-emissions scenario, using Cal-Adapt's suite of climate change tools.

2.9.2 Heat and Wildfire—Alamo, Contra Costa County

Due to its inland location, Alamo is expected to see higher than average maximum and minimum temperatures, with substantially warmer summers compared to the current conditions. Residents can also expect to experience a greater number of extreme heat days and warmer nights, both of which may cause increased use of or reliance on air conditioning. Alamo is unlikely to see any major changes in average annual or average 1-day precipitation by 2050 but could likely see extended periods of both dry spells and heavy rain, with the year-to-year variation in both increasing significantly. Due in part to the expected increase in duration of periods of drought, followed by heavy rains, and vice versa, Alamo is expected to see an increase in wildfire conditions by 2050.

2.9.3 Warmer Nights and Coastal Hazards—Half Moon Bay, San Mateo County

Half Moon Bay is expected to see higher-than-average maximum and minimum temperatures by 2050, though not on the scale of more inland jurisdictions. Similarly, the area is likely to see only a slight increase in extreme heat days. However, the more substantial impacts will come from an increase in warmer nights, which suggests that residents may be less likely to rely on evenings to both cool homes and maintain temperature-sensitive crop productivity. Half Moon Bay is likely to experience longer dry spells and more prolonged and severe drought episodes, as well as more intense winter storms. As a coastal community, Half Moon Bay could see increased intensity in winter wave activity associated with stronger storms, leading to damage to coastal ecosystems and infrastructure. Finally, by mid-century, many of the area's beaches will see impacts from SLR including more frequent flooding, especially during winter storms and extreme precipitation events.

2.9.4 Heavy Precipitation and Flooding—Healdsburg, Sonoma County

Healdsburg is also expected to see higher-than-average maximum and minimum temperatures by 2050, including substantially more warmer nights. The area will also see a greater number of extreme heat days. In particular, warming will have impacts on viticulture (potentially requiring change in wine varietals to ones that are more heat- and drought-tolerant) and agricultural workers. However, one of the greatest climate risks for Healdsburg is the potential for an increase in extreme precipitation. The region receives 42 inches (106 cm) of rain annually on average, substantially higher than many other regions of the Bay Area. By 2050, Healdsburg is projected to see an increase of only about 1.5 inches (38 mm), though the annual range could go as high as 62 inches (165 cm). Like most of the Bay Area, Healdsburg could see more intense winter storms leading to localized urban and rural flooding. Upstream, more intense precipitation in the Russian River watershed may also occur. Because of this, Healdsburg residents are likely to see an increase in flooding, a hazard that already impacts the southeastern part of the city, where the Russian River and Foss Creek contribute to localized flooding. Finally, Healdsburg will likely experience an increase in wildfire potential owing to hotter and drier conditions overall, a hazard that will be greatest when offshore Diablo winds occur prior to season-ending fall precipitation.

2.9.5 Drought and Wildfire—Morgan Hill, Santa Clara County

Morgan Hill is expected to see major impacts from higher temperatures across all indicators, especially average maximum temperatures, and warmer nights, particularly in summer months. The area is unlikely to see major changes in precipitation beyond the expected increased winter storm intensity, but residents will see increased lengths of dry spells and more severe droughts. A particular concern for Morgan Hill is wildfire risk. The area is already located in the very high fire hazard severity zone and is projected to see an increase in fire potential due to warmer and drier conditions that favor drought and a more receptive fire environment.

2.9.6 Sea Level Rise and Flooding—Sausalito, Marin County

Sausalito is expected to see moderate increases in average maximum and minimum temperatures by 2050, though the main temperature impacts are likely to come from warmer nights. Precipitation projections are on track with much of the rest of the Bay Area, but Sausalito is expected to feel the impacts of more consistent and extreme droughts. Currently, Sausalito is exposed to coastal flooding hazards and frequently experiences flooding during King Tide events. By 2050, it is likely that Sausalito residents will see more frequent and extreme flooding due to SLR, including levee overtopping. Many businesses and residences along the waterfront will be impacted by coastal flooding and extreme precipitation events in 2050.

Chapter 3.

Social Systems



Physical changes caused by climate change are stressing the San Francisco Bay Area's social systems, including public health, the economy, labor markets, housing and emergency infrastructure. These systems are interconnected and highly sensitive to climate disruptions. While the Bay Area is a global hub of innovation and wealth, it is also a region defined by stark inequity. Therefore, the impacts of extreme heat, sea level rise, and wildfire smoke will not be borne equally by all Bay Area residents.

The "human element" of this report highlights an important reality: Existing social vulnerabilities act as multipliers for climate risk. Historic land-use decisions, housing shortages, and aging infrastructure interact with changing weather patterns to create disproportionate burdens on low-income communities, communities of color, and the workforces essential to the region. This chapter analyzes how climate hazards threaten these systems and identifies opportunities to build resilience that is both structural and equitable.

Key Messages

1. **Systemic Vulnerability**: Historic policies (e.g., redlining) have created a landscape where specific geographies and populations face significantly higher climate risks, including heat islands and flood exposure, compared to wealthier neighbors.
2. **Public Health Strain**: The region faces a compounding "triple threat" of worsening air quality, unprecedented extreme heat events, and expanding vector-borne diseases, all of which challenge infrastructure not built for high temperatures.
3. **Economic and Labor Disruption**: Climate hazards threaten the physical safety of the workforce—particularly in outdoor and essential sectors—and the physical assets of the region's massive technology and tourism economies.
4. **Displacement Crisis**: Residents face a dual displacement threat: immediate physical displacement from hazards like wildfires and sea level rise, and chronic economic displacement driven by the rising cost and scarcity of insurance.

3.1 Racial Equity and Climate Justice

Communities that have experienced high pollution burdens, disinvestment, poverty, and systemic racism and discrimination face increased risk and vulnerability in the face of climate change (see the Fifth Assessment's "Racial Equity and Climate Justice Statewide Topical Report" for more). For example, analysis has shown that communities that were redlined in the 1930s have lower levels of greenspace, a critical feature for mitigating extreme heat and urban heat island effects today (Nardone et al., 2021).

Box 5: *Case Study II: Youth-Led Research for Community Resilience—Communities United for Restorative Youth Justice (CURYJ)*

CURYJ leverages youth-led participatory action research to influence municipal planning, including its current HEATED project which informs Oakland's Local Hazard Mitigation Plan. By training formerly incarcerated youth as researchers, the organization gathers critical data on how residents access resources during climate emergencies. This case study illustrates how engaging those most vulnerable to environmental risks results in more effective community resilience hubs and safety strategies. See Case Study II: "Communities United for Restorative Youth Justice: Youth-Led Research for Community Resilience," in **Appendix A.**

To quantify this uneven landscape, the Bay Area Jobs First Collaborative identified priority zip codes in the region using the Healthy Places Index (HPI) (Muldavin et al., 2023). HPI uses a social determinants of health approach to spatially represent the conditions that drive health outcomes. HPI combines 23 indicators in the following categories: economic, education, social clean environment, transportation, neighborhood, housing, and healthcare access (Maizlish, 2023).

Youth Perspective on Climate Accountability

> ***"My generation is going to be bearing the brunt of the impact of climate change. This is the result of older generations making decisions that prioritized profits over people. This is not going to impact those oil barons, politicians"***

—Padma Balaji, from the Bay Area Youth Climate Summit, a youth-led non-profit dedicated to building community and amplifying youth leadership in climate action, reflected on the perspectives and strengths that young people bring to climate solutions. Padma Balaji added that young people feel a sense of urgency that adults and policymakers may not. See Case Study IV: "Bay Area Youth Climate Summit: Youth Leadership for Climate Resilience" in ***Appendix A.***

The data reveal that while the Bay Area generally scores high on health metrics, specific "hot spots" of vulnerability persist. Out of the 1,500 census tracts in the nine-county region, 275 (approximately 18%) fall below the 50th percentile statewide (Muldavin et al., 2023). Twenty-five of 250 zip codes in the Bay Area have an HPI that falls below the statewide average. While overall, the Bay Area has higher HPI scores than surrounding regions (**Figure 26**), the region does have several hot spots with higher HPI scores. These include Richmond (**Figure 27**), Vallejo, and areas in West Oakland, Bay View Hunters Point in San Francisco, and East Palo Alto. Contra Costa County, which is vulnerable to sea level rise (**Figure 23**) and flooding from shallow groundwater (**Figures 25** and **A2–4**), is home to the largest number of priority zip codes in the region.

TOOLS AND RESOURCES

- Climate-Related Risks Faced by Low and Moderate-Income Communities and Communities of Color: Survey Results
- UCLA Mapping Shade
- Healthy Places Index
- Climate Vulnerability Index

Centering Equity in Climate Resilience

> ***"Equity to us means centering race, class, ability, gender, and power in every conversation. We believe in power-sharing, and we create space for youth to show up fully as themselves, because real climate resilience includes everyone."***

—Lil Milagro Henriquez from Youth Mycelium Network. When asked how they approach equity and inclusion, Lil Milagro Henriquez replied, "How do you not?" Equity is central to Mycelium Youth Network's work, which prepares youth, who are the workforce of tomorrow, to shape a more just and climate-resilient future. See full interview in ***Appendix B.***

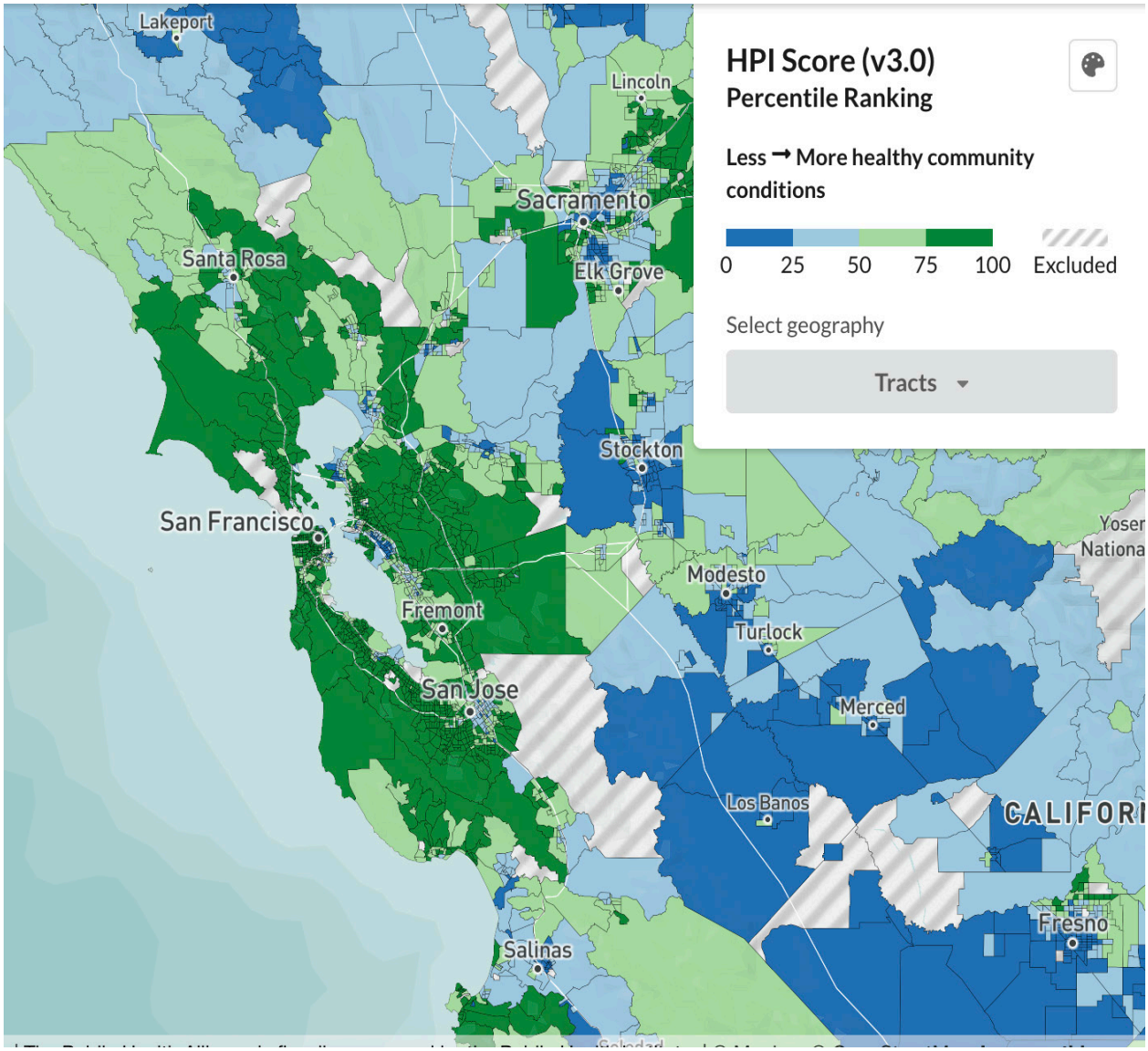


Figure 26: *Map displaying Healthy Places Index (HPI) scores for the Bay Area region (Source: Public Health Alliance).*

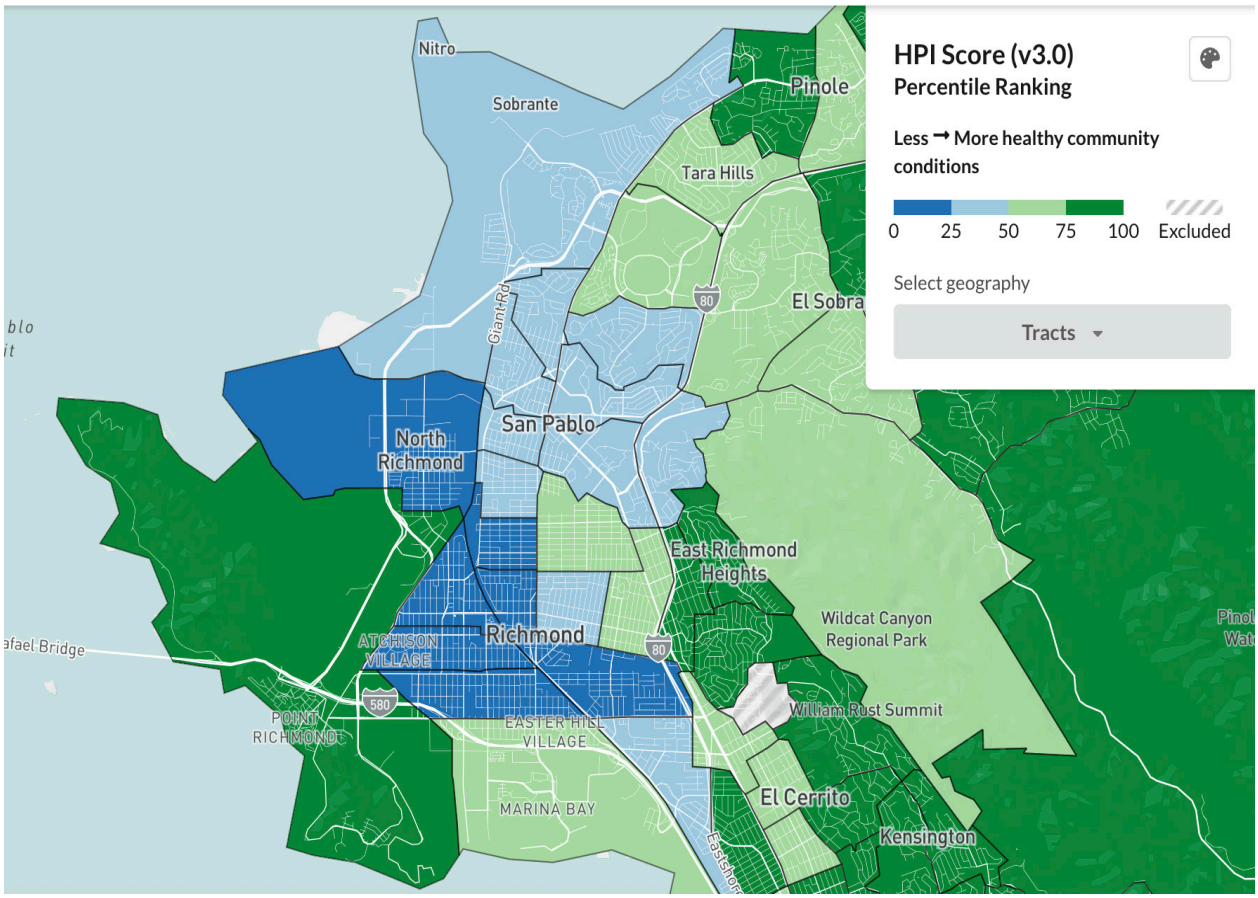


Figure 27: *HPI Score in Richmond (Source: Public Health Alliance).*

3.2 Public Health

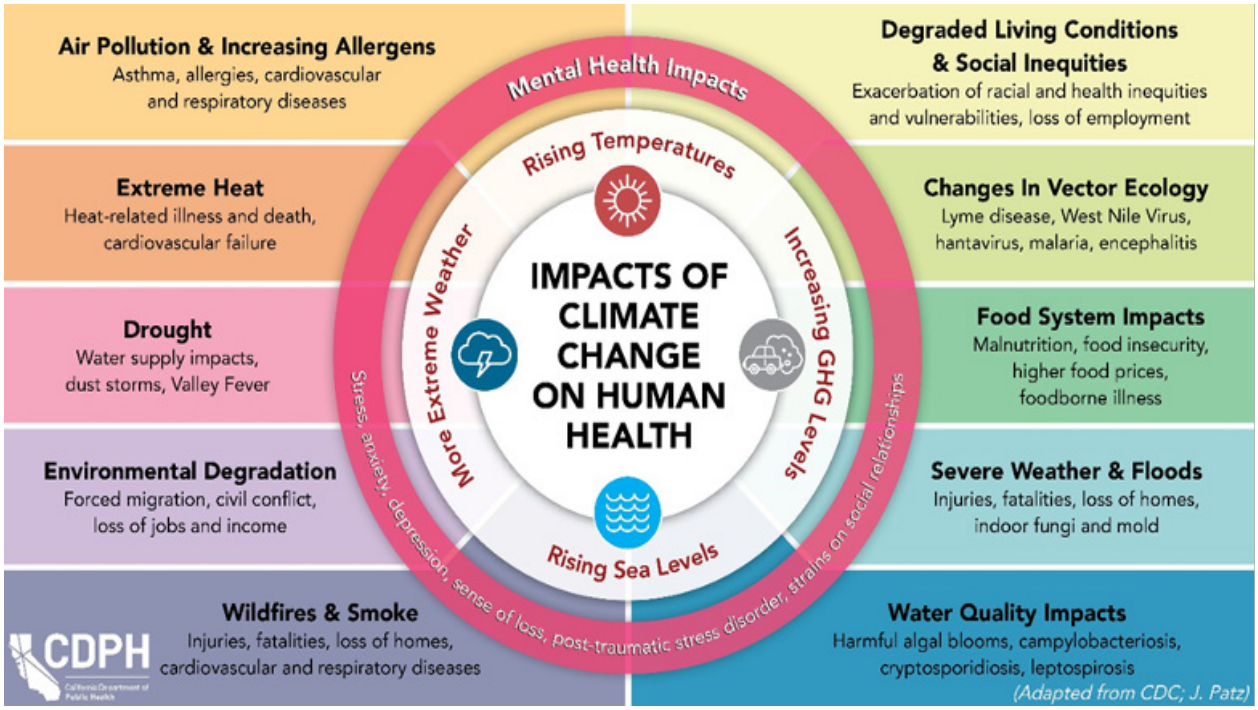


Figure 28: *Impacts of Climate Change on Human Health. Adapted from the Centers for Disease Control and Prevention (CDC) and J. Patz (California Department of Public Health).*

Climate change has impacted and will continue to impact every community across the globe in ways big and small. In the Bay Area, climate change poses significant, multifaceted, and compounding threats to public health, ranging from deteriorating air quality and extreme heat events to expanding vector-borne disease risks. These health impacts matter critically in the Bay Area context because they disproportionately affect the region's most vulnerable populations while straining healthcare systems that serve nearly 8 million residents across diverse geographic and socioeconomic landscapes (Jerrett et al., 2024).

Beyond the Data: Capturing Lived Environmental Health Impacts

> ***"Even though major corporations in our area have downsized, we're still surrounded on three sides by highways, so pollution just sits here. When winds shift, the pollution hits our neighborhood even harder but how do you measure the impact of that? We've been gathering self-reported health stories, not in strict categories, but in open-ended conversations. We have found patterns like asthma across multiple generations that (were) never formally diagnosed, so it doesn't show up in the data."***

—Pam D Jones from Belle Haven Empowered, responding to what her organization is doing to build climate and community resilience in her neighborhood in Palo Alto. See full interview in ***Appendix B.***

3.2.1 Key Climate Risks

The three most significant climate-related public health risks in the region:

- **Wildfire smoke:** Exposure now affects the entire region annually, with fine particulate matter concentrations projected to increase by 20–50% by 2050 due to longer fire seasons and more intense burning. The resulting poor air quality will increase rates of asthma and respiratory illness, particularly for children and the elderly, and worsen cardiovascular disease rates.
- **Extreme heat:** The number of days above 95°F (35°C) is expected to triple by 2050 in inland areas like Antioch and Livermore. Low-income communities and residents of older housing stock without air conditioning are most vulnerable, with heat-related mortality risk highest among adults over 65 and outdoor workers in agriculture and construction.
- **Vector-borne diseases:** Climate-driven changes in temperature and precipitation patterns are also expanding the geographic range and season length for disease vectors like *Aedes aegypti* mosquitoes, which can transmit Zika, dengue, and chikungunya viruses and have now established populations in several Bay Area counties for the first time.

These issues intersect with the region's housing affordability crisis, as people are pushed to live in crowded conditions, in higher-risk areas, or in housing with poor ventilation and climate control, resulting in poorer health outcomes (see the Fifth Assessment's "Climate-Induced Human Displacement and Migration Statewide Topical Report").

3.2.2 Air Quality and Wildfires

During the expanding wildfire season in California, air quality in the region now regularly reaches hazardous levels, with PM2.5 concentrations exceeding EPA standards by 300–500% (Kramer et al., 2023). During major fire events, the rising smoke and toxic chemicals make air quality unsafe for communities even hundreds of miles away from the fire sites. The tragic loss of life and property in these expanding fires underscores the short- and long-term morbidity and mortality from poor air quality and related factors. Air pollution, particularly from transported emissions, can compound respiratory issues, particularly for children and those closer to highways. Emergency department visits for respiratory conditions increase by 10–25% during poor air quality episodes. While there is little data on all-cause excess mortality in the months and years after a fire, the total human health toll is vastly underestimated due to unmeasured indirect deaths from smoke exposure, healthcare disruption, displacement, and cascading socioeconomic impacts (Brumberg et al., 2021).

A brief analysis prepared by the Federal Reserve Bank of San Francisco, "Wildfire Smoke in the San Francisco-Oakland Metro Area," reports that the average person in the San Francisco-Oakland metro area went from experiencing about three days per year of medium smoke overhead to an average of 13 days per year in the second half of the decade.

3.2.3 Extreme Heat and Infrastructure Vulnerabilities

Smelling the Benzene: The Frontline Reality of a Bay Area School

> ***"I know for sure it comes from the Chevron refinery because I can see the smoke in the air and smell the chemicals. It's not always the same smell, but I know it's things like benzene that they release. I notice it even more at the school because we're closer, and the wind blows in that direction. So I know the air is polluted, definitely. And I check it always on my app for the air quality."***

—A Bay Area resident who works in special education expressed frustration with what she sees as the obvious insufficiency of current environmental regulations. The fact that her school is allowed to be near an oil refinery, she explains, has undermined her trust in government institutions and the information they provide.

Climate change can drive extreme heat, and particularly hot, dry weather drives wildfires which impacts health (Bell et al., 2024). Heat-related emergency department visits have tripled since 2005 in the Bay Area, with inland counties like Contra Costa and Solano experiencing the steepest increases (Gould et al., 2025). Approximately 40% of the region's population—roughly 3.2 million people—live in areas classified as having high heat vulnerability due to factors including age, poverty, and housing quality (OEHHA California Communities Extreme Heat Scoring System, n.d.). Children and the elderly are often the most affected. Extreme heat events are a problem across the state, but the Bay Area faces unique infrastructure vulnerabilities. With its historically mild climate, San Francisco has the nation's lowest air conditioning ownership rate—45% (34% central air, 11% room units) versus 92% national average—and nearby cities like Oakland and Hayward rank among the lowest, making residents particularly susceptible to health impacts when temperatures rise. Housing in the Bay Area is also frequently built for milder temperatures without insulation.

Furthermore, the region relies on electrical infrastructure designed for an era of lower energy consumption. This aging grid is unprepared for the additional strain of heat events, with transformer failures common when customers increase air conditioning use. Transportation infrastructure also suffers, with roads and sidewalks buckling from thermal expansion—a phenomenon observed in Santa Rosa, San Rafael, and San Jose during recent heat waves—and wet winters that can drive additional movement under the concrete (Hodge & Greve, 2017). These compounding infrastructure deficits mean that even moderate heat events that might be manageable in other regions can overwhelm Bay Area systems and create serious public health risks, particularly as rebuilding this infrastructure will come with a high cost.

3.2.4 Vector-Borne Disease

Changing precipitation patterns—warmer winters combined with more rain—are altering the distribution of disease-carrying mosquitoes and ticks. There is growing concern about West Nile virus transmission and the potential for other vector-borne diseases to establish in the region (Nigusie et al., 2021).

RESOURCES AND PLANNING

The Bay Area has launched several major climate health adaptation initiatives, including the regional Climate and Health Program led by the Bay Area Regional Health Inequities Initiative

and the Climate Resilience Network, coordinated by the San Francisco Bay Conservation and Development Commission (BCDC). Local health departments across all nine counties have developed Climate Health Profiles and are implementing targeted interventions such as cooling centers, air filtration programs for vulnerable populations, and enhanced vector surveillance systems. Hospitals are developing more climate-targeted disaster management planning programs. The Bay Area Air Quality Management District operates a comprehensive air quality monitoring network and public alert system, while projects like the California Building Resilience Against Climate Effects (CalBRACE) Project work to address disparities in climate health impacts through community-based interventions and policy advocacy.

At the university level, Bay Area and other University of California (UC) schools are at the forefront of climate change adaptation and mitigation research, particularly in health-related areas. The UC-wide Disaster Resilience Network facilitates collaborative research across the eight UC universities, focusing on engineering, climate modeling, health justice, and educational initiatives. Similarly, the UCSF based Center for Climate Health and Equity spearheads education and research efforts connecting climate science with public health outcomes. Individual universities host numerous specialized programs and research centers driving innovation in this field. At UC Berkeley for example, the Berkeley Climate Change Network works to bridge connections between students, academics, and policymakers to accelerate climate science progress. Across the various schools and graduate divisions, departments engage students in developing innovative methodologies, fostering research partnerships both internationally and domestically, while directing significant research initiatives that have global impact.

GAPS AND NEEDS

Given the breadth of climate change's impacts on the health of the people of the Bay Area, many challenges lie ahead. Addressing these health impacts requires understanding complex, interconnecting pathways of harm. Beyond direct physical risks, climate change destabilizes the foundations of health, causing displacement and loss of employment, housing, and insurance. It also erodes social structures, leading to food insecurity, isolation, and increased violence. These combined factors drive illness and mortality in ways that are difficult to predict. Consequently, securing funding and collaboration to map and mitigate these risks will be important. This will especially be the case for scaling up community-based adaptation measures and addressing the underlying social determinants that amplify climate health vulnerabilities (see the Fifth Assessment's "Racial Equity and Climate Justice Statewide Topical Report" for more).

Box 6: *Case Study III: Tackling extreme heat through participatory design—Climate Resilient Communities (CRC)*

The North Fair Oaks case study is an example of a successful participatory design model, bringing together residents, nonprofits, and technical partners to tackle extreme heat. Originating from a direct community request, CRC developed and tested mobile cooling kits through a consensus-based process that included door-to-door feedback. This initiative proves that when technical solutions are co-created with local leadership, they not only solve immediate environmental challenges but also strengthen the long-term social fabric of the neighborhood. See the case study III "Climate Resilient Communities: Tackling extreme heat through participatory design" in the **Appendix A.**

TOOLS AND RESOURCES

- California Department of Public Health. Climate Change and Health Vulnerability Indicators for California.
- Climate Change and Public Health in California: A Structured Review of Exposures, Vulnerable Populations, and Adaptation Measures.
- Climate Change and Health Equity, California Department of Public Health.
- Overcoming Barriers to Successful Climate and Health Adaptation Practice: Notes from the Field
- Climate Change & Health Vulnerability Indicators for California
- Sacramento and Bay Area Regional Health Profile
- South San Francisco Air Quality Dashboard by Rise South City is a real-time air quality dashboard for South San Francisco, integrating data from PurpleAir and Clarity air monitors, providing residents with accessible information through a bilingual platform.

3.3 Economics

The Bay Area's economy supports millions of jobs and faces direct threats from climate-induced impacts on natural resources, the built environments, and the regional workforce. These impacts are likely to be exacerbated by disruptions to global supply chains that underpin the region's economic contributions. Climate change will affect all sectors of the Bay Area economy, with complex interconnection across sectors such as transportation, telecommunications, utilities, and goods movement that could amplify vulnerabilities, especially during emergencies (see the Fifth Assessment's "Climate Impacts to the Economy Statewide Topical Report" for more).

Climate change is already affecting the Bay Area economy in several ways. Analysis of the 2017 North Bay Wildfires documented significant economic losses in Napa and Sonoma counties (Bellisario et al., 2021). The analysis showed a sharp dip in tourist activity, as measured by airport passenger levels and hotel tax revenue.

The Insurance Trap: Financial Barriers to Recovery from Climate Impacts

> ***"I've seen a lot of flooding in the community, but the hardest impacts have been on mom-and-pops who have owned their homes for a long time. Their houses were damaged when floodwaters entered and destroyed their homes. These are people who don't have the resources to recover. I'll suggest calling their insurance, but they'll say, 'No, I can't afford the higher premiums. I'm afraid to call.' Meanwhile, they're left dealing with flooded basements or some pumps they've never had to turn on."***

—A community organizer who co-founded a climate justice youth organization in Oakland, reflecting on how aging infrastructure and compounding crises, from flooding and pollution to housing instability, leave longtime residents especially vulnerable.

Commerce in the Bay Area will likely be strongly influenced by inundation and flooding in bayside communities and commercial areas. A report prepared for the Fifth Assessment, "Assessing Cost Effectiveness of Coastal Climate Adaptation Solutions in California: CoSMoS-Adapt," uses the CoSMoS-Adapt tool to assess coastal risks and adaptation solutions in three study areas, including

Half Moon Bay (San Mateo County). It projects that total economic damages from a 100-year flood in Half Moon Bay could increase from $4 million at present to $63.3 million by 2085, without adaptation. It also finds that adaptation can substantially lower this risk (see the full report for additional details).

TOOLS AND RESOURCES

- Extreme Heat's Impacts on a Local Economy: Phoenix, AZ - Federal Reserve Bank of San Francisco
- Rising Wildfire Risk for the 12th District Economy - Federal Reserve Bank of San Francisco
- Climate Change and the Geography of the U.S. Economy - Federal Reserve Bank of San Francisco

3.4 Labor and Workforce

Climate change represents an imminent threat to the San Francisco Bay Area workforce, necessitating strategic intervention to accelerate adaptation and mitigation. Climate hazards directly erode worker health and productivity. Extreme heat significantly raises the risk of fatalities and injury, causing quantifiable productivity losses of 29–41.3% in physically demanding sectors like construction (Alahmad et al., 2025). This risk interacts with underlying socioeconomic vulnerabilities; for instance, Latino workers are disproportionately represented in high-exposure outdoor industries ("Climate Change Impacts Across California—Workers and Employers," 2022). Furthermore, sea level rise threatens critical economic centers, potentially placing up to 320,000 employees at risk of displacement due to inundation or transportation failures under high SLR scenarios (Heberger et al., 2012). Climate adaptation creates new labor demands for building resilience infrastructure. Regional initiatives, including the BCDC's Regional Shoreline Adaptation Plan and the USACE Bay Area SLR study, will require specialized ecological engineers and construction workers, particularly for nature-based solutions. A primary consideration for adaptation is ensuring that resilience construction projects mandate high-road labor standards and safety protocols, preventing the transfer of climate hazard risk to the workers building protection infrastructure (Licker et al., 2022).

Youth workforce development is important for sustaining the region's climate response over the long term. Expanding paid apprenticeships, career pathways, and partnerships with community colleges and unions can prepare Bay Area youth—particularly from frontline and underserved communities—to fill emerging jobs in clean energy, resilience construction, and climate planning while supporting intergenerational economic mobility.

Beyond Job Training: Fostering Hope and Purpose

> ***"We train young people for climate jobs that are urgently needed. But it's more than just job training; it's about empowerment. We want young people to know that whatever skills or background they bring, whether they're artists or engineers, they can contribute to climate solutions. We create an environment where youth can discover a purpose, build skills, and feel hopeful. When they work on big projects; they see immediate impacts and start to believe change is possible."***

*—Jennifer Lopez from The Watershed Project. When asked how The Watershed Project is building climate and community resilience, Jennifer talked about their youth employment and development program, Green Collar Corps, where their goal is to connect people to meaningful work that improves quality of life and the environment (see full interview in **Appendix B**).*

Climate mitigation and adaptation efforts can provide an opportunity for workforce development in new areas, which can develop pathways for workers in high-emitting industries (e.g., the fossil fuel industry). Policies, including building electrification and energy efficiency, require a major structural shift in the energy workforce (Bohn et al., 2025a). The City of Berkeley's Just Transition Pilot Program provides one example, linking electrification upgrades directly to minimum labor standards and economic benefits for low-to-moderate income communities. There is opportunity for future planning to focus on retraining workers displaced from fossil fuel sectors (e.g., in Contra Costa County) while ensuring that the high-growth jobs created in the clean energy economy offer technical training and access for traditionally vulnerable populations (Bohn et al., 2025b).

TOOLS AND RESOURCES

- Putting California on the High Road: A Jobs and Climate Action Plan for 2030
- Impact of U.S. Labor Productivity Losses from Extreme Heat - San Francisco Fed

Empowering Frontline Communities in the Green Transition—How it is Affecting Communities Today

> ***"Focusing on economic and workforce development, I've seen how BIPOC (Black, Indigenous, People Of Color) communities often lack the capacity and resources to implement climate solutions, despite being on the frontlines. There's a huge gap, and opportunity, in preparing our communities for green, clean jobs. For example, during an [electric vehicles or EV] push, it became clear we weren't equipping Black and Latino auto shop owners for EV repairs. Now, through community-driven planning, we're working to build local infrastructure, empowering community developers and contractors to lead on shoreline adaptation, trails, tree maintenance, and more."***

*—Keta Price from Hood Planning, reflecting on how Hood Planning Group's focus on economic and workforce development came from the realization that there is a lack of representation in who leads, implements, and benefits from climate work, especially in BIPOC communities like the one she belongs to in East Oakland (see full interview in **Appendix B**).*

Box 7: *Case Study IV: Youth Leadership for Climate Resilience —Bay Area Youth Climate Summit*

Through initiatives like their annual summits and upcoming Green Career Fair, the Bay Area Youth Climate Summit (BAYCS) connects hundreds of students to hands-on action planning. The case study in the Appendix details how this peer-led model transforms climate anxiety into determination by fostering a strong sense of community. By treating climate change as a multi-dimensional issue, BAYCS prepares the next generation of leaders to tackle environmental challenges with resilience. See the case study IV "Bay Area Youth Climate Summit: Youth Leadership for Climate Resilience" in **Appendix A.**

3.5 Communications

Information, telecommunications, and technology are particularly important sectors of the Bay Area economy that provide residents, businesses, and organizations with essential resources and access to knowledge. Efficient information and communication systems are an integral part of ensuring that the Bay Area is prepared for expected population and business growth, especially under a changing climate. Maintaining telecommunications services during extreme events (e.g., flying generators to remote areas, bringing portable cell towers, predicting wildfire patterns so that retardant can be applied to telecom equipment) is already extremely costly and likely to become more so with climate change. As telecommunication infrastructure continues to age and the intensity of climate-induced events becomes more extreme, these sectors are likely to see increased costs for maintenance and operation of critical systems (Posadzki, 2023).

Silicon Valley is home to several major technology companies' headquarters, office campuses, and data centers, drawing workers from other parts of the Bay Area to the coastal areas of Santa Clara and San Mateo counties. Many of these campuses and facilities, sometimes worth more than $2 billion, are exposed to flooding from rising sea levels. Technology companies in the Bay Area with facilities exposed to SLR by the end of the century include Facebook, Google, Yahoo, LinkedIn, Cisco, and eBay (Berke et al., 2023; Marketplace Staff & Ackerman, 2019). In addition to being vulnerable to climate change, the growing use of artificial intelligence and data centers is increasing energy and water demands. The California Energy Commission predicts that growth in data centers in the Bay Area could lead to a doubling of peak electricity load by 2026 (Paulson, 2022).

Mapping Vulnerability: A Door-to-Door Approach to Crisis Planning

> ***"We're currently implementing a project funded by the BA UASI [Bay Area Urban Areas Security Initiative] grant focused on emergency management. One of the biggest gaps we've identified is communication during crises, so this grant is allowing us to conduct a door-to-door outreach campaign to reach all 1,500 households in Belle Haven. It includes health checks and assessments of residents' needs, like mobility, disability status, and language access. We're building a real map of who lives in the neighborhood and what support they may need."***

*—Juanita Croft from Belle Haven Community Development Fund reflecting on the lack of emergency infrastructure in her community and how she is working toward making sure there is a plan in place for every person (see full interview in **Appendix B**).*

3.6 Human Displacement

Wildfires are currently the dominant cause of mass rapid displacement, yet data show that most households remain within the immediate region, straining adjacent, unprepared communities (Sharygin, 2021). Concurrently, chronic stress drives preemptive displacement: a 2025 survey found that 60% of Bay Area residents are very concerned about climate-driven increases in home insurance costs, and 58% are concerned about being unable to obtain coverage at all (PPIC, 2025). This financial worry about climate risk acts as a potent, non-catastrophic destabilizer (see the Fifth Assessment's "Climate-Induced Human Displacement and Migration Statewide Topical Report" for more).

SLR presents the largest physical risk to Bay Area residents and businesses, directly exposing nearly 15,000 households in socially vulnerable communities, two-thirds of which are located near contaminated sites (Adapting to Rising Tides, 2020). Compounding this, regional planning documents reveal a significant future liability, with 64,400 planned housing units in Priority Development Areas (PDAs) exposed to future flooding (Adapting to Rising Tides, 2020). Despite the regional commitment of $17.4 billion to SLR infrastructure, regional planning frameworks currently lack explicit, actionable policy recommendations for managing human displacement or strategically preparing climate-safe "receiving communities" (Plan Bay Area 2050, 2021).

RESOURCES

- Residential Instability in the Bay Area through the COVID-19 Pandemic - Federal Reserve Bank of San Francisco
- Housing Market Interventions and Residential Mobility in the San Francisco Bay Area - Federal Reserve Bank of San Francisco

A Personal Account of Displacement

> ***"We felt like climate refugees—that's how I felt, and I still feel that way sometimes. I see what's happening in LA, and think, this is January, and this is happening. So what are we going to get in September? What are we going to get in April?"***

—While the term "climate refugee" might, for some, conjure up images of peoples crossing national borders, one woman we talked to in the Bay Area described her experience during the October 2020 wildfires driving around the state in search of clean air for her four-month old daughter.

3.7 Emergency Capacity

The San Francisco Bay Area's social systems face deficits in emergency capacity, primarily driven by escalating climate hazards like extreme heat and wildfire smoke (Ackerly et al., 2018). Immediate response depends on the complex interdependence of communication, transportation, and public health networks; disruption to one component, such as power strain caused by high temperatures, risks a failure of the entire emergency management system (Ackerly et al., 2018; Julius Maxwell et al., 2018). The resulting health burden is severe, with temperatures above 85°F (29.4°C) documented to trigger increases in emergency room visits and mortality (Shahagadkar, 2024).

A major structural deficit is the lack of household resilience and access to air conditioning. This capacity gap disproportionately affects low-income and underserved communities. Mobility analyses confirm that lower-income populations often cannot reduce travel during heat waves, increasing their exposure risk and straining public services (Widerynski et al., 2017).

Existing resources include the Bay Area Air Quality Management District's (BAAQMD) Clean Air Center Program, which funds centers to mitigate smoke and heat impacts, and the San Francisco Department of Public Health's Climate Health Program, which provides resources and checklists specifically for clinicians to manage health surges. Studies show that integrating mobility data and priority community metrics into emergency logistics improves access and transportation assistance for vulnerable, zero-vehicle households by ensuring the social safety net reaches those who need it most (Widerynski et al., 2017).

The Fifth Assessment report "Climate Change-Related Occupational Hazards" examines risks to heat stress and wildfire smoke illnesses in prisons and warehouse settings, and how climate change alters these risks (Noth et al., 2026). Preliminary findings show that projected 95th percentile temperatures are elevated in several Bay Area prisons compared to elsewhere in the state, particularly in the mid- and late-century—see quote below. The report comes with both regional- and facility-specific information and will feature a section on mitigation of climate-related exposures in such facilities.

Box 8: *Case Study V: Disability and Climate Risk: Land Use, Disproportionate Wildfire Risk, and Inclusive Wildfire Resilience Planning*

This case study examines the dangerous intersection of disability, aging, and wildfire exposure through the DisabilitYIMBY project. Data analysis reveals that seniors and people with disabilities are disproportionately concentrated in fire-prone areas due to a lack of accessible housing elsewhere. The study concludes that while inclusive emergency alerts are vital, the most effective resilience strategy is ensuring that vulnerable populations have the economic power and housing options to live outside of hazard zones. See the case study "Disability and Climate Risk: Land Use, Disproportionate Wildfire Risk, and Inclusive Wildfire Resilience Planning" in **Appendix A.**

When Evacuation Isn't an Option

> ***"At juvenile detention centers like Santa Rita Jail, there is no access to safe drinking water or adequate medical care, and evacuation plans are often insufficient. In emergencies, employees may leave—but incarcerated people cannot. How do we ensure that such plans are in place so that no one is left behind?"***

—Catalina Garzon with Communities United for Restorative Youth Justice (CURYJ), an organization that was founded to end youth criminalization and mass incarceration. Catalina Garzon gave an example of why juvenile centers are particularly vulnerable to climate hazards. CURYJ is not traditionally defined as a climate organization but treats climate resilience as inseparable from struggles against incarceration, policing, poverty, and environmental racism. See Case Study II: "Communities United for Restorative Youth Justice: Youth-Led Research for Community Resilience" in ***Appendix A.***

Chapter 4.

Natural and Working Lands & Waters



The Bay Area is incredibly diverse, with nine counties and more than 100 cities whose communities span dense urban centers, agricultural valleys, and coastal and mountain landscapes. This geographic and cultural mosaic is mirrored in the region's natural ecosystems (estuaries, redwood forests, oak woodlands, grasslands, wetlands, and chaparral) that together form one of the most biodiverse regions in North America. These ecosystems support thousands of native species, provide essential ecosystem services, and create a sense of space that connects residents to land and water.

For millennia, the Ramaytush, Chochenyo, Karkin, Tamien, Muwekma, Coast Miwok, Patwin, Wappo, and Pomo Peoples have shaped and sustained these landscapes through sophisticated ancestral land management techniques such as cultural burning, seasonal harvesting, and watershed stewardship. Their knowledge systems continue to guide contemporary efforts to restore ecological balance, revitalize biodiversity, and strengthen community resilience in the face of accelerating climate change, despite the state's history of genocide and exclusion. The Bay Area is home to several Land Back and co-management projects that are re-establishing Indigenous practices on the landscape.

Working lands form a vital part of this landscape. Vineyards, orchards, dairies, and rangelands not only sustain rural economies and local food systems but also play an important role in carbon sequestration and broader climate resilience. Alongside these agricultural areas, the region's natural landscapes support extraordinary biodiversity. Redwood forests, oak woodlands, wetlands, and chaparral ecosystems provide habitat for endangered species as well as migratory wildlife that depend on the Bay Area's unique ecological corridors.

The stewardship of these lands is shared across a wide spectrum of owners and managers. Public agencies at the federal, state, and regional levels work alongside Tribal nations, nonprofits, and local stewards to conserve ecosystems and maintain public access. Together, they protect critical natural resources, from the waters of the San Francisco Bay, Delta, and surrounding watersheds, to the fisheries, mineral deposits, and timber that have long supported the region.

These natural and working lands also contribute immeasurably to quality of life. Outdoor recreation, whether hiking in the redwoods, boating along the coast, or exploring local parks, attracts residents and visitors alike, sustaining tourism and strengthening the regional economy. At the same time, these lands generate jobs, deliver ecosystem services, and bolster the Bay Area's resilience in the face of climate change.

4.1 Indigenous Knowledge

As discussed above, Bay Area Tribes continue to play a critical role in shaping the biodiversity and tending the lands and waters of the region. Despite the profound historic and ongoing challenges of the California genocide, missionization, land dispossession, and systemic exclusion from regional planning processes, regional Tribes continue to lead land stewardship for their ancestral homelands. Today, Tribal communities across the region maintain cultural fire, tend coastal and estuarine ecosystems, revitalize plant and food systems, protect sacred sites, and lead rematriation and restoration projects grounded in ancestral place-based knowledges. This cultural continuity demonstrates that Indigenous stewardship is a living, adaptive foundation for climate resilience and adaptation in the Bay Area.

A Blueprint for Sovereignty: How an Unrecognized Tribe Reclaimed Its Land in Perpetuity

> ***"This is the first land return in the South Bay in over 200 years that's under 100% Tribal control. This isn't an easement. This is full ownership, and it will be in the Tribe's possession in perpetuity. … We want to do our part to restore the land. … Knowing that a Tribe that is not recognized, that doesn't have a lot of resources, is able to do this … it gives other people the opportunity to know that they don't have to just take a cultural easement, that we don't just have to take crumbs."***

—Chairwoman Quirina Geary, Tamien Nation. See Case Study I: "Tamien Nation: Land Back, Cultural Stewardship, and Climate Resilience in the South Bay" in ***Appendix A.***

The Bay Area has been at the heart of the modern Land Back movement, which calls for the return of Indigenous lands to Indigenous stewardship and governance. In 1969, Indigenous activists from across the country occupied Alcatraz Island for 19 months, asserting treaty rights and demanding the return of federal lands to Native peoples. The occupation galvanized a generation of Indigenous activism, inspiring the creation of cultural centers, education institutions, and land trusts that continue to advance Indigenous sovereignty today.

Regional Tribes also continue to exercise robust climate resilience and adaptation leadership. From the Amah Mutsun Land Trust's cultural burning and oak woodland restoration in the Santa Cruz Mountains (for more on this program, see an interview hosted on the Amah Mutsun Land Trust's website) to Sogorea Te' Land Trust's rematriation of land and the Shuumi land tax (**Text Box 9**), Bay Area Tribes are actively reclaiming authority over their ancestral territories and shaping regionwide resilience strategies. The Federated Indians of Graton Rancheria (Coast Miwok and Southern Pomo) lead large-scale stewardship of coastal estuaries and convene intertribal climate-resilience gatherings that weave together collaborative Indigenous governance, climate action, and regional partnerships.

Box 9: *Land Back and Rematriation in the Bay Area*

The Sogorea Te' Land Trust (STLT), an urban Indigenous women-led organization, spearheads Land Back efforts—termed *rematriation*—across the unceded Lisjan (Ohlone) territory in the Bay Area. Operating without federal recognition, the STLT created the voluntary **Shuumi Land Tax** (Chochenyo for "gift") to bypass traditional legal barriers. This progressive model provides funds for the acquisition of urban parcels, allowing the Lisjan Ohlone to build community centers, gardens, and ceremonial spaces. Rematriation extends beyond real estate; STLT has facilitated the return of cultural items, including ancient arrowheads and grinding stones, in partnership with non-Indigenous residents (Ixierda, 2022) Paying the Shuumi Land Tax is presented as an ethical imperative, requiring non-Indigenous residents to acknowledge the land's stolen history and support Ohlone self-determination and cultural vitality. For more on Shuumi Land Tax, see the Sogorea Te' Land Trust website.

TOOLS AND RESOURCES

The Allyship Spectrum is a tool to reflect on how actions impact Native communities. It helps set goals, reprioritize efforts, and strengthen relationships. By using the spectrum, individuals and organizations can become more intentional, accountable, and supportive allies to Native communities.

4.2 Biodiversity and Habitat

The Bay Area has already lost more than 85% of historic tidal wetlands to development (WERC, 2017). In response, regional restoration efforts (e.g., the South Bay Salt Pond Restoration Project) have restored thousands of acres in the past two decades.

These ecosystems and the species that depend on them are increasingly under pressure from climate change. Rising seas threaten Ridgway's Rail habitat, while prolonged droughts place additional stress on valley oaks and steelhead trout populations. Biodiversity and habitat in the Bay Area encompass the range of native species and ecological communities, from coastal marshes and redwood forests to urban green corridors and estuarine systems. These ecosystems are vital for climate resilience—they buffer flood risks, sequester carbon, support pollinators, and sustain fisheries and recreation. This rich biodiversity is increasingly under threat from habitat fragmentation, sea level rise, wildfire, and shifting species ranges (San Francisco Estuary Institute, 2020). Conservation planning in the region increasingly relies on robust data tools such as the Bay Area Greenprint and SFEI's EcoAtlas that support regional biodiversity assessments and conservation planning.

Box 10: *Case Study VI: Cultural Burning and Indigenous Collaboration at 'Ootchimin 'Ooyakma (Jasper Ridge Nature Preserve)*

The management of 'Ootchamin 'Ooyakma illustrates the critical role of Indigenous science in addressing California's wildfire crisis. The Muwekma Ohlone Tribe and Stanford University have partnered to reintroduce "good fire" to the landscape, blending fuel reduction goals with ceremonial cultural practices to protect the wildland–urban interface. This partnership confirms that Traditional Ecological Knowledge (TEK) is not only culturally vital but ecologically essential, offering a scalable framework for effective, relationship-based climate adaptation. See case study VI: "Cultural Burning and Indigenous Collaboration at 'Ootchimin 'Ooyakma (Jasper Ridge Nature Preserve)" in **Appendix A**.

Box 11: *Case Study VII: A Living Model of Adaptation: Teaching, Healing, and Restoring with Suscol Intertribal Council*

This case study shares an example of intertribal collaboration to support teaching and restoration practices on the land. It details the work of the Suscol Intertribal Council in Napa Valley, where Traditional Ecological Knowledge meets innovative science to restore riparian habitats and soil health. By utilizing techniques ranging from mycelium remediation to the use of microbial "bokashi balls" for water purification, the Council has created a living model of ecological resilience. This case study illustrates how Indigenous-led restoration effectively combines habitat recovery with the cultivation of medicinal plants, offering a scalable template for healing land impacted by toxicity. See case study VII: "A Living Model of Adaptation: Teaching, Healing, and Restoring with Suscol Intertribal Council" in **Appendix A**.

Healing the Land, the Wildlife, and the Community

> ***"Land back doesn't just help the Tribe—it helps the land, the wildlife corridors, and everyone who depends on these ecosystems."***

—Lillian Camarena, Tamien Nation. See Case study I: "Tamien Nation: Land Back, Cultural Stewardship, and Climate Resilience in the South Bay" in ***Appendix A.***

Due to sea level rise, with limited space to move inland, many wetland habitats—and the species that rely on them—are being squeezed out. The US EPA reports that the San Francisco Bay has lost over 90% of its shoreline wetlands and 40% of the total San Francisco Bay aquatic ecosystem in the last 150 years, leading to the special protection of more than 90 species of plants and animals (US EPA, 2012). Gray whale populations along the California coast have dropped below 13,000, their lowest since the 1970s, due to climate-driven declines in Arctic sea-ice algae, a critical food source. Malnourished whales are now washing up in the Bay Area (Duggan, 2025). Western monarch butterfly populations in the Bay Area have plummeted. Once-common overwintering sites now report as few as four butterflies, with climate stress, heat, and habitat loss as major drivers (Bartlett, 2024). Conservation experts highlight habitat connectivity as one of the most effective climate adaptation strategies—ensuring species can migrate as conditions shift (Penrod et al., 2013). Warmer temperatures and wildfires are stressing redwood forests, oak woodlands, and chaparral systems, leading to altered species composition, pest outbreaks, and habitat loss (Harrison et al., 2024). Habitat fragmentation and urban heat disproportionately affect pollinators, amphibians, and migratory birds in urban and peri-urban areas, where adaptive space and water resources are limited.

Advancing Community-Led, Nature-Based Solutions

> ***"Climate resilience is inseparable from community resilience. Urban microclimates, neglected infrastructure, and lack of access to green spaces all increase vulnerability. I've learned how much root systems and species like oysters matter in protecting the land, and how closely environmental health ties into the community's well-being."***

*—Shy Walker from Ninth Root, talking about what they had learned about climate and community resilience. Often, the response to climate impacts involves a lot of gray infrastructure that reduces access to green spaces for the community. Ninth Root wants to figure out how we can have community-led, nature-based solutions that incorporate both environmental and community needs. (See full interview in **Appendix B**).*

TOOLS AND RESOURCES

Coastal and Estuarine Ecosystems

- Baylands Ecosystem Habitat Goals – This SFEI project integrates climate change science and sediment supply projections through 2100, recommending urgent tidal marsh restoration: ~42,000 acres needed in 15 years to sustain wetlands and protect infrastructure.
- San Francisco Bay Eelgrass Habitat Suitability Model – Developed by Audubon California and partners, this tool uses climate-scenario modeling (e.g. sea level rise, salinity shifts, marine heat waves) to identify future-resilient eelgrass sites—critical for shoreline stabilization and carbon storage.

Nature-Based Adaptation and Shoreline Resilience

- San Francisco Bay Shoreline Adaptation Atlas – From SFEI and SPUR, this includes spatial mapping of opportunities for nature-based solutions—e.g. living shorelines, oyster reefs, sediment placement—to support coastal biodiversity and reduce flood risk.
- Sediment for Wetland Adaptation Project — BCDC's Sediment & Soil Beneficial Reuse Action Plan outlines a regional strategy to supply >450 million cubic yards of sediment through 2100, essential for wetland restoration and coastal defense.

Terrestrial and Urban Biodiversity

- Golden Gate Biosphere Region Climate Adaptation – EcoAdapt and GGBN produced vulnerability briefs, species distribution modeling, and adaptation strategies for 21 ecosystems and species (e.g. coastal dune, chaparral, redwood forests, kingfisher) using downscaled data and partner input.
- Connecting Urban Biodiversity – A Bay Area-wide collaboration led by the California Academy of Sciences and TOGETHER Bay Area, showcasing the use of community science and species modeling (e.g. Western Bluebird, Monarch butterfly) to integrate biodiversity into urban planning.

4.3 Water (Surface and Groundwater)

As discussed in the climate science section, the relationship between groundwater and sea level rise is likely to lead to enhanced flooding throughout the Bay, resulting in extended damages to infrastructure and public health impacts. Recent studies suggest that flooding from emergent groundwater could impact a larger area across the region than wave-induced flooding from sea level rise alone (Randolph, 2022).

The San Francisco Bay Area faces escalating water supply instability driven by climate change impacts on both remote surface sources and local subsurface environments. Reliability of imported water, which sustains major population centers, is severely threatened by the destabilization of the Sierra Nevada snowpack, the primary natural reservoir for California (DWR, n.d.). Current projections forecast a critical 48–65% loss of the historical April 1 snowpack average by the end of the century, drastically accelerating melt and complicating long-term storage and delivery. Concurrently, rising sea levels are increasing saltwater intrusion into the Sacramento-San Joaquin Delta, necessitating increased freshwater outflow and further limiting imported supply (DWR, n.d.).

Addressing this systemic vulnerability requires aggressive local diversification of water sources, including the use of recycled water. Regional agencies are shifting capital investment toward a circular water economy. Key targets include achieving water recycling and purification goals capable of meeting at least 10% of Santa Clara County's total water demands by 2035 (Santa Clara Valley Water District, 2024). Simultaneously, valuing urban stormwater capture for groundwater recharge and mandating compound risk assessments that fully account for subsurface hydraulic impacts and geotechnical instability are essential steps toward building drought resilience and safeguarding public health infrastructure.

Local water security is compounded by previously underestimated hazards. Analysis indicates that local land subsidence, with rates exceeding 10 mm/year in some coastal fill areas, increases risks associated with SLR (Shirzaei & Bürgmann, 2018). Maps that fail to incorporate subsidence risks underestimate 100-year inundation hazards by 3.7% to over 90.9%, exposing a larger area of critical shoreline infrastructure to catastrophic flooding (Shirzaei & Bürgmann, 2018). Furthermore, a rising regional groundwater table, correlated with SLR, poses a significant and often-neglected threat to the 36 coastal wastewater treatment plants (WWTPs) that serve over 5.7 million residents (Hummel et al., 2018).

TOOLS AND RESOURCES

- Marin City marks beginning of flood-control project
- City of San Rafael Sea Level Rise Collaborative
- Are Water Resources Keeping Up with U.S. Economic Needs? - San Francisco Fed

4.4 Coastal Issues

The Bay Area's coastal lands include tidal marshes, estuaries, coastal grasslands, redwood forests, and working rangelands, all of which serve as critical carbon sinks and provide biodiversity, flood protection, and recreational value (Vaughn et al., 2022). Bay Area marine and coastal ecosystems also hold deep cultural significance for regional Tribes, who have long harvested mussels, clams, oysters, seaweed, surf fish, and salmon, and used abalone, olivella, and clam shells in regalia and ceremony. Continued access to shorelines, fishing grounds, and estuarine landscapes is essential for sustaining traditional food systems, cultural practices, and intergenerational knowledge. These landscapes, however, are increasingly threatened by sea level rise, saltwater intrusion, erosion, wildfire, and urban encroachment, posing risks to carbon sequestration, habitat integrity, and agricultural viability. At the same time, coastal rangelands and farms offer opportunities for climate-smart practices such as compost application, conservation grazing, and habitat restoration, which can improve soil health, build resilience, and strengthen rural economies.

Box 12: *Case Study VIII***:** *Integrating Climate Safety with Affordable Housing: The Canal Community Resilience Planning Project*

This San Rafael case study illustrates how climate adaptation can serve as a vehicle for equity in communities facing both high flood risk and gentrification pressures. By forming a resident-led Steering Committee and engaging over 3,000 locals, the project ensures that resilience planning addresses the "blind spots" of traditional policy, specifically the intersection of climate safety, affordable housing, and displacement. The work highlights that protecting a community from water requires simultaneously protecting their right to stay. See Case Study VIII: "The Canal Community Resilience Planning Project" in **Appendix A**.

San Francisco Bay is one of the largest estuaries in the nation and is the terminus of the Sacramento-San Joaquin Delta. With sea levels rising, BCDC experts expect a jump of 3.1 to 6.6 feet (0.94 to 2 meters) by 2100. This trend puts the region's entire infrastructure, environment, and communities at serious risk (California Coastal Commission Sea Level Rise Policy Guidance, 2024). Low-lying neighborhoods, highways, ports, airports, wastewater treatment facilities, and critical industrial and recreational sites are all vulnerable to inundation, flood damage, and pollution mobilization (Bay Adapt, 2024).

- Nearly every aspect of Bay-Delta ecosystems will be affected by climate change as a result of rising sea levels, increases in air temperatures, changes in precipitation, changes in sediment supply, and more. Natural areas of the shore will need to adapt or transform.
- The interruption of natural processes over the past 200 years as the region has developed has decreased natural Bay-Delta resiliency. A dynamic, resilient ecosystem has become a rigid landscape with brittle features that will have trouble adapting.

- New approaches that use natural shoreline infrastructure, like beaches, marshes, and mudflats, together with managed retreat where necessary, can create more resilient shorelines that respond well to changing conditions.

The Bay Adapt Joint Platform presents a regional vision for coordinated adaptation to rising sea levels. The Joint Platform is a consensus-based document that was developed in 2021. It includes nine actions and 21 specific tasks. 55 Bay Area cities, counties, and nonprofits have endorsed the Joint Platform since its adoption. Action 9 in the joint platform is to track progress and report results to guide future actions. Bay Adapt published the first Joint Platform Impact in 2025. Key results since 2021 include the following:

- 35 adaptation projects have been completed since 2021.
- 44,000 acres of projects have been completed.
- Nearly a dozen initiatives to support climate literacy and support leadership development have been developed.
- A majority of cities and counties have started planning for sea level rise adaptation.
- The Metropolitan Transportation Commission (MTC) and Association of Bay Area Governments (ABAG) completed the Sea Level Rise Adaptation Funding and Investment Framework (MTC/ABAG & BCDC, 2023).

4.5 Agriculture

Agriculture contributes significantly to the region's economy, cultural identity, and food security. This interconnected system of farms, food-producing sectors, restaurants, grocery stores, and other businesses employs nearly half a million people, or about 13% of the region's workforce (Payne et al., 2023). For California as a whole, the four agricultural segments—distribution, processing, production, and support—together account for $311 billion in annual sales, create more than 1.2 million jobs, and provide $84 billion in worker earnings (Dompka et al., 2025).

The Bay Area region's agriculture is diverse; specialty crops like fruits, nuts, vegetables, nursery crops, and flowers form the backbone of the sector, particularly in Napa and Sonoma County. Other important food-producing systems in the Bay are range livestock, poultry, fish, and shellfish. However, these agricultural systems are facing mounting risks.

4.5.1 Key Climate Risks to Agriculture

Farmers across the Bay Area are already feeling the impacts of the changing climate. The most significant threats include:

- **Water volatility:** The Bay Area consumes less water for agriculture compared to other regions of the State (Mount et al., 2023). Variable precipitation and extreme storms risk flooding agricultural lands, washing out roads, and damaging food distribution infrastructure.
- **Temperature Shifts and Fog Reduction**: Warmer winters pose a unique threat to specialty crops by reducing the "chill hours" required for successful blooms and high yields. Concurrently, a lack of winter freezes allows pests and pathogens to survive and thrive year-round (Cornwall

et al., 2014). Additionally, there is high uncertainty regarding the future of coastal summer fog, which currently protects highly productive grape-growing areas in Marin, Napa, and Sonoma counties from extreme heat.

- **Sea Level Rise and Groundwater Hazards**: Coastal agriculture faces severe risks from sea level rise and rising groundwater. This combination causes flooding, degrades low-lying work lands, and leads to saltwater intrusion into vital groundwater irrigation sources. Furthermore, rising groundwater can mobilize toxic contaminants left in the soil, pushing them toward watersheds and threatening the region's front-line aquaculture sites (Hill et al., 2023).
- **Wildfire and Extreme Heat**: Increasing wildfires directly threaten crop survival and food manufacturing infrastructure. Extended periods of extreme heat also severely reduce labor productivity and increase health risks for agricultural workers.

4.5.2 Crop-Specific Risks

VITICULTURE (WINE PRODUCTION)

The Bay Area's vineyards produce grapes that are sold at the highest prices in the state (CDFA, 2021-2022). Sonoma and Napa County vineyards also support a workforce of over 40,000. While short-term warming might slightly increase overall yields, it threatens to lower the quality—and therefore the profitability—of the grapes (Chaplin-Kramer, 2012). Warming causes grapevines to flower, set fruit, and ripen earlier. This earlier bud break paradoxically increases the risk of frost damage, requiring growers to use more water for frost protection in the spring, as well as for heat protection in the summer (Hannah et al., 2013). Long-term, North Bay growers may need to shift to more heat-tolerant grape varieties and will face increased competition as northern regions (like Oregon, Washington, and British Columbia) become more suitable for high-end viticulture.

RANGELANDS AND LIVESTOCK

Rangelands and livestock make up nearly 80% of the Bay Area's agricultural footprint. These vast, open areas support primarily beef cattle, with smaller but still significant dairy herds in Sonoma and Marin Counties. For these operations, the climate challenge is just as real—though it looks different than for vineyards. Rangelands are susceptible to precipitation, heat, and wildfire-related impacts from climate change, which can result in reduced forage quality and quantity. Forage availability—critical for grazing—throughout the Bay Area is projected to decline as the "forage season" shrinks due to increased temperatures and more variable extreme precipitation events.

ADAPTATION AND RESILIENCE

Despite these risks, adaptation is actively underway. In the North Bay, vineyards are adjusting canopy and irrigation management to combat heat, while some growers are experimenting with new, heat-tolerant crops—including tropical fruits. Concurrently, regional climate data dashboards (e.g., California Climate Hubs, USDA) and academic studies are equipping farmers with downscaled models on yields, water demand, and vulnerabilities, allowing them to make data-driven decisions to future-proof their operations.

4.6 Land Use, Land Conversion, and Community Development

The way we design and develop our cities has always shaped the character of the Bay Area—but now, those decisions are becoming critical to the region's climate future. Development influences flood exposure, wildfire vulnerability, heat resilience, and equitable access to safe living environments. Where we build determines who faces flood risks, who is exposed to wildfire and heat, and who has access to safe, livable neighborhoods. As climate change accelerates, land use choices will either deepen existing inequities or help us build a more resilient, inclusive, and sustainable region.

Land use directly influences energy demand from buildings and transportation, urban water use, and even the frequency of wildfire ignitions. Poor planning can worsen climate impacts—amplifying urban heat islands, increasing runoff during extreme storms, and pushing people into areas with higher climate risk. The Bay Area's persistent housing affordability crisis is already forcing many families to move farther north, south, and inland—often into regions with greater exposure to heat, fire, and flood. Without intervention, these trends threaten to further entrench environmental injustice.

Box 13: *Case Study IX: Bay Area Resilience Hotpots: A Blueprint for Community-Driven Adaptation Action*

Greenbelt Alliance's "Resilience Hotspots" initiative utilizes robust spatial analysis to identify 18 Bay Area locations where high climate risk intersects with social vulnerability. By layering physical data with socioeconomic factors, the project created a blueprint for prioritizing nature-based solutions in underserved communities. This data-driven approach has effectively moved beyond theory, catalyzing over $3 million in funding for local adaptation projects in areas like Gilroy and North Richmond. See case study IX: "Bay Area Resilience Hotpots: A Blueprint for Community-driven Adaptation Action" in **Appendix A**.

Land conversion from open space to urban uses continues despite land conservation efforts. Even as land conservation efforts continue, open space is still being lost to urban development. This gradual erosion of natural buffers—wetlands, greenbelts, forests—undermines resilience. In wildfire-prone areas, building too close to these buffers without aligning development with fire-safe planning can dramatically raise fire risk. In flood zones, filling or paving over wetlands removes nature's ability to absorb water, increasing the threat of flooding during storms and king tides. Still, examples of forward-thinking planning are emerging:

- San Francisco's planning initiatives (e.g., Islais Creek and Yosemite Slough adaptation strategies) are integrating sea level mapping, flood overlay zones, community-informed designs, and green infrastructure in shoreline development.
- Smart-growth tools (e.g., EPA's Smart Growth Strategies) promote integrating hazard resilience—earthquake, flood—into land use planning to protect vulnerable communities, especially low-income and transit-dependent residents.
- Organizations like Greenbelt Alliance are partnering with local governments to embed equitable, nature-based land-use policies—prioritizing wildfire greenbelts, floodplain buffers, and climate-resilient zoning.

Amid these systemic threats stands another less visible but equally stubborn barrier: property fragmentation. In highly vulnerable communities like Foster City and Gallinas, a patchwork of actions and ownership complicates adaptation. For example, 45% of residential parcels in Alameda County are under some sort of shared governance (e.g., homeowners associations

or condo boards) (Lamb & Olshansky, 2024). With land divided among private homeowners' associations (HOAs), public entities, and mixed ownership, installing coordinated "gray" infrastructure (like seawalls or levees) and "green" solutions (such as living shorelines or restored wetlands) becomes significantly more complex and expensive—requiring alignment across a web of partners.

4.6.1 Key Climate Risks

By 2050, up to 3.3 ft of Bay-level rise threatens priority development zones and shoreline communities. Land subsidence in parts of the Bay could push flooding even farther inland, potentially exposing 125–429 km^2 of land to flooding (Shirzaei & Bürgmann, 2018). Conversion of greenbelt buffers to housing increases fire risk, especially where greenbelt planning is not aligned with development strategies.

Climate adaptation alone doesn't guarantee resilience. In fact, rapid redevelopment, even when well-intentioned, can trigger climate gentrification—a phenomenon where newly climate-resilient neighborhoods become unaffordable, displacing longtime residents (Ayazi & Popken, 2026). In response, some communities are exploring tools like community land trusts and collective property regimes to retain affordability and ensure climate benefits are shared, not sold (Lamb & Olshansky, 2024).

TOOLS AND RESOURCES

- The San Francisco Estuary Institute's Baylands & Shoreline Resilience team released the Adaptation Toolkit and Baylands Resilience Metrics Mapbook (2025), which support nature-based planning for shoreline development and community protection (SFEI, 2025).
- Bay Adapt's Regional Shoreline Adaptation Plan, 2024.
- Agencies and collaboratives mobilizing efforts: Major actors include ABAG, MTC, BCDC, Save The Bay, Greenbelt Alliance, San Francisco Estuary Partnership, California Coastal Conservancy, city-led programs (e.g., Burlingame, South San Francisco overlay districts), and grassroots collaboratives such as the Canal Community Resilience Project in San Rafael (Sneed, 2024).

4.6.2 Gaps and Needs

Despite growing awareness and regional coordination, critical gaps remain. Equitable green infrastructure—parks, greenways, levees, wetlands—in frontline communities remains chronically underfunded. Local jurisdictions often lack the technical expertise or financial resources to implement complex zoning reforms, pursue managed retreat, or build resilience infrastructure at scale. According to the Adapting to Rising Tides survey, 92% of Bay Area shoreline jurisdictions reported "insufficient funds" as a barrier to sea level rise adaptation, along with a desire for more technical support and inter-jurisdictional coordination (Adapting to Rising Tides, 2021).

Without new funding models and stronger governance frameworks, even the most ambitious plans risk falling short—leaving vulnerable communities exposed to rising water, hotter temperatures, and worsening air quality.

Chapter 5.

Built Systems



Much of the Bay Area's infrastructure, including transit lines, power grids, housing, and wastewater plants, is built directly along the shoreline. Being close to the water has long been a major economic advantage, but today it is also the region's biggest vulnerability.

Climate change is testing the physical limits of these systems. Rising sea levels are a slow-moving but relentless stressor, threatening to inundate highways and housing, while extreme heat and storms deliver acute shocks that can buckle rails and strain the energy grid. Crucially, these physical risks are interconnected, intensifying impacts; a failure in the power grid can impact water delivery, and a flooded highway can cut off emergency services. This section examines the fragility of the region's interconnected infrastructure and the growing gap between the cost of adaptation and available funding.

Confronting the Legacy of Environmental Injustice

> ***"The neighborhoods in Oakland and Fruitvale do not look like that by accident. A few decades ago, they took trees out of the neighborhood to make surveillance easier, which created the heat island effect, worse air pollution, over-policing, and industrialization—a million different intersections. What we are dealing with is not accidental or natural but intentional, an effect of the built environment. It's important to acknowledge that climate change is one thing, and adaptive capacity and vulnerability are another—shaped by the built environment and the decisions we made"***

— Jacy Bowles, Communities United for Restorative Youth Justice (CURYJ), reflecting on how climate change intersects with existing systems of harm. See Case Study II: "Communities United for Restorative Youth Justice: Youth-Led Research for Community Resilience" in **Appendix A.**

Key Messages

- **The Adaptation Funding Gap:** The cost to protect the shoreline is staggering, estimated between $81–$147 billion by 2050, yet current revenue forecasts cover only a fraction— about $5.5 billion—of this need.
- **Interconnected Failure:** Infrastructure systems are codependent. A climate impact on one sector (e.g., power outage from heat) triggers cascading failures in others (e.g., wastewater pump failure or transit shutdown).
- **The "Squeeze" on Development:** The region faces a planning paradox: there is increasing need for housing given its growing population, yet 64,400 planned units are currently sited in areas prone to future flooding.
- **Hidden Hazards:** Beyond visible flooding, rising groundwater threatens to mobilize contaminants from over 400 toxic sites and compromise underground infrastructure like sewer lines.

5.1 Sea Level Rise and Bay Area Infrastructure

Sea level rise (SLR) is one of the major long-term climate threats to the Bay Area. Every county in the Bay Area faces some risk from rising bay and ocean levels (**Figure 25**), but the magnitude of financial liability is only just becoming clear. A 2023 report by MTC/ABAG and BCDC found that the cost of adaptation to sea level rise in the San Francisco Bay could range from $81–$147 billion by

2050, while available revenue from existing federal, state, regional and local funding programs is forecasted at just around $5.5 billion (MTC/ABAG & BCDC, 2023).

The US Geological Survey's Hazard Exposure Reporting and Analytics (HERA) tool estimates a location's exposure to sea level rise under different SLR and storm scenarios. Using HERA, we estimated the number of housing units and land values at risk of inundation under different SLR and storm scenarios. For consistency with the SLR and groundwater rise analyses, we estimated exposure under the following scenarios in 2100:

- Baseline: No SLR and no storm
- Intermediate Scenario for 2100: 3.3 feet of SLR with no storm and with a 100-year event
- High Scenario for 2100: 6.6 feet of SLR with no storm and with a 100-year event

The high scenario for 2100 (6.6 ft of SLR with a 100-year event) is consistent with the high scenario included in the minimum requirements in for sea level rise scenarios in the Regional Shoreline Adaptation Plan for the Bay Area, which requires local governments to consider 4 scenarios (Bay Adapt, 2024).

These results show significant risks in the Bay Area. Under the most extreme scenarios (6.6 ft of SLR and a 100-year high water event), close to 20% of San Mateo County's housing stock is at risk of inundation (**Figure 29**). Marin and Alameda Counties also face high exposure under this extreme scenario. The value of land at risk of inundation is also significant in several Bay Area counties (**Figure 30**).

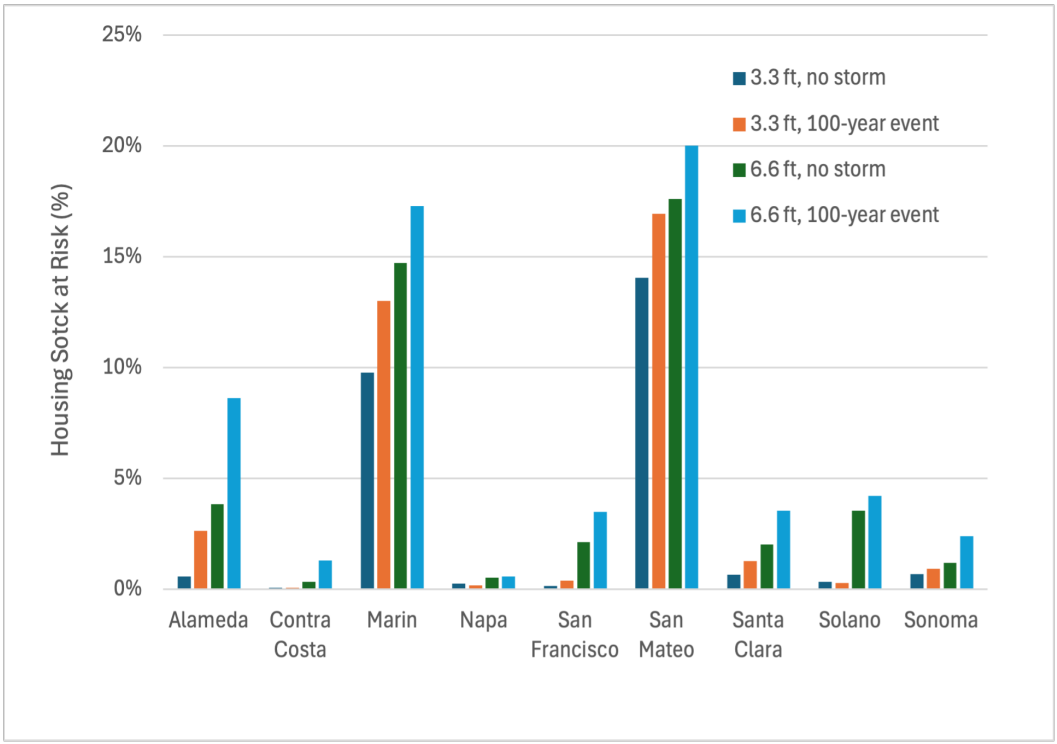


Figure 29: *Percent of current housing stock, by county, at risk under different SLR and high-water scenarios. Results produced using the HERA tool from USGS.*

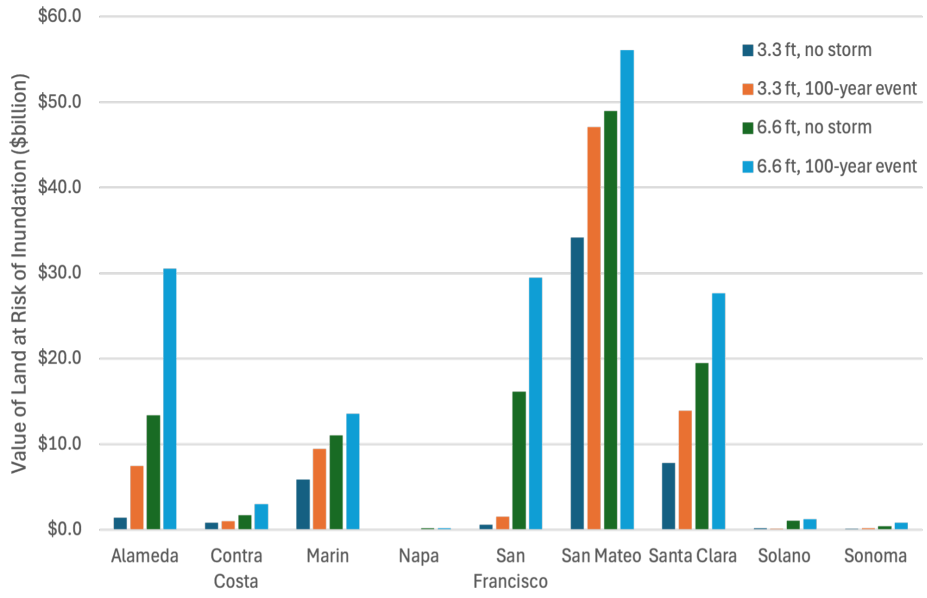


Figure 30: *Value of Land in Bay Area Counties at risk of inundation under different SLR and high-water event scenarios. Results produced using the HERA tool from USGS.*

5.2 Toxic Sites

Rising sea levels also pose a risk to toxic sites in the region. As the Bay rises, so does the shallow groundwater table, which can remobilize contaminants from the region's industrial past before surface flooding even begins. An analysis of SLR in the Bay Area identified 423 hazardous sites at risk of flooding by the end of the century under a high emission scenario, based on an analysis completed using SLR projections developed for California's Fourth Climate Change Assessment (Cushing et al., 2023). The hazardous sites considered in this analysis included oil and gas facilities, landfills, hazardous waste treatment facilities, wastewater treatment facilities, and other industrial sites. Alameda, San Mateo, and Contra Costa counties were among the top five counties in California for the number of toxic sites at risk of flooding.

5.3 Transportation

Transportation in the Bay Area sits at the intersection of land use, energy systems, and climate resilience. However, this system is also among the most vulnerable to climate impacts. Much of the Bay Area's infrastructure—airports, highways, railways, and transit hubs—is concentrated along the shoreline, where rising seas, storm surge, and flooding threaten to disrupt mobility for nearly eight million residents. Subsidence, extreme heat, and more frequent storms further compound the risks, jeopardizing the flow of people, goods, and emergency services across the region.

The vulnerabilities are already well-documented. The Adapting to Rising Tides (ART) program has identified major segments of highways (e.g., Highway 101, Interstate 580, and Highway 37), roads, rail lines, BART stations, ferry terminals, and the Bay Trail as vulnerable to coastal inundation and tidal flooding (Adapting to Rising Tides, 2020). Recent studies model traffic impacts: even modest coastal flooding in the 2020–2040 window can cause cascading delays far inland, especially in communities with sparse alternate routes, independent of proximity to shoreline (Kasmalkar et al., 2020). The Bay Trail—now about 356 miles long and planned to reach 500 miles—serves as a critical non-motorized corridor but is increasingly prone to erosion, surface flooding, and closures (*The San Francisco Bay Trail Risk Assessment and Adaptation Prioritization Plan, n.d.*).

The Cost of Transportation Infrastructure on Frontline Communities

> ***"By the freeway, I smell smoke and exhaust—it's not a good environment. After a car crash, I've even had parts of the car fall down here. I don't like it. It feels like poison. You could get lung cancer or other health problems, so you just try your best to wrap yourself up and stay safe."***

—A public housing resident in Oakland explained that, coming to the US as a war refugee decades ago, she has always felt the need to stay vigilant. She understands her immediate surroundings to be full of risk, environmental and otherwise.

Summary of key climate impacts on the economics of transportation and utilities

- **Sea level rise and groundwater:** Critical infrastructure damage, groundwater contamination due to proximity to hazardous sites, and shifts in traffic and transportation congestion.
- **Variable precipitation (storms and droughts):** Impacts on water resource availability and quality, increased reliance on groundwater, flooding of critical infrastructure, and reduced snowpack.
- **Rising temperatures and extreme heat:** Increased demand for energy, higher energy costs, reduced performance of energy infrastructure, and evaporation impacts on water availability and storage.
- **Wildfire:** Critical infrastructure damage, safety risks to utility workers, impacts on water quality, and public safety power shutoffs.
- **General impacts:** Job growth (e.g., increased maintenance and repair needs), increased demand for resources (water, power, etc.), and shifts in job locations and workforce types that will impact energy usage.

Box 14: *Transportation Fuel Transition*

California is developing a Transportation Fuel Transition Plan, led by the California Energy Commission and California Air Resources Board, to ensure that the shift away from fossil fuels occurs in a way that is reliable, affordable, and equitable. This transition will have major implications for the Bay Area, as the region is home to three operational refineries: the PBF Energy Martinez Refinery, the Valero Benicia Refinery, and the Chevron Richmond Refinery. As the vehicle fleet electrifies and gasoline and diesel consumption decline, the region may experience both opportunities and challenges: improved air quality and reduced emissions, but also potential refinery closures, job transitions, and risks to fuel affordability and supply reliability. For the Bay Area, this underscores the need to plan for refinery community transitions, invest in charging and fueling networks, and strengthen resilience to potential supply disruptions, particularly as climate extremes put new pressures on both the energy and transportation systems.

5.3.1 Key Climate Risks

- **Sea Level Rise & Coastal Flooding:** Roadways such as State Route 37 are projected to be intermittently or permanently inundated by 2050; closures can last days and block access between key employment/commercial corridors (Landers, 2022).
- **Network Disruptions & Cascading Delays:** Even localized flooding or transit station closure (e.g., Embarcadero) can propagate regional disruptions, causing wide commuter delays and isolating vulnerable populations (Suckale et al., 2020).
- **Extreme Storm Damage & Subsidence:** Increased winter storms and rising groundwater levels exacerbate slope failures and drainage issues—undermining highways (e.g. SR-1, SR-121) and bridges—and intensify flooding risks, especially for rail tracks and seawall-adjacent infrastructure (Shirzaei & Bürgmann, 2018).
- **Extreme heat:** It causes damage to roads and railways, like the record-setting 2022 extreme heat event where heat played the main role in partial derailment of a BART train by causing a curve in the rail (Alvarez, 2022).

5.3.2 Resources and Planning

- San Francisco Metropolitan Transit Agency's Climate Adaptation and Resilience program is evaluating and upgrading waterfront transit corridors—particularly the Embarcadero and Ocean Beach network—with plans to raise roadways, critical bridges, and facilities for up to seven feet of sea level rise (SFMTA, n.d.).
- Regional agencies like the BCDC, MTC, Caltrans, and BART collaborate through the ART Program, Bay Adapt Joint Platform, and the State Climate Resilience Improvement Plan for Transportation (SCRIPT) to plan and fund climate-resilient improvements across the region.
- Sonoma County Transportation Authority published a "Planning a More Resilient Highway 37 for All" plan that balances transportation needs with protecting and enhancing sensitive marshland habitats.

5.3.3 Gaps and Needs

Despite these efforts, significant gaps remain. The region lacks sufficient redundancy in its transit and rail corridors, leaving large populations vulnerable to single points of failure. Long-term funding for adaptation, especially in low-income corridors, remains inadequate. Finally, flood modeling and climate data are not yet fully integrated into everyday transportation planning, limiting the region's ability to anticipate and manage risks before they become crises.

5.4 Power Grid / Energy Consumption & Distributed Generation

Rising temperatures are reshaping how, when, and where energy is used. Hotter summers drive up air-conditioning demand, while warmer winters will lead to decline in winter heating demand. Increasing building energy efficiency and resilience at a regional level will be challenging due to large numbers of older houses, multi-family housing units, and small office buildings. Meanwhile, a shift to more distributed generation, such as solar, wind, and storage, presents new challenges in managing the electrical grid (Nwaigwe et al., 2019).

The current system is under stress. In California, extreme weather events—heat waves, storms, and wildfires—were responsible for nearly 61% of the state's major outages between 2000 and 2023. PG&E, the utility serving much of Northern California, has been particularly impacted (Freedman & Chen, 2024). In 2024-25, PG&E rolled out a Climate Adaptation and Vulnerability Assessment (CAVA) analyzing risks from rising temperatures, storms, wildfire, and sea-level rise for utility assets through 2050 (PG&E, 2024). Meanwhile, demands from AI and data centers are projecting up to 3.5 GW of new load in the Bay Area alone—equivalent to powering about 6.5 million homes—raising concerns around reliability, cost, and emissions if renewables don't keep pace (Wolfe, 2024).

The climate risks are unambiguous. Extreme heat events and peak load surges during heat waves may lead to rotating outages if grid storage, transmission, and demand-side management measures lag behind. Rapid electrification of buildings, transport, and industry, including data centers, threatens to push demand past existing infrastructure limits; large investments (an estimated $46–$63 billion by 2045) are needed to upgrade transmission and other elements of the grid. Failure to upgrade transmission and other grid infrastructure could increase vulnerability to congestion, outages, and stranded renewable assets (Yang, 2025).

There is also a need for faster deployment of undergrounding or grid-hardening technologies in vulnerable areas, along with stronger coordination between utilities, CPUC, California Independent System Operator, and local communities, to ensure equitable adaptation and transparent planning. Without these measures, summer peaks, extreme weather, and rapid load growth could overrun the system's capacity and undermine energy reliability, cost, and sustainability.

5.5 Buildings

By the end of this century, sea levels around San Francisco Bay may rise three to six feet or more. Coupled with more extreme weather patterns, over 6% of San Francisco's land (about four square miles), called the "Sea Level Rise Vulnerability Zone," could be inundated by temporary or permanent flooding (San Francisco Planning, n.d.). A significant portion of Bay Area buildings are at increasing risk from flooding and erosion due to rising seas and subsiding land. Collaborative regional assessments (e.g., Adapting to Rising Tides) have documented vulnerabilities in infrastructure and buildings across multiple Bay Area counties.

Summary of key economic risks

- **Sea level rise and groundwater:** Flooding of infrastructure and coastal buildings.
- Variable precipitation (storms and droughts): Flooding of infrastructure and low-lying buildings, storm damage to infrastructure, and interruption of services during power outages.
- **Rising temperatures and extreme heat:** Higher energy costs and interruption of services during power outages.
- **Wildfire:** Increased threats to worker health and safety, infrastructure damage, and increased demand for services during emergency events.
- **General impacts:** Job growth (e.g., climate tech, repair of telecommunications systems, increased demand for services) and increased cost of labor.

5.5.1 Resources and Planning

- The SF Planning Department's Sea Level Rise Action Plan integrates vulnerability assessment and adaptation strategies for public buildings and municipal assets.
- Regional efforts such as Adapting to Rising Tides (in partnership with BCDC, BART, EBMUD, ports, and transit agencies) are coordinating adaptation planning for buildings and infrastructure.
- BCDC's 2024 Shoreline Strategy supports shoreline protection, flood management, and adaptation planning for utilities and built assets.
- The Urban Displacement project aims to understand the nature of gentrification, displacement, and exclusion in American cities. It focuses on creating tools to help communities identify the pressures surrounding them and take more effective action.
- The Federal Reserve Bank of San Francisco describes Recent Innovations in Reducing Home Energy Costs and Improving Resilience for Low- and Moderate-Income Renters and Homeowners
- The California Energy Commission operates the Equitable Building Decarbonization Program

High-resolution mapping of vulnerabilities, especially where flood risk is compounded by land sinking, is insufficiently detailed in many locales. Structural condition data—how buildings will physically respond to flooding, erosion, and inundation—is often lacking. Funding for retrofits is uneven, and lower-income shoreline communities are at risk of being left behind in adaptation planning and investment. Robust equity-centered engagement remains essential to ensure that adaptation strategies are fair, effective, and inclusive.

5.6 Natural Infrastructure

Natural infrastructure can play an important role in climate change adaptation, enhancing biodiversity and ecosystem services while reducing societal risks. In the San Francisco Bay Area, these systems are critical: they protect coastal communities from sea level rise and storms, reduce urban heat and flooding, and support biodiversity and public well-being in the face of climate change. Urban parks and trees enhance cooling and provide shade and can strengthen social ties and local communities.

The Bay Area has lost over 85% of its original tidal marsh habitat, and fewer restored acres remain to serve as living buffers for flooding and storm surge. The San Francisco Estuary Institute's Adaptation Atlas identifies mapped opportunities for nature-based shoreline interventions (living shorelines, horizontal levees, transition zones) across the Bay (Beagle et al., 2019). Urban-scale initiatives like the Sunset Natural Resilience Project and Next Generation Urban Greening in neighborhoods such as Islais Creek are laying groundwork for widespread green stormwater infrastructure.

5.6.1 Key Climate Risks

- **SLR and storm surge** continue to erode shoreline ecosystems, making restored marshes and wetlands essential buffers; without them, flood risk increases notably, especially in low-lying shoreline zones.
- **Sediment shortfalls:** Currently, the sediment supply in the Bay is adequate to meet the sediment needed by tidal marshes and tidal flats. However, as sea level rise accelerates in the coming decades, the sediment needed for these habitats to survive will increase considerably. In addition, a healthy sediment supply will be needed to support the thousands of acres of restored tidal marsh that is being planned around the Bay (SFEI 2015)
- **Urban flooding & stormwater overload:** areas like Islais Creek, which is built on fill, face intensified groundwater and surface flooding, but green infrastructure like bioswales and soft creeks offer multiple benefits, including water retention and heat reduction (SFEI, n.d.).

5.6.2 Gaps and Needs

- Key gaps include insufficient long-term sediment management strategies to sustain tidal wetlands under rising seas, and limited implementation funding or coordinated governance to scale natural infrastructure equitably across vulnerable communities.

5.7 Wastewater, Stormwater, and Water Systems

The Bay Area's wastewater, stormwater, and drinking water systems all face escalating risks from climate change: shrinking water supplies, rising seas, and aging systems not equipped to cope with the extreme changes.

5.7.1 Threats to the Regional Water Supply

The region's water agencies rely on a diverse portfolio of local and imported sources of water **(Figure 31**). The reliability of these sources will vary dramatically in both the short and long term as climate change affects snowpack levels and runoff (e.g., see **Figures 13** and **14**). Climate change will require improved stormwater management in the Bay Area as extreme storm events increase in size and frequency. The reliability of imported surface water, which sustains major population centers, is severely threatened by the destabilization of the Sierra Nevada snowpack (DWR, n.d.). Current projections forecast a critical 48–65% loss of the historical April 1 snowpack average

by the end of the century, drastically complicating long-term storage and delivery (DWR, n.d.). Additionally, rising local sea levels increase saltwater intrusion into the Sacramento-San Joaquin Delta, requiring greater freshwater outflow and further limiting supply (DWR, n.d.).

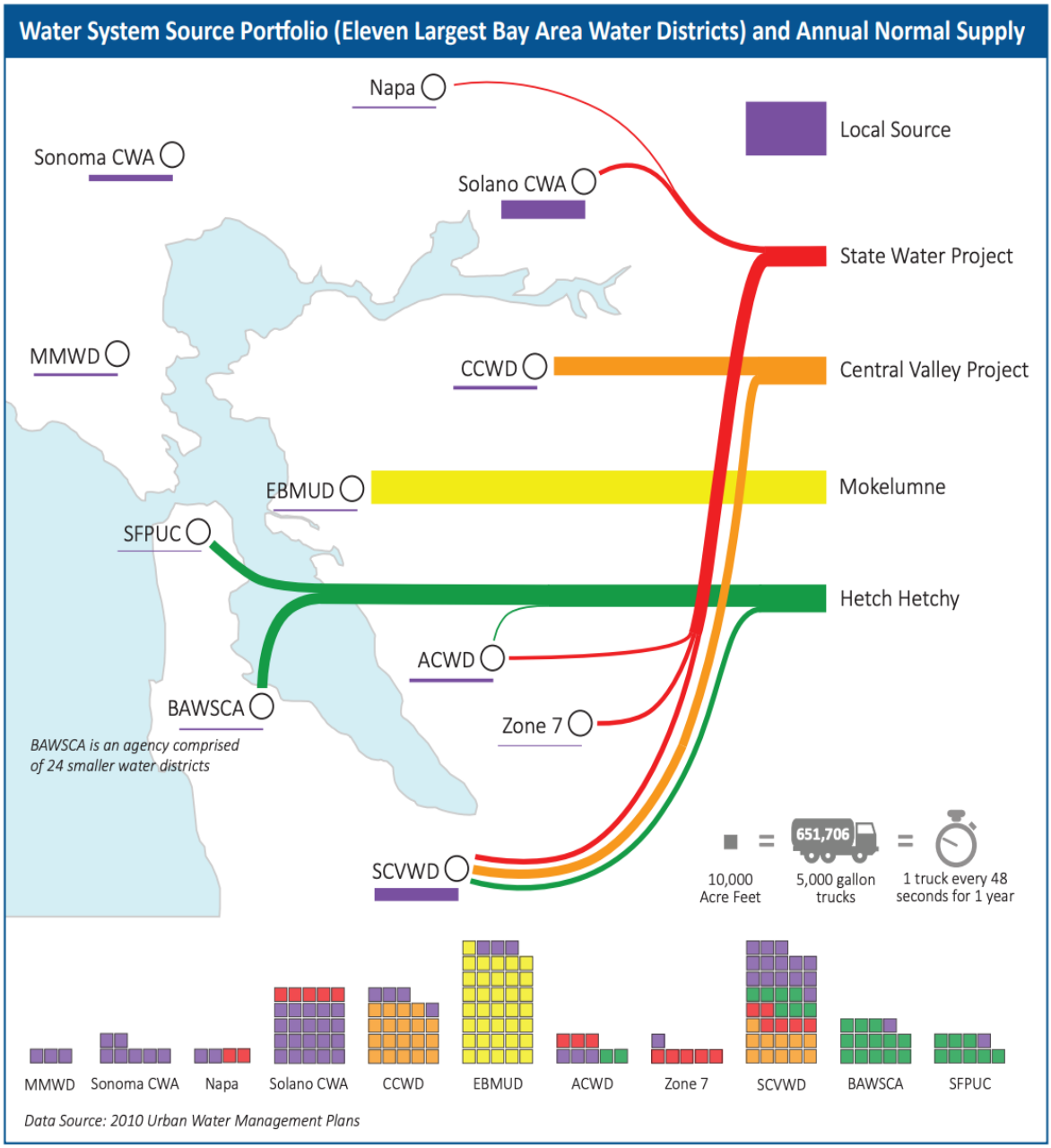


Figure 31: *The Bay Area relies on sources outside of the region for over two-thirds of its water supply. This includes the State Water Project (red line in above figure), the Mokelumne River Watershed (yellow line in above figure), and Hetch Hetchy (green line in above figure) (Germeraad et al., 2014).*

5.7.2 Infrastructure Vulnerability: Wastewater and Stormwater

While water supply shrinks, the infrastructure designed to manage wastewater and stormwater is being overwhelmed.

The region's wastewater treatment plants, historically located along bay shorelines where effluent discharge was convenient, are now highly vulnerable to future sea level rise. Analysis of 36 coastal wastewater treatment plants that serve over 5.7 million residents indicates that the risk of hydraulic failure is compounded by a rising groundwater table beneath the facilities (Hummel et al., 2018; Shirzaei & Bürgmann, 2018). This groundwater flooding, often neglected in initial risk assessments, threatens to overwhelm subterranean infrastructure (Hummel et al., 2018). Furthermore, more extreme precipitation events will overwhelm combined sewer capacity—leading to more frequent overflows, public health risks, and degraded Bay water quality (San Francisco Bay Regional Water Board, n.d.). This climate-driven volatility also increases pollution, sedimentation, and the risk of harmful algal blooms, which threaten ecological habitats and beneficial water uses.

The Ticking Clock of Coastal Infrastructure

> ***"The city does have a system where storm water and sewer water are separated. Storm water and groundwater are then pumped back into the Bay, but these systems are not built to pump salt water. Currently, at high tide, there is seepage of salt water into the pumps which is damaging and corroding them. No significant flooding event yet, but if they were to fail, there would be a significant health and safety risk for the community."***

—Aaron Burnett from Canal Alliance, talking about an emerging worry in the Canal Neighborhood that they are starting to think about. See full interview in ***Appendix B.***

To build resilience, regional agencies are aggressively investing in a circular water economy. The Santa Clara Valley Water District (SCVWD) aims to develop recycled and purified water to meet at least 10% of Santa Clara County's total water demands by 2035 (Santa Clara Valley Water District, 2024). This shift also prioritizes the value of urban stormwater runoff for groundwater recharge, mitigating pollution and offsetting drought impacts (DWR, n.d.).

How Neglected Infrastructure Impacts Day-to-Day Life

> ***"We also have significant issues with stormwater and groundwater flooding, because East Oakland lacks proper infrastructure to manage the storm water, which turns heavy rains into public health risks. Living and working in East Oakland, these issues impact our day-to-day life."***

—Keta Price from Hood Planning: Helping Communities Reimagine their Built Environment. See full interview in ***Appendix B.***

5.8 Housing

The Bay Area projects rapid growth, adding 1.4 million jobs and nearly as many households by 2050—underscoring the urgent need for resilient housing planning (*Final Plan Bay Area 2050*, 2021). Housing instability is exacerbated by climate change, which increases hazards while simultaneously eroding affordability, particularly for low-income residents. Housing is both affected by climate drivers and contributes to regional emissions and social equity challenges.

Safeguarding Vulnerable Renters from Climate Crises

> ***"Disabled individuals are especially vulnerable to climate displacement because they are disproportionately renters and low income (individuals and families), among other risk factors – and if they get displaced, people with disabilities can rarely secure the transportation, housing, employment, and support they need to comfortably relocate. To adapt equitably, we must build dramatically more multifamily housing in climate-safe areas like the Peninsula flats and guarantee that enough units are affordable and/or have advanced accessibility features. We must also create an accessible, inclusive, and equitable Bay Area so disabled individuals can stay in our communities if they get displaced from their homes."***

—Alex Ghenis, Accessible Climate Strategies. See Case Study V: "Disability and Climate Risk: Land Use, Disproportionate Wildfire Risk, and Inclusive Wildfire Resilience Planning" in ***Appendix A.***

Climate drivers, including sea level rise and wildfire, directly jeopardize housing stock. Vulnerability analysis confirms that 64,400 planned housing units in Priority Development Areas (PDAs) are exposed to future flooding risk (Adapting to Rising Tides, 2020). Simultaneously, wildfire risk, which has intensified across the state, now adversely impacts residential real estate values, with insurance proving ineffective at mitigating these adverse financial effects. These compound risks pose a greater threat to the stability of mortgage markets and accelerate housing wealth loss (Bengali & Nechio, 2024).

The concentration of hazards on vulnerable populations highlights a profound equity challenge. Nearly 15,000 households in socially vulnerable communities are exposed to sea level rise, often residing in fragile housing where residents—particularly the elderly, low-income, or those without vehicles—lack the financial means or capacity to prepare or recover from disasters (Adapting to Rising Tides, 2020). Maintaining housing integrity is fundamental to retaining all residents in the wake of a disaster.

Regional planning requires integrating resilience policies directly into housing programs. The Metropolitan Transportation Commission and the Association of Bay Area Governments have committed to resilience planning, estimating $6 billion is needed for housing-related seismic hazard mitigation alone, targeting 385,000 seismically vulnerable units. Furthermore, ABAG provides resources for local jurisdictions to incorporate diverse resilience policies into their Housing Element updates, focusing on reducing exposure and improving adaptive capacity against hazards like wildfire (ABAG, 2015, 2025). This dual focus—on physical mitigation and equity-driven land use—is essential for securing the region's housing future.

TOOLS AND RESOURCES

- Wildfires and Real Estate Values in California - Federal Reserve Bank of San Francisco
- Resources specific to the intersection of housing and wildfire.
  ABAG provides technical assistance to Bay Area jurisdictions and wildfire professionals working at the intersection of wildfire risk and housing preservation, production, and protection. – How to Preserve & Protect Housing – Program Overview
- Resource on the various resilience policies that could be incorporated into a Housing Element or other housing plan: Resilient Housing Policies & Programs

5.8.1 Key Climate Risks

- Extreme heat—with Bay Area temperatures projected to rise by 4–6 °F (2.2–3.3°C) by 2050—will disproportionately affect renters and residents in heat-prone neighborhoods, increasing energy demand and health risks (Climate Vulnerability Assessment, County of Alameda Community Climate Action Plan, 2023).
- Sea level rise and flooding threaten low-lying homes in shoreline cities like Redwood City, where around 22,000 residents (27%) are in zones projected to flood within 25 years (Lee, 2025).
- High-risk communities—low-income renters, seniors, and frontline neighborhoods—face **compounded threats** from hazard exposure, displacement pressure, and limited adaptation resources.

5.8.2 Jobs-to-Housing Imbalance

Regional-scale planning efforts are underway to ensure that the region can support a high level of residential and job growth, with a focus on shifting the latter toward "Growth Areas" as defined in Plan Bay Area 2050. The plan expects that 35% of new jobs will be located in Santa Clara County because of the rapidly growing technology and information sectors, as well as the anticipated growth in healthcare and education sectors needed to meet the demands of an expanding population (Plan Bay Area 2050, 2021).

The East Bay is anticipated to take on one third of new housing and one third of new job growth for the region, providing an opportunity for strategic planning to alleviate the existing commute stress on transit systems which results from the jobs-to-housing imbalance in East Bay counties.

5.8.3 Gaps and Needs

- Major gaps remain in building homes in hazard-prone zones, ensuring protections for vulnerable renters, integrating resilient design in affordable housing, and reforming slow local permitting that stifles adaptation-aligned housing projects (California Assembly Select Committee on Permitting Reform, 2025).

5.9 Emergency Capacity & Mobility

Emergency capacity and mobility encompass the region's ability to respond to and evacuate during disasters, including emergency services (fire, police, EMS), evacuation corridors, transit, and logistical coordination networks. Immediate emergency response relies on the critical interdependence between communication, transportation, and public health/safety networks, where disruption to one component—such as power failure during a heat wave—creates systemic failure across all systems (Ackerly et al., 2018; Julius Maxwell et al., 2018).

Climate change is dramatically increasing the frequency and complexity of demands placed on these systems. Wildfire and smoke emergencies now pose a significant threat to educational stability; during the 2017–18 and 2019–20 school years, more than 1,600 schools closed during such emergencies, affecting an average of 950,000 students per year, a massive surge compared to historical averages (Ehlers et al., 2025). Furthermore, extreme heat places immense strain on emergency services and healthcare systems; with only about 47% of households possessing air conditioning, the majority of the population relies on cooling centers, straining public health logistics (Widerynski et al., 2017). To learn about how displacement from climate-related events impacts education in California, see the Fifth Assessment's "Climate-Induced Human Displacement and Migration Statewide Topical Report."

Evacuation Challenges and Infrastructure Deficits in Frontline Communities

> ***"Everyone in East Oakland and Fruitvale is particularly vulnerable. With limited access to vehicles, frequent gridlock, and sea level rise advancing into East Oakland, these neighborhoods will flood long before the hills do. The infrastructure simply isn't there—and years of disinvestment in these communities have created this reality."***

—Catalina Garzon, Communities United for Restorative Youth Justice (CURYJ), reflecting on the neighborhoods that are most vulnerable to climate change and the reasons why they are so vulnerable. See Case Study II: "Communities United for Restorative Youth Justice: Youth-Led Research for Community Resilience" in ***Appendix A.***

Built infrastructure supporting mobility faces compound risks. Seismic vulnerability remains a threat to critical transit lifelines, although major adaptation efforts, such as the vital BART Transbay Tube Retrofit, were completed in 2024 to address flooding risks in a major earthquake (Bay Area Rapid Transit, 2024). However, extreme weather events like floods and high tides still threaten to clog evacuation roads, transit corridors, and essential service routes. A gap persists in achieving equitable access for evacuation. Vulnerable communities—including low-income, elderly, and zero-vehicle households—often lack the financial means or physical capacity to prepare or respond effectively. Ensuring accessible transit and evacuation systems for frontline communities is an important component of the emergency planning process (Widerynski et al., 2017).

"One Road In, One Road Out": The Fragility of Wildfire Evacuation

> ***"In Marin County, wildfire is our biggest concern when it comes to physical safety. With only one road in and one road out, evacuation during a fire is a major worry for our community."***

—A social worker living in the wooded hills of Marin County reflected on the fragility of daily life. The threat of wildfire feels immediate and personal, and the reality of having only one road in and out shapes how they plan for safety.

Summary of climate impacts on the economics of community and emergency services

(Payne et al., 2023)

- **Sea level rise and groundwater:** Infrastructure damage and reduced access to services and/or impacted regions.
- **Variable precipitation (storms and droughts):** Infrastructure damage, reduced access to impacted regions, and interruption of services due to power outages.
- **Rising temperatures and extreme heat:** Critical infrastructure damage, higher energy costs, interruption of services due to power outages, and increased risk to public/worker health and safety (leading to increased demand for services).
- **Wildfire:** Infrastructure damage, interruption of services, and increased risk to public health.
- **General impacts:** Job growth, increased demand for services, and increased risks to healthcare workers and emergency responders.

TOOLS AND RESOURCES

- The Bay Area Urban Areas Security Initiative's Community Resilience Program supports emergency capacity expansion with GIS vulnerability tools and equity-focused funding.
- Regional plans like the Regional Emergency Coordination Plan and local frameworks—San Francisco's Hazard & Climate Resilience Plan and ClimateSF—govern multi-hazard emergency coordination, response, and equity-driven implementation frameworks.

The Tsunami Wake-Up Call, or Preparedness as Resilience

> ***"We've also learned that climate resilience means more than infrastructure, it's about health, safety, and emergency preparedness. During a tsunami warning last year, there was no clear evacuation plan for our community, which only has one road in and out."***

—Aaron Burnett from Canal Alliance talking about what he has learned about climate resilience through his work in the Canal Neighborhood. See full interview in ***Appendix B.***

Chapter 6.

Regional Governance



The nine-county Bay Area faces a suite of intersecting and cascading climate risks that require action at different scales, across sectors, and by the public and private sectors. Throughout the engagement activities conducted for this report, participants often mentioned governance as a major challenge for adaptation activities in the region. In this case, we use the term "governance" to refer to the coordination and collaborative structures, relationships, and activities that can support coordinated adaptation and resilience actions.

In this section, we highlight some existing governance structures that support coordinated climate adaptation.

Leveraging Youth Organizing in Climate Action

> ***"I believe that young people also bring new solutions to the climate crisis. We know how to organize (especially by leveraging the use of technology and social media), bring a fresh perspective on climate issues through our lived experiences, and retain open mindsets to learn and understand the climate crisis thoroughly. When young people are given a platform to vocalize their input on climate policy, we can create more inclusive, sustainable policies."***

—Emily Yang, San Francisco Youth Commission. See Case Study IV: "Bay Area Youth Climate Summit: Youth Leadership for Climate Resilience" in ***Appendix A.***

6.1 Coordinating Across Jurisdictions and Impacts

6.1.1 Tribal Partnerships

Tribal Nations play a critical role in Bay Area climate governance, yet current adaptation structures often overlook or under-resource Tribal participation. Co-management (the shared planning, stewardship, and decision-making authority between Tribal governments and public agencies) is essential for ensuring that adaptation strategies integrate place-based knowledge, protect cultural resources, and uphold Tribal sovereignty. The Muwekma Ohlone Tribe's collaboration with Jasper Ridge Biological Preserve to conduct cultural burns provides a successful example of such a partnership (see Case Study VI in **Appendix A**).

Expanding Tribal representation in regional governance bodies and planning processes would strengthen adaptation and resilience efforts and ensure that the region's resilience strategies benefit from Indigenous leadership and knowledge systems.

6.1.2 Sea Level Rise

Addressing sea level rise (SLR) in the Bay Area requires coordination across jurisdictional boundaries to be most effective and to avoid maladaptation. The Bay Area has established several structures that support coordination and collaboration.

SENATE BILL 272

Senate Bill 272 requires that all local governments on the open coast and along the San Francisco Bay shoreline develop plans to adapt to SLR. The San Francisco Bay Conservation and Development Commission (BCDC) is working with local jurisdictions in the Bay Area to support plan development. BCDC developed Regional Shoreline Adaptation Plan (RSAP) Guidelines,

provides liaisons to support plan development, and developed the Regional Shoreline Adaptation Plan Atlas (RSAP Atlas), an online data and mapping tool to support plan development.

BAY ADAPT

Bay Adapt is a collaborative organization convened by BCDC to support regional agreement on the actions needed to prepare the region for rising sea levels. Bay Adapt convenes partners, hosts an environmental justice caucus, and is led by a Leadership Advisory Group that includes representatives from local, regional, and federal agencies, local non-profits, academia, and business. In 2021, Bay Adapt adopted the Joint Platform, a consensus-based strategy to support regional adaptation. Bay Adapt issued an impact report on progress toward implementation of the Joint Platform in 2025 (Bay Adapt, 2025).

ONESHORELINE

OneShoreline is a county-wide agency established to address SLR, flooding, coastal erosion, and regional stormwater infrastructure in San Mateo County. OneShoreline was established through state legislation that expanded on the mission of the San Mateo Flood Control District. OneShoreline has developed planning guidance for San Mateo County and its cities to support local planning and permitting processes. They also developed an interactive online Map of Future Conditions to accompany this guidance document.

6.1.2 Heat and Air Quality

Many of the partners engaged in the development of this report identified a need to address the cross-sectoral effects of climate impacts, especially extreme heat. Responding to extreme heat events requires actions across many sectors of government, including public health, parks, public works, and utilities. Some local jurisdictions have established workgroups to address the systemic effects of extreme heat.

San Francisco and Santa Clara County have both established heat and air quality resilience workgroups (HAQR). The workgroups share resources and data and facilitate coordinated implementation of strategies to mitigate extreme heat and poor air quality.

Box 15: *Case Study X: San Francisco Heat and Air Quality Resilience Project (HAQR)*

The San Francisco Heat and Air Quality Resilience Project (HAQR) highlights the importance of centralizing planning for climate adaptation. By bringing together 14 city departments and numerous community partners, the project generated a comprehensive plan with 33 strategies to improve air quality and temperature management. The case study suggests that for cities without established heat programs, fostering deep relationships with partners is necessary for effective technical implementation of these programs. See Case Study X: "Scaling Urban Resilience: San Francisco Heat and Air Quality Resilience Project (HAQR)" in **Appendix A.**

"We Installed Monitors Ourselves": The Fight for Air Quality Data in South San Francisco

> ***"South San Francisco is surrounded by freeways (101, 280, and 380) and located near San Francisco International Airport. Despite that, we had almost no data on air pollution until we installed monitors ourselves. But the community already knew, kids were getting asthma, residents had respiratory issues."***

—Julio Garcia from Rise South City. The residents of South San Francisco had anecdotal evidence that their air quality was bad, pointing to residents' high levels of asthma and respiratory issues. See full interview in ***Appendix B.***

6.2 Coordinating and Collaborative Structures

Beyond specific climate hazards, several organizations act as the connective tissue for the region, fostering shared learning and advocacy.

6.2.1 Bay Area Climate Adaptation Network

The Bay Area Climate Adaptation Network (BayCAN) is a regional collaborative that includes local and regional government, nonprofit, and private sector members. BayCAN meets quarterly for information exchange and shared learning, coordinates activities at a regional and subregional level, provides funding navigation and consultation support, and convenes an equity working group.

6.2.2 Bay Area Regional Collaborative

The Bay Area Regional Collaborative (BARC) coordinates the activities of four regional agencies: the Metropolitan Transportation Commission, Association of Bay Area Governments, Bay Conservation and Development Commission, and Bay Area Air Quality Management District. BARC adopted a shared workplan to advance collaborative projects to support resilience and reduce greenhouse gas emissions in the region.

6.2.3 TOGETHER Bay Area

TOGETHER Bay Area is a regional coalition of government agencies, nonprofits, businesses, and Tribes dedicated to conservation and equitable land stewardship. Grounded in the understanding that their work takes place on Indigenous lands, the organization actively integrates Tribal relations across all its priorities to help return these lands to health. Native-led member organizations are the Amah Mutsun Land Trust, Association of Ramaytush Ohlone, Sogorea Te' Land Trust, and Tamien Nation. TOGETHER's work for Tribal relations and alliances spans across the coalition's priorities. For example, building capacity for these alliances by co-leading the "Right Relations" training program with the Native-led Redbud Resource Group, elevating Native voices at their annual conference, and advocating for accessible funding pathways like the California Natural Resources Agency's Tribal Nature-Based Solutions grant program.

6.2.4 Oakland-Alameda Adaptation Committee

The Oakland Alameda Adaptation Committee is a coalition of cities on the Bay shoreline that span from Oakland south to Oyster Bay. The Committee coordinates flood and adaptation projects in the region.

6.3 Youth Organizing and Action

Governance is not only about agencies; it is about community power. Youth movements in the Bay Area are shifting the narrative from passive awareness to active leadership.

Fostering Youth Leadership: Transforming Climate Grief into Resilience

> ***"I grew up always knowing that climate change existed and that my future would be impacted by it. I felt like 'why is no one doing anything about it?' Recycling, EVs etc. was the narrative to solve climate change, but doing that never made me see the impacts of the individual action. The 2020 wildfire was a wakeup call for me and the other youth. I didn't think I had any power to make a difference, but I found an overwhelming sense of community through BAYCS."***

—Padma Balaji, Bay Area Youth Climate Summit. See Case Study IV: "Bay Area Youth Climate Summit: Youth Leadership for Climate Resilience" in ***Appendix A.***

6.3.1 California Indian Museum and Cultural Center

The California Indian Museum and Cultural Center (CIMCC), located in Santa Rosa, serves as a dedicated community resilience hub for Native populations across Sonoma, Mendocino, and Lake counties. By educating the public on California Indian history and contemporary life, CIMCC empowers local Native youth through several key initiatives that intersect with environmental and community resilience:

- **Climate-Ready Health Training:** The Tribal Community Health Representative program equips Native community members with the skills to educate others and respond to the specific health impacts of climate change, advocating for Tribal health equity.
- **Healthy Ecosystems Curriculum:** This initiative highlights the vital connection between sustainable environments, such as California's oak woodlands and traditional Indigenous food sources like those of the Pomo people. Students learn methods for supporting ecosystem resilience and analyze the impacts of natural disasters, over-consumption, and industrial development.
- **The Cultural Pathways Project:** Developed alongside Native Culture Bearers and mental health professionals, this enhanced Healing Through Cultural Arts program integrates wellness techniques with traditional arts to promote mental health, sustain cultural identity, and strengthen family bonds.
- **Tribal Youth Ambassadors:** Pomo and Miwok youth serve as community advocates, leading educational projects and public presentations to raise awareness about Tribal cultures and modern issues.

6.3.2 Bay Area Youth Climate Summit

The Bay Area Youth Climate Summit (BAYCS) is a youth-led organization established in 2020 to support youth-led action on climate change. In addition to hosting an annual summit, the organization hosts workshops, writes a regular newsletter, and leverages social media to educate and engage youth across the Bay Area. A 30-member Youth Advisory Council leads the organization.

6.3.3 Communities United for Restorative Youth Justice (CURYJ)

CURYJ was established in 2011 to mobilize youth to end mass incarceration and youth criminalization. Based in the Fruitvale in Oakland, CURYJ provides fellowships to formerly incarcerated youth to lead projects in their neighborhood. This has included work to address extreme heat in the Fruitvale area through an audit of local parks and green space, hosting Town Nights on the warmest nights of the year to build community and interrupt violence, and developing and training youth to be organizers and leaders.

"Losing Years of Progress": The Effect of Fear on Community Engagement

> ***"The fear of immigration enforcement is the most significant barrier right now [for community engagement]. With recent reports of immigration agents in the city, people are scared to attend meetings or even answer the phone. We're facing the possibility of losing 4 to 5 years of progress due to fear, and it is a justified fear. Even legal residents and citizens are increasingly hesitant to engage. The undocumented immigrant community is the one with the biggest needs, those were the voices we were trying to lift at the forefront."***

*—Julio Garcia from Rise South City (see full interview in **Appendix B**)*

Box 16: *Case Study XI: San Francisco Youth Commission*

The San Francisco Youth Commission case study underscores the necessity of including young people, who will face significantly more extreme heat days and sea level rise by late century, in today's policy decisions. Representing over 113,000 youth, the Commission brings essential urgency to climate discussions, advocating for solutions that address the long-term livability of the city. Their work demonstrates that youth leadership is not just about advocacy, but about securing a just future through direct legislative engagement. See full Case Study XI "Empowering the Next Generation: San Francisco Youth Commission" in **Appendix A.**

Chapter 7.

Conclusion



The Bay Area continues to stand at the forefront of both the challenges and the opportunities presented by a changing climate. Since the 2018 Bay Area Regional Report for California's Fourth Climate Change Assessment, the region has experienced accelerating impacts of climate change, including historic wildfires, droughts, intensifying heat, and sea level rise, while also demonstrating an extraordinary capacity for innovation, collaboration, and resilience.

This 2026 Regional Report highlights the stories of Bay Area communities who are already confronting these impacts and leading the way toward equitable, place-based solutions. Through the case studies and firsthand accounts featured throughout the report, we see the human dimensions of adaptation—how residents, Tribal Nations, local governments, and community-based organizations are working on the ground to implement climate adaptation solutions and collaborating with each other. Their experiences reveal not only the urgency of this moment, but also the creativity and commitment that define the Bay Area's response.

The projects and partnerships described throughout this report underscore a key lesson: effective climate action is grounded in relationships. From neighborhood-scale resilience hubs and wildfire preparedness programs to regional data collaborations, these initiatives demonstrate what is possible when science, policy, and community expertise work together.

7.1 Areas for Future Research

The engagement and analysis of climate impacts conducted for this report reveal areas for future research on climate impacts and on the governance and finance systems needed to build resilience in the region.

7.1.1 Generation of Climate Model Data in Future California Climate Change Assessment Reports

The climate in California demonstrates high variability among seasons, years, and decades. This is especially true for California's precipitation, which also exhibits large differences across the state (e.g., Northern versus Southern California) and regionally (e.g., the western versus eastern slopes of the Sierra Nevada). While we are confident that the most severe California storms will become substantially wetter and temperatures will increase, any quantitative interpretation of the LOCA2 and LOCA2-Hybrid projection for decision-making should be made cautiously. Extracting the human-induced signal from the natural variability in climate change projections is challenging, and is best achieved with large ensembles of climate model simulations (Tebaldi et al., 2021). Because of computational, financial, and human limitations, the LOCA2 and LOCA2-Hybrid used herein preclude a comprehensive quantitative assessment of human-induced changes to California's climate. We commend the data providers for their thorough and thoughtful approach to model selection and downscaling in support of current and past California Climate Change Assessments (Krantz et al., 2021; Pierce et al., 2016). While these products provide a uniform dataset for assessment across the reports, substantial uncertainty remains in these projections. Climate modeling through dynamical downscaling provides more defensible projection results (based on known physical mechanisms) than statistical downscaling procedures do. However, aforementioned resource limitations preclude dynamically downscaling large, global climate model

ensembles. Because statistical downscaling algorithms are trained on the historical climate of the recent past using gridded products (e.g., Pierce et al., 2014, 2023), they may not fully incorporate these known physical mechanisms of variability and/or change. For instance, the LOCA2 and LOCA2-Hybrid downscaling algorithm has built-in assumptions that limit physical feedbacks that shape precipitation increases with warming (Siler et al., 2026). There is strong evidence that structural changes in extreme storms are underestimated by statistical downscaling (Baek et al., 2024). Furthermore, LOCA2 and LOCA2-Hybrid do not account for oceanic modulation of coastal land temperatures (Ullrich, 2023). In general, these projections are inconsistent with others in the literature (Dong et al., 2019; Huang, Stevenson, et al., 2020; Huang, Swain, et al., 2020)1.

It is unlikely that downscaling technology will advance far enough to solve these data generation limitations in time for California's Sixth Climate Change Assessment, if ever. However, by leveraging machine learning and other advanced computational approaches to downscale climate data, there may be an opportunity to expand the range of possible future climates and to understand the magnitude of human-induced climate change relative to the natural variability of California's climate. Finally, minimal independent validation of the data for California has been performed (Baek et al., 2024; Ullrich, 2023), thereby limiting confidence in projection skill. Despite these limitations, which are well-known within the Earth system modeling and climate hazard communities, downscaled projections nonetheless can provide insight to inform adaptations that reduce environmental hazards posed to California's communities. Users of climate model data should exercise their own expert judgment and the recommendations of the guidance document.

7.1.2 Climate Impacts

The Bay Area is already experiencing climate impacts, and there are fairly high levels of certainty in the projections for increasing temperature, including more frequent extreme heat events. However, there are several areas that remain uncertain and require additional research, including:

- **Fog**: Fog plays an important role in the Bay Area's climate and ecology. Because fog is a complex phenomenon to model, large uncertainties remain about how fog patterns could change in future climate conditions. Reductions in coastal fog could result in increased demand for energy for cooling and impact ecosystems. This is an important future area of research to understand impacts on people, the built environment, and natural systems in the Bay Area.
- **Rising Sea Levels and Vertical Land Motion**: Projections show extensive impacts from rising sea levels and related rising groundwater levels. Rising sea levels pose risks to infrastructure, communities, and economic centers of the Bay Area. Current projections also show further risk from rising groundwater levels associated with rising sea levels. Recent analysis of vertical land motion suggests that current projections likely underestimate these risks in the Bay Area due to the subsidence in the region. Understanding vertical land motion under future conditions is an important area for future research.

7.1.3 Governance and Finance

Building resilience in the Bay Area requires significant investment and high levels of regional coordination and collaboration. Because of this, finance and governance will be critical areas for future research and regional work.

- **Finance**: The Association of Bay Area Governments (ABAG) and the Metropolitan Transportation Commission (MTC) estimate that preparing the region for rising sea levels will require at least $120 billion. This estimate only addresses one hazard and does not account for cascading and interacting effects between climate impacts. Because of this, the regional cost of adaptation and resilience is likely to be far greater. Identifying pathways to use currently available resources and identify additional resources to support relevant research, adaptation, and resilience will be critical for the region.
- **Regional Coordination and Collaboration**: Adaptation in the Bay Area requires collaboration across jurisdictions and the public and private sectors. Recent legislation and the Bay Conservation and Development Commission (BCDC)'s leadership provides an example for how the region is coordinating on addressing rising sea levels in San Francisco Bay. However, few examples exist for coordination on other impacts, such as extreme heat or wildfire. Focused efforts to identify priorities for regional collaboration on preparedness activities, including planning and project implementation, will be important for the region. Taking advantage of existing collaborative structures, such as BARC and BayCAN, can provide a valuable starting point to develop these priorities.

Looking ahead, the Bay Area's path to resilience will require sustained investment, innovation, and coordination across all sectors. The findings of this report, and the voices within it, should inform the next generation of climate policies, research priorities, and funding decisions. They also remind us that adaptation is not only a technical challenge, but a collective process of reimagining what thriving communities look like in a changing world.

References



Ackerly, D., Jones, A., Stacey, M., & Riordan, B. (2018). *San Francisco Bay Area Summary Report. California's Fourth Climate Change Assessment*.

ABAG. (2015). *Housing*. Association of Bay Area Governments. https://abag.ca.gov/our-work/resilience/policy/housing

ABAG. (2025). *Wildfires—How to Preserve & Protect Housing—Program Overview*. Association of Bay Area Governments. https://abag.ca.gov/technical-assistance/wildfires-how-preserve-protect-housing-program-overview

***Adapting to Rising Tides.* (2020).** Bay Conservation and Development Commission (BCDC) and Metropolitan Transportation Commission/Association of Bay Area Governments (MTC/ABAG).

Adapting to Rising Tides. (2021). *Sea Level Rise Adaptation Progress, Gaps & Needs.* San Francisco Bay Conservation and Development Commission (BCDC). https://www.adaptingtorisingtides.org/project/sea-level-rise-adaptation-progress-gaps-needs/

Alahmad, B., Lung, S.-C. C., Makar, A., Alwadi, Y., Chiu, C.-H., Hu, S.-C., Chen, L.-J., Chen, H. H., & Chen, C. Y. (2025). Heat stress and productivity losses in urban construction workforces. *Nature Cities*, *2*(8), 703–707. https://doi.org/10.1038/s44284-025-00283-1

Alvarez, F. (2022, June). 140-degree railroad tracks led to Bay Area train derailment—*Los Angeles Times*. Los Angeles Times. https://www.latimes.com/california/story/2022-06-23/140-degree-railroad-tracks-led-to-bay-area-train-derailment

Ayazi, H., & Popken, B. (2026). Climate-Induced Human Displacement & Migration Topical Report (California's Fifth Climate Change Assessment). University of California, Berkeley. https://www.climateassessment.ca.gov/2816/

Baek, S. H., Ullrich, P. A., Dong, B., & Lee, J. (2024). Evaluating downscaled products with expected hydroclimatic co-variances. Geoscientific Model Development, 17(23), 8665–8681. https://doi.org/10.5194/gmd-17-8665-2024

Barnard, P. L., Erikson, L. H., Foxgrover, A. C., Hart, J. A. F., Limber, P., O'Neill, A. C., van Ormondt, M., Vitousek, S., Wood, N., Hayden, M. K., & Jones, J. M. (2019). Dynamic flood modeling essential to assess the coastal impacts of climate change. *Scientific Reports*, 9(1), 4309. https://doi.org/10.1038/s41598-019-40742-z

Bay Adapt. (2024). *Regional Shoreline Adaptation Plan*. San Francisco Bay Conservation and Development Commission (BCDC). https://www.bayadapt.org/regional-shoreline-adaptation-plan/

Bay Adapt. (2025). *Bay Adapt Impact Report 2021-2025*. https://www.bayadapt.org/bay-adapt-impact-report-2025/

Bay Area Equity Atlas. (n.d.). *Indigenous Populations in the Bay Area*. Retrieved February 20, 2026, from https://www.bayareaequityatlas.org/about/californias-tribal-nations/indigenous-populations-in-the-bay-area

Bay Area Rapid Transit. (2024). *Transbay Tube Retrofit—Completed 2024*. https://www.bart.gov/about/projects/eqs/retrofit

Beagle, J., Lowe, J., McKnight, K., Safran, S., Tam, L., & Szambelan, S. J. (2019). *San Francisco Bay Shoreline Adaptation Atlas | San Francisco Estuary Institute.* https://www.sfei.org/projects/san-francisco-bay-shoreline-adaptation-atlas

Befus, K. M., Barnard, P. L., Hoover, D. J., Finzi Hart, J. A., & Voss, C. I. (2020a). Increasing threat of coastal groundwater hazards from sea-level rise in California. *Nature Climate Change, 10*(10), 946–952. https://doi.org/10.1038/s41558-020-0874-1

Befus, K. M., Barnard, P. L., Hoover, D. J., Finzi Hart, J. A., & Voss, C. I. (2020b). Increasing threat of coastal groundwater hazards from sea-level rise in California. *Nature Climate Change, 10*(10), 946–952. https://doi.org/10.1038/s41558-020-0874-1

Bell, M. L., Gasparrini, A., & Benjamin, G. C. (2024). Climate Change, Extreme Heat, and Health. *The New England Journal of Medicine, 390*(19), 1793–1801. https://doi.org/10.1056/NEJMra2210769

Bellisario, J., Kallerman, P., Cowan, G., & Raisz, A. (2021). *The True Cost of Wildfires*. Bay Area Council Economic Institute. https://www.bayareaeconomy.org/report/the-true-cost-of-wildfires/

Bengali, L., & Nechio, F. (2024, August 26). *Wildfires and Real Estate Values in California* [Letter]. https://www.frbsf.org/research-and-insights/publications/economic-letter/2024/08/wildfires-and-real-estate-values-in-california/

Berke, P., Yu, S., Malecha, M., & Cooper, J. (2023). Plans that Disrupt Development: Equity Policies and Social Vulnerability in Six Coastal Cities. *Journal of Planning Education and Research, 43*(1), 150–165. https://doi.org/10.1177/0739456X19861144

Bohn, S., Payares-Montoya, D., & McConville, S. (2025a). *California's Energy Workforce: Needs and Opportunities. Public Poilcy Institute of California*. https://www.ppic.org/?show-pdf=true&docraptor=true&url=https%3A%2F%2Fwww.ppic.org%2Fpublication%2Fcalifornias-energy-workforce-needs-and-opportunities%2F

Bohn, S., Payares-Montoya, D., & McConville, S. (2025b). *California's Energy Workforce: Needs and Opportunities*. Public Policy Institute of California.

Bosserelle, A. (2022). *Groundwater Rise and Associated Flooding in Coastal Settlements Due To Sea-Level Rise: A Review of Processes and Methods*. https://doi.org/10.1029/2021EF002580Digital%20Object%20Identifier%20(DOI)

Brumberg, H. L., Karr, C. J., & COUNCIL ON ENVIRONMENTAL HEALTH. (2021). Ambient Air Pollution: Health Hazards to Children. *Pediatrics, 147*(6), e2021051484. https://doi.org/10.1542/peds.2021-051484

***California Assembly Select Committee on Permitting Reform.* (2025).** California State Assembly.

***California Coastal Commission Sea Level Rise Policy Guidance.* (2024).** California Coastal Commission. https://opc.ca.gov/wp-content/uploads/2024/05/California-Sea-Level-Rise-Guidance-2024-508.pdf

California Sea Level Rise Science Task Force, California Ocean Protection Council, & California Ocean Science Trust. (2024). *California Sea Level Rise Guidance: 2024 Science and Policy Update*. https://opc.ca.gov/wp-content/uploads/2024/05/California-Sea-Level-Rise-Guidance-2024-508.pdf

Calkin, D. E., Cohen, J. D., Finney, M. A., & Thompson, M. P. (2014). How risk management can prevent future wildfire disasters in the wildland-urban interface. *Proceedings of the National Academy of Sciences, 111*(2), 746–751. https://doi.org/10.1073/pnas.1315088111

Cassidy, E. (2023, March 18). *Precipitation Piles on in California*. NASA Science. NASA. (2023, March 18). https://science.nasa.gov/earth/earth-observatory/precipitation-piles-on-in-california-151107/

Chaplin-Kramer, R. (2012). *Climate Change and the Agricultural Sector in the San Francisco Bay Area: Changes in Viticulture and Rangeland Forage Production Due to Altered Temperature and Precipitation Patterns*. https://escholarship.org/uc/item/1rp9w0kj

Chen, D., Rojas, M., Samset, B., Cobb, K., Diongue Niang, A., Edwards, P., Emori, S., Faria, S., Hawkins, E., Hope, P., Huybrechts, P., Meinshausen, M., Mustafa, S., Plattner, G.-K., & Tréguier, A.-M. (2021). 2021: Framing, Context, and Methods. In Climate *Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 147–286). Cambridge University Press. https://doi.org/10.1017/9781009157896.003

Chen, X., & Wang, H. (2023). Impact of sea level rise on asphalt pavement responses considering seasonal groundwater and moisture gradient in subgrade. *Transportation Geotechnics, 40*, 100992. https://doi.org/10.1016/j.trgeo.2023.100992

Clemesha, R. E. S., Gershunov, A., Iacobellis, S. F., Williams, A. P., & Cayan, D. R. (2016). The northward march of summer low cloudiness along the California coast. *Geophysical Research Letters, 43*(3), 1287–1295. https://doi.org/10.1002/2015GL067081

Climate Change Impacts Across California—Workers and Employers. (n.d.). Retrieved February 19, 2026, from https://lao.ca.gov/Publications/Report/4587

Climate Vulnerability Assessment, County of Alameda Community Climate Action Plan. (2023). County of Alameda. https://www.acgov.org/cda/planning/documents/Appendix-B-Climate-Vulnerability-Assessment.pdf

Cornwall, C, S. Moore, D. DiPietro, & S. Veloz. (2014). *Climate Ready Sonoma County: Climate Hazards and Vulnerabilities.*

Cushing, L. J., Ju, Y., Kulp, S., Depsky, N., Karasaki, S., Jaeger, J., Raval, A., Strauss, B., & Morello-Frosch, R. (2023). Toxic Tides and Environmental Injustice: Social Vulnerability to Sea Level Rise and Flooding of Hazardous Sites in Coastal California. *Environmental Science & Technology, 57*(19), 7370–7381. https://doi.org/10.1021/acs.est.2c07481

Dettinger, M. (2011). Climate Change, Atmospheric Rivers, and Floods in California – A Multimodel Analysis of Storm Frequency and Magnitude Changes. *JAWRA Journal of the American Water Resources Association, 47*(3), 514–523. https://doi.org/10.1111/j.1752-1688.2011.00546.x

Dompka, A., Hill, A., & Wilcher, A. (2025). *California's Working Landscapes: Evolving Contributions to National, State, and Regional Economies*. University of California, Agriculture and Natural Resources. https://ucanr.edu/sites/default/files/2026-01/WorkingLandscapes-Compliant-Dec_0.pdf

Dong, L., Leung, L. R., Lu, J., & Yang, G. (2019). Contributions of Extreme and Non-Extreme Precipitation to California Precipitation Seasonality Changes Under Warming (Pt. 13470–13478). *Geophysical Research Letters, 46*(22). https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2019GL084225

Duggan, T. (2025, June). *West Coast whale population plunges to lowest level since 1970s*. San Francisco Chronicle. https://www.sfchronicle.com/climate/article/gray-whale-count-20384014.php

Durre, I., Arguez, A., Schreck, C. J., Squires, M. F., & Vose, R. S. (2022). Daily High-Resolution Temperature and Precipitation Fields for the Contiguous United States from 1951 to Present. *Journal of Atmospheric and Oceanic Technology, 39*(12), 1837–1855. https://doi.org/10.1175/JTECH-D-22-0024.1

DWR. (n.d.). *Climate Change and Water*. California Department of Water Resources. Retrieved February 19, 2026, from https://water.ca.gov/Programs/All-Programs/Climate-Change-Program/Climate-Change-and-Water

East Bay Regional Parks. (2019). *Native Peoples of the East Bay: Past to Present*. https://www.ebparks.org/sites/default/files/Native_Peoples_Map_Brochure_2020.pdf

Ehlers, T., Frost, J., Madeira, C., & Shim, I. (2025). *Macroeconomic impact of weather disasters: A global and sectoral analysis*. https://www.bis.org/publ/work1292.pdf

Fawcett, E. (2023, March 2). California Digs Out From Barrage of Snow Before the Next Storm. *The New York Times*. https://www.nytimes.com/2023/03/02/us/california-snow.html

Freedman, A., & Chen. (2024, April 29). *The rise of extreme weather-related power outages in California*. Axios. https://www.axios.com/local/san-francisco/2024/04/29/california-extreme-weather-power-outages

Germeraad, M., Mieler, D., & Brechwald, D. (2014). *Cascading Failures: Earthquake Threats to Transportation and Utilities*. Association of Bay Area Governments.

Gershunov, A., Hatchett, B., Weyant, A., Dettinger, M., Su, L., Rhoades, A., Williams, P., Anderson, M., Rittelmeyer, P., Lettenmayer, D., Cayan, D., Niño, R. L., Guirguis, K., Corringham, T., Maendly, R., & Ralph, F. M. (2025). Atmospheric Rivers and Floods in California's Changing Hydroclimate. *San Francisco Estuary and Watershed Science, 23*(3). https://doi.org/10.15447/sfews.2025v23iss3art3

***Glossary of Meteorology*. (n.d.).** American Meteorological Society. Retrieved February 19, 2026, from https://www.ametsoc.org/ams/publications/glossary-of-meteorology/

Gorman, S., Trotta, D., & Trotta, D. (2023, March 21). Explainer: What California's atmospheric rivers mean for drought, floods, fires. *Reuters*. https://www.reuters.com/business/environment/what-californias-atmospheric-rivers-mean-drought-floods-fires-2023-03-21/

Gould, C. F., Heft-Neal, S., Heaney, A. K., Bendavid, E., Callahan, C. W., Kiang, M. V., Graff Zivin, J., & Burke, M. (2025). Temperature extremes impact mortality and morbidity differently. *Science Advances, 11*(31), eadr3070. https://doi.org/10.1126/sciadv.adr3070

Govorcin, M., Bekaert, D. P. S., Hamlington, B. D., Sangha, S. S., & Sweet, W. (2025). Variable vertical land motion and its impacts on sea level rise projections. *Science Advances, 11*(5), eads8163. https://doi.org/10.1126/sciadv.ads8163

Gurdak, J. (2025). *Groundwater Response to Tides, Seawater Intrusion, and Sea-Level Rise in Santa Clara County, California*.

Habel, S., Fletcher, C. H., Anderson, T. R., & Thompson, P. R. (2020). Sea-Level Rise Induced Multi-Mechanism Flooding and Contribution to Urban Infrastructure Failure. *Scientific Reports, 10*(1), 3796. https://doi.org/10.1038/s41598-020-60762-4

Habel, S., Fletcher, C. H., Barbee, M. M., & Fornace, K. L. (2024). Hidden Threat: The Influence of Sea-Level Rise on Coastal Groundwater and the Convergence of Impacts on Municipal Infrastructure. *Annual Review of Marine Science, 16*(Volume 16, 2024), 81–103. https://doi.org/10.1146/annurev-marine-020923-120737

Habel, S., Fletcher, C. H., Rotzoll, K., & El-Kadi, A. I. (2017). Development of a model to simulate groundwater inundation induced by sea-level rise and high tides in Honolulu, Hawaii. *Water Research, 114*, 122–134. https://doi.org/10.1016/j.watres.2017.02.035

Hamlington, B. D., Bellas-Manley, A., Willis, J. K., Fournier, S., Vinogradova, N., Nerem, R. S., Piecuch, C. G., Thompson, P. R., & Kopp, R. (2024). The rate of global sea level rise doubled during the past three decades. *Communications Earth & Environment, 5*(1), 601. https://doi.org/10.1038/s43247-024-01761-5

Hamlington, B. D., Cheon, S. H., Thompson, P. R., Merrifield, M. A., Nerem, R. S., Leben, R. R., & Kim, K.-Y. (2016). An ongoing shift in Pacific Ocean sea level. *Journal of Geophysical Research: Oceans, 121*(7), 5084–5097. https://doi.org/10.1002/2016JC011815

Hannah, L., Roehrdanz, P. R., Ikegami, M., Shepard, A. V., Shaw, M. R., Tabor, G., Zhi, L., Marquet, P. A., & Hijmans, R. J. (2013). Climate change, wine, and conservation. *Proceedings of the National Academy of Sciences, 110*(17), 6907–6912. https://doi.org/10.1073/pnas.1210127110

Harrison, S., Franklin, J., Hernandez, R. R., Ikegami, M., Safford, H. D., & Thorne, J. H. (2024). Climate change and California's terrestrial biodiversity. *Proceedings of the National Academy of Sciences, 121*(32), e2310074121. https://doi.org/10.1073/pnas.2310074121

Hatchett, B. J., Cao, Q., Dawson, P. B., Ellis, C. J., Hecht, C. W., Kawzenuk, B., et al. (2020). Observations of an extreme atmospheric river storm with a diverse sensor network. *Earth and Space Science*, 7, e2020EA001129. https://doi.org/10.1029/2020EA001129

Heberger, M., Cooley, H., Moore, E., & Herrera, P. (2012). *THE IMPACTS OF SEA LEVEL RISE ON THE SAN FRANCISCO BAY*.

Hill, K., Hirschfeld, D., & Lindquist, C. (2023). *Rising Coastal Groundwater as a Result of Sea-Level Rise Will Influence Contaminated Coastal Sites and Underground Infrastructure*. https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2023EF003825

Hodge, G. A., & Greve, C. (2017). On Public–Private Partnership Performance: A Contemporary Review. *Public Works Management & Policy, 22*(1), 55–78. https://doi.org/10.1177/1087724X16657830

Huang, X., Stevenson, S., & Hall, A. D. (2020). Future Warming and Intensification of Precipitation Extremes: A "Double Whammy" Leading to Increasing Flood Risk in California. *Geophysical Research Letters, 47*(16), e2020GL088679. https://doi.org/10.1029/2020GL088679

Huang, X., Swain, D. L., & Hall, A. D. (2020). Future precipitation increase from very high resolution ensemble downscaling of extreme atmospheric river storms in California. *Science Advances, 6*(29), eaba1323. https://doi.org/10.1126/sciadv.aba1323

Hummel, M. A., Berry, M. S., & Stacey, M. T. (2018). Sea Level Rise Impacts on Wastewater Treatment Systems Along the U.S. Coasts. Earth's Future, 6(4), 622–633 https://doi.org/10.1002/2017EF000805

Ixierda, I. (2022, November 21). More than 100 Cultural Items Voluntarily Returned. Sogorea Te' Land Trust. https://sogoreate-landtrust.org/2022/11/21/more-than-100-cultural-items-voluntarily-returned/

Jerrett, M., Connolly, R., Garcia-Gonzales, D. A., Bekker, C., Nguyen, J. T., Su, J., Li, Y., & Marlier, M. E. (2024). Climate change and public health in California: A structured review of exposures, vulnerable populations, and adaptation measures. *Proceedings of the National Academy of Sciences of the United States of America, 121*(32), e2310081121. https://doi.org/10.1073/pnas.2310081121

Johnstone, J. A., & Dawson, T. E. (2010). Climatic context and ecological implications of summer fog decline in the coast redwood region. *Proceedings of the National Academy of Sciences of the United States of America, 107*(10), 4533–4538. https://doi.org/10.1073/pnas.0915062107

Julius Maxwell, K., Grambsch, A., Kosmal, A., Larson, L., & Sonti, N. (2018). Built Environment, Urban Systems, and Cities. *In: Reidmiller, D.R.; Avery, C.W.; Easterling, D.R.; Kunkel, K.E.; Lewis, K.L.M.; Maycock, T.K.; Stewart, B.C., Eds. 2018. Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II. Washington, DC: U.S. Global Change Research Program*. Pp. 438–478., II, 438–478. https://doi.org/10.7930/NCA4.2018.CH11

Kasmalkar, I. G., Serafin, K. A., Miao, Y., Bick, I. A., Ortolano, L., Ouyang, D., & Suckale, J. (2020). When floods hit the road: Resilience to flood-related traffic disruption in the San Francisco Bay Area and beyond. *Science Advances, 6*(32), eaba2423. https://doi.org/10.1126/sciadv.aba2423

Khan, S., Reynolds, K., Pathak, T., Anderegg, L., Bremer-Kelly, L., Campe, S., Campos, B., Chakraborty, A., Huning, L., Jha, P., Reed, C., Trugman, A., Whitaker, A., & Wilcher, A. (2026). *Sierra Nevada Regional Report* (California's Fifth Climate Change Assessment). University of California, Merced. https://www.climateassessment.ca.gov/2810/

Knott, J., Elshaer, M., & Jo Sias, D. (2017). *Assessing the Effects of Rising Groundwater from Sea Level Rise on the Service Life of Pavements in Coastal Road Infrastructure*. https://journals.sagepub.com/doi/10.3141/2639-01

Kramer, A. L., Liu, J., Li, L., Connolly, R., Barbato, M., & Zhu, Y. (2023). Environmental justice analysis of wildfire-related PM2.5 exposure using low-cost sensors in California. *Science of The Total Environment, 856*, 159218. https://doi.org/10.1016/j.scitotenv.2022.159218

Krantz, W., Pierce, D., Goldenson, N., & Cayan, D. (2021, November 29). *Memorandum on Evaluating Global Climate Models for Studying Regional Climate Change in California* [Letter]. https://www.energy.ca.gov/sites/default/files/2022-09/20220907_CDAWG_MemoEvaluating_GCMs_EPC-20-006_Nov2021-ADA.pdf

Lamb, Z., & Olshansky, R. (2024). *Bayshore Urbanism: Property and Climate Change Adaptation on San Francisco Bay*. Next10. https://www.next10.org/sites/default/files/2024-10/next10-bayshore-urbanism-final.pdf

Landers, J. (2022, March). *Key Northern California highway to be protected from sea level rise*. American Society of Civil Engineers. https://www.asce.org/publications-and-news/civil-engineering-source/civil-engineering-magazine/article/2022/03/key-northern-california-highway-to-be-protected-from-sea-level-rise

Lee, J. (2025, April). Silicon Valley's Redwood City has California's highest flood risk. *San Francisco Chronicle*. https://www.sfchronicle.com/weather/article/redwood-city-sea-level-flood-20253300.php

Licker, R., Dahl, K., & Abatzoglou, J. T. (2022). Quantifying the impact of future extreme heat on the outdoor work sector in the United States. *Elementa: Science of the Anthropocene, 10*(1), 00048. https://doi.org/10.1525/elementa.2021.00048

Maizlish, N. 2023. H*ealthy Places Index Guidance for Public Health Surveillance and Monitoring Health Outcomes, Services, and Clinical Quality in Healthcare Systems*. Public Health Alliance of Southern California. https://phasocal.org/wp-content/uploads/2023/06/PHA_HPI_Guidance_Report523_4.pdf

Mak, M., Neher, J., May, C., Finzi Hart, J., & Wehner, M. (2023). *San Francisco Precipitation in Warmer World. Volume 1: State of the Science*.

Mark, M., Harris, E., Lightner, M., Vandever, J., & May, K. (2016). San Francisco Bay Tidal Datums and Extreme Tides Study Final Report. https://www.adaptingtorisingtides.org/wp-content/uploads/2016/05/20160429.SFBay_Tidal-Datums_and_Extreme_Tides_Study.FINAL_.pdf

Marketplace Staff & Ackerman, D. (2019). *Climate change impacts are coming to Big Tech's doorstep*. Retrieved February 19, 2026, from https://www.marketplace.org/story/2019/09/16/climate-change-impacts-are-coming-to-big-techs-doorstep

Mauhay-Moore, S. (2023, January 2). *SF is now the least air-conditioned city in the US. SF Gate*. https://www.sfgate.com/local/article/san-francisco-lacks-air-conditioning-17685873.php

May, C. (2020). Rising groundwater and sea-level rise. *Nature Climate Change, 10*(10), 889–890. https://doi.org/10.1038/s41558-020-0886-x

May, C. L., Mohan, A. T., Plane, E., Lopez, D. R., Mak, M., Luchinsky, L., Hale, A., & Hill, K. (2022). *Shallow Groundwater Response to Sea-Level Rise: Alameda, Marin, San Francisco, and San Mateo Counties*. https://doi.org/10.13140/RG.2.2.16973.72164

Metropolitan Transportation Commission and Association of Bay Area Governments. (2025). *Plan Bay Area 2050+: Final Regional Growth Forecast*. https://planbayarea.org/sites/default/files/meetings/attachments/6184/9aiv_24_1550_Attachment_C_Final_Regional_Growth_Forecast.pdf

Milliken, R. (2009). *Ethnohistory and Ethnoegeogrpahy of the Coast Miwok and Their Neighbors, 1783-1840*. National Park Service, Golden Gate National Recreation Area. https://www.nps.gov/goga/learn/historyculture/upload/2009-Final-Coast-Miwok-Report.pdf

Mount, J., Hanak, E., & Peterson, C. (2023). *Water Use in California*. Public Poilcy Institute of California. https://www.ppic.org/wp-content/uploads/jtf-water-use.pdf

MTC/ABAG & BCDC. (2023). *Sea Level Rise Adaptation Funding and Investment Framework Final Report*. Metropolitan Transportation Commission / Association of Bay Area Governments and the San Francisco Bay Conservation and Development Commission. https://mtc.ca.gov/sites/default/files/documents/2023-07/SLR_Framework_Final_Report.pdf

Muldavin, E., Cross, C., & Gould, S. (2023). Section 3.2 Regional Summary: Public Health. In *Bay Area Jobs First Collaborative: Califonira Jobs First Regional Plan Part 1*.

Nardone, A., Rudolph, K. E., Morello-Frosch, R., & Casey, J. A. (2021). Redlines and Greenspace: The Relationship between Historical Redlining and 2010 Greenspace across the United States. *Environmental Health Perspectives, 129*(1), 17006. https://doi.org/10.1289/EHP7495

Nigusie, A., Gizaw, Z., Gebrehiwot, M., & Destaw, B. (2021). Vector-Borne Diseases and Associated Factors in the Rural Communities of Northwest Ethiopia: A Community-Based Cross-Sectional Study. *Environmental Health Insights, 15*, 11786302211043049. https://doi.org/10.1177/11786302211043049

Noth, E., Sklar, R., Martindale, C., Schelling, M., Fenske, T., Silberstein, J., Ryder, O., Kramer, S., Pavlovic, N., Lurmann, F., Bertozzi, S., & Khan, A. (2026). *Climate Change-Related Occupational Hazards* (California's Fifth Climate Change Assessment). University of California, Berkeley. https://www.climateassessment.ca.gov/2730/

Nuttle, W. K., & Portnoy, J. W. (1992). Effect of rising sea level on runoff and groundwater discharge to coastal ecosystems. *Estuarine, Coastal and Shelf Science, 34*(2), 203–212. https://doi.org/10.1016/S0272-7714(05)80106-4

Nwaigwe, K. N., Mutabilwa, P., & Dintwa, E. (2019). An overview of solar power (PV systems) integration into electricity grids. *Materials Science for Energy Technologies, 2*(3), 629–633. https://doi.org/10.1016/j.mset.2019.07.002

O'Brien, J. P., & Marston, B. (2022, March 31). A Changing PCT: Climate change is already altering the trail experience. *Pacific Crest Trail Association*. https://www.pcta.org/2022/a-changing-pct-90289/

***OEHHA - California Communities Extreme Heat Scoring System.* (n.d.).** Retrieved February 19, 2026, from https://calheatscore.calepa.ca.gov/

Oritz. (2025, June 17). *Fog-free San Francisco? Experts ponder California climate future*. https://www.thecalifornian.com/story/news/2025/06/17/san-francisco-fog-california-climate-future-global-warming/84236081007/

Patricola, C. M., Wehner, M. F., Bercos-Hickey, E., Maciel, F. V., May, C., Mak, M., Yip, O., Roche, A. M., & Leal, S. (2022). Future changes in extreme precipitation over the San Francisco Bay Area: Dependence on atmospheric river and extratropical cyclone events. *Weather and Climate Extremes, 36*, 100440. https://doi.org/10.1016/j.wace.2022.100440

Paulson, L. D. (2022, June 17). *Silicon Valley Tech Giants Moving the Needle on Renewable Technologies*. NewsData, LLC. https://www.newsdata.com/california_energy_markets/regional_roundup/silicon-valley-tech-giants-moving-the-needle-on-renewable-technologies/article_b353611a-ee73-11ec-82b9-7f78e036ddf9.html

Payne, H., Bedsworth, L., & Alex, K. (2023). *Regional Summary: Climate and Environmental Impacts*. Community Economic Resilience Fund.

Penrod, K., Garding, P. E., Paulman, C., & Beier, P. (2013). *Critical Linkages: Bay Area and Beyond | Adaptation Clearinghouse*. https://www.adaptationclearinghouse.org/resources/critical-linkages-bay-area-and-beyond.html

PG&E. (2024). *Climate Adaptation and Vulnerability Assessment*. https://www.pge.com/en/about/corporate-responsibility-and-sustainability/taking-responsibility/climate-change-adaptation.html

Pierce, D. W., Cayan, D. R., & Dehann, L. (2016). *Creating Climate projections to support the 4th California Climate Assessment*. https://loca.ucsd.edu/~pierce/IEPR_Clim_proj_using_LOCA_and_VIC_2016-06-13b.pdf

Pierce, D. W., Cayan, D. R., Feldman, D. R., & Risser, M. D. (2023). Future Increases in North American Extreme Precipitation in CMIP6 Downscaled with LOCA. *Journal of Hydrometeorology, 24*(5), 951–975. https://doi.org/10.1175/JHM-D-22-0194.1

Pierce, D. W., Cayan, D. R., & Thrasher, B. L. (2014). Statistical Downscaling Using Localized Constructed Analogs (LOCA)*. *Journal of Hydrometeorology, 15*(6), 2558–2585. https://doi.org/10.1175/JHM-D-14-0082.1

Plan Bay Area 2050. (2021). *Plan Bay Area 2050*. Association of Bay Area Governments, Metropolitan Transportation Commission. https://planbayarea.org/technical-resources/previous-plans/plan-bay-area-2050-2021

Plane, E., Hill, K., & May, C. (2019). A Rapid Assessment Method to Identify Potential Groundwater Flooding Hotspots as Sea Levels Rise in Coastal Cities. *Water, 11*(11), 2228. https://doi.org/10.3390/w11112228

Polade, S. D., Gershunov, A., Cayan, D. R., Dettinger, M. D., & Pierce, D. W. (2017). Precipitation in a warming world: Assessing projected hydro-climate changes in California and other Mediterranean climate regions. *Scientific Reports, 7*, 10783. https://doi.org/10.1038/s41598-017-11285-y

Posadzki, A. (2023, June). Telecoms are a lifeline when disaster strikes, but climate change is putting infrastructure at risk. *The Globe and Mail*. https://www.theglobeandmail.com/business/article-telecom-networks-climate-change-weather/

PPIC. (2025). *Most Californians Are Very Concerned about Home Insurance Costs and Availability due to Climate-Related Risks*. Public Policy Institute of California. https://www.ppic.org/press-release/most-californians-are-very-concerned-about-home-insurance-costs-and-availability-due-to-climate-related-risks/

Rahimi, R., Tavakol-Davani, H., Graves, C., Gomez, A., & Fazel Valipour, M. (2020). Compound Inundation Impacts of Coastal Climate Change: Sea-Level Rise, Groundwater Rise, and Coastal Precipitation. *Water, 12*(10), 2776. https://doi.org/10.3390/w12102776

Randolph, S. (2022). *Sea Level Rise, Climate Adaptation Policies and Strategies in the San Francisco Bay Area*. Bay Area Council Economic Institute.

Rhoades, A. M., Zarzycki, C. M., Hatchett, B. J., Inda-Diaz, H., Rudisill, W., Bass, B., Dennis, E., Heggli, A., McCrary, R., McGinnis, S., Ombadi, M., Rahimi-Esfarjani, S., Slinskey, E., Srivastava, A., Szinai, J., Ullrich, P. A., Wehner, M., Yates, D., & Jones, A. D. (2024). Anticipating how rain-on-snow events will change through the 21st century: Lessons from the 1997 new year's flood event. *Climate Dynamics, 62*(9), 8615–8637. https://doi.org/10.1007/s00382-024-07351-7

Rittelmeyer, P., Bowers, C., & Guan, B. (2025). *Coupling of Atmospheric Rivers and Levee Failure Events in California's Sacramento–San Joaquin Delta, 1980–2021*. https://doi.org/10.1175/WCAS-D-23-0136.1

San Francisco Estuary Institute. (2020). San Francisco Bay Shoreline Adaptation Atlas: Working with Nature to Plan for Sea Level Rise Using Operational Landscape Units. https://www.sfei.org/projects/san-francisco-bay-shoreline-adaptation-atlas

San Francisco Bay Regional Water Board. (n.d.). *Climate Change*. Retrieved February 19, 2026, from https://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/climate_change/

San Francisco Planning. (n.d.). *Sea Level Rise Adaptation*. Retrieved March 16, 2026, from https://sfplanning.org/sea-level-rise-action-plan

Santa Clara Valley Water District. (2024). *Recycled and Purified Water*. https://www.valleywater.org/your-water/recycled-and-purified-water

Schwartz, R. E., Gershunov, A., Iacobellis, S. F., & Cayan, D. R. (2014). North American west coast summer low cloudiness: Broadscale variability associated with sea surface temperature. *Geophysical Research Letters, 41*(9), 3307–3314. https://doi.org/10.1002/2014GL059825

SFEI. (2015). *Baylands Ecosystem Habitat Goals Project*. San Francisco Estuary Institute. https://www.sfei.org/projects/baylands-ecosystem-habitat-goals-project

SFEI. (n.d.). *Next Generation Urban Greening*. San Francisco Estuary Institute. Retrieved August 5, 2026, from https://www.sfei.org/projects/next-generation-urban-greening

Shahagadkar, B. R. (2024, June 21). California's Bay Area is Heating Up. Its Infrastructure Isn't Designed For It. *Inside Climate News*. https://insideclimatenews.org/news/21062024/california-bay-area-heat-infrastructure/

Sharygin, E. (2021). Estimating Migration Impacts of Wildfire: California's 2017 North Bay Fires. In D. Karácsonyi, A. Taylor, & D. Bird (Eds.), *The Demography of Disasters: Impacts for Population and Place* (pp. 49–70). Springer International Publishing. https://doi.org/10.1007/978-3-030-49920-4_3

Shirzaei, M., & Bürgmann, R. (2018). Global climate change and local land subsidence exacerbate inundation risk to the San Francisco Bay Area. *Science Advances, 4*(3), eaap9234. https://doi.org/10.1126/sciadv.aap9234

Shulgina, T., Gershunov, A., Hatchett, B. J., Guirguis, K., Subramanian, A. C., Margulis, S. A., Fang, Y., Cayan, D. R., Pierce, D. W., Dettinger, M., Anderson, M. L., & Ralph, F. M. (2023). Observed and projected changes in snow accumulation and snowline in California's snowy mountains. *Climate Dynamics, 61*(9), 4809–4824. https://doi.org/10.1007/s00382-023-06776-w

Siirila-Woodburn, E. R., Rhoades, A. M., Hatchett, B. J., Huning, L. S., Szinai, J., Tague, C., Nico, P. S., Feldman, D. R., Jones, A. D., Collins, W. D., & Kaatz, L. (2021). A low-to-no snow future and its impacts on water resources in the western United States. *Nature Reviews Earth & Environment, 2*(11), 800–819. https://doi.org/10.1038/s43017-021-00219-y

Siler, N., Koszuta, M., Rahimi, S., Norris, J., Hall, A., & Ullrich, P. (2026). Examining the Robustness of Weakened Orographic Influence on Precipitation in Downscaled Climate Projections Over the Western US. *Geophysical Research Letters, 53*(1), e2025GL119251. https://doi.org/10.1029/2025GL119251

Simpson, I. R., McKinnon, K. A., Kennedy, D., Lawrence, D. M., Lehner, F., & Seager, R. (2024). Observed humidity trends in dry regions contradict climate models. *Proceedings of the National Academy of Sciences, 121*(1), e2302480120. https://doi.org/10.1073/pnas.2302480120

Sneed, A. (2024, January 19). Elevate Communities to Lead: A Story from San Rafael's Canal Neighborhood. Bay Adapt. https://www.bayadapt.org/blog/elevate-communities-to-lead-a-story-from-san-rafaels-canal-neighborhood/

Su, X., Liu, T., Beheshti, M., & Prigiobbe, V. (2020). Relationship between infiltration, sewer rehabilitation, and groundwater flooding in coastal urban areas. *Environmental Science and Pollution Research, 27*(13), 14288–14298. https://doi.org/10.1007/s11356-019-06513-z

Suckale, J., Miao, Y., & Bick, I. A. (2020, August 5). *Bay Area coastal flooding triggers regionwide commute disruptions*. https://news.stanford.edu/stories/2020/08/bay-area-coastal-flooding-triggers-regionwide-commute-disruptions

Sweet, W., Hamlington, B., Kopp, R. E., Weaver, C., Barnard, P. L., Bekaert, D., Brooks, W., Craghan, M., Dusek, G., Frederikse, T., Garner, G., Genz, A. S., Krasting, J. P., Larour, E., Marcy, D., Marra, J. J., Obeysekera, J., Osler, M., Pendleton, M., … Zuzak, C. (2022). Global and regional sea level rise scenarios for the United States. In *Technical Report* (NOS.01). National Oceanic and Atmospheric Administration. https://pubs.usgs.gov/publication/70229139

Tebaldi, C., Dorheim, K., Wehner, M., & Leung, R. (2021). Extreme metrics from large ensembles: Investigating the effects of ensemble size on their estimates. *Earth System Dynamics, 12*(4), 1427–1501. https://doi.org/10.5194/esd-12-1427-2021

***The San Francisco Bay Trail Risk Assessment and Adaptation Prioritization Plan.* (n.d.).** Retrieved February 19, 2026, from https://www.arup.com/en-us/projects/the-san-francisco-bay-trail-risk-assessment-and-adaptation-prioritization-plan/

Ullrich, P. (2023). *Validation of LOCA2 and STAR-ESDM Statistically Downscaled Products* (LLNL--TR-856094, 2202926, 1085545; p. LLNL--TR-856094, 2202926, 1085545). https://doi.org/10.2172/2202926

US EPA, R. 09. (2012, December 5). *What Are the Challenges in the San Francisco Bay Delta?* [Overviews and Factsheets]. (Southwest, California, Water Bodies). https://www.epa.gov/sfbay-delta/challenges

Vaidyanathan, A., Saha, S., Vicedo-Cabrera, A. M., Gasparrini, A., Abdurehman, N., Jordan, R., Hawkins, M., Hess, J., & Elixhauser, A. (2019). Assessment of extreme heat and hospitalizations to inform early warning systems. *Proceedings of the National Academy of Sciences, 116*(12), 5420–5427. https://doi.org/10.1073/pnas.1806393116

VanderMolen, K., Kimutis, N., & Hatchett, B. J. (2022). Recommendations for increasing the reach and effectiveness of heat risk education and warning messaging. *International Journal of Disaster Risk Reduction, 82*, 103288. https://doi.org/10.1016/j.ijdrr.2022.103288

Vaughn, L. S., Plane, E., Harris, K., Robinson, A., & Grenier, L. (2022). *Leveraging Wetlands for a Better Climate Future: Incorporating Blue Carbon into California's Climate Planning*. San Francisco Estuary Institute. https://www.sfei.org/documents/leveraging-wetlands-better-climate-future-incorporating-blue-carbon-californias-climate

Vose, R. S., Applequist, S., Squires, M., Durre, I., Menne, M. J., Williams, C. N., Fenimore, C., Gleason, K., & Arndt, D. (2014). *NOAA Monthly U.S. Climate Gridded Dataset (NClimGrid)* (Version 1) [Dataset]. NOAA National Centers for Environmental Information. https://doi.org/10.7289/V5SX6B56

WERC. (2017). *Wetland Restoration in the San Francisco Bay Delta and Pacific Northwest.* United States Geological Survey (USGS) Western Ecological Resource Center. https://www.usgs.gov/centers/werc/science/wetland-restoration-san-francisco-bay-delta-and-pacific-northwest

Widerynski, S., Schramm, P., Conlon, K., Noe, R., Grossman, E., Hawkins, M., Nayak, S., Roach, M., & Hilts, A. (2017). *The Use of Cooling Centers to Prevent Heat-Related Illness: Summary of Evidence and Strategies for Implementation Climate and Health Technical Report Series Climate and Health Program, Centers for Disease Control and Prevention*. https://doi.org/10.13140/RG.2.2.32267.59688

Wolfe, S. (2024, June 24). PG&E expects 3.5 GW data center growth by 2029. *Factor ThisTM*. https://www.renewableenergyworld.com/energy-business/pge-expects-3-5-gw-data-center-growth-by-2029/

Yang, V. (2025). *Understanding California's Transmission Development Delays and Paths to Reform | Union of Concerned Scientists*. Union of Concerned Scientists. https://www.ucs.org/resources/understanding-californias-transmission-development-delays-and-paths-reform

Appendix A.

Case Studies



Case Study I: Tamien Nation: Land Back, Cultural Stewardship, and Climate Resilience in the South Bay

The Tamien Nation, Indigenous people of the Santa Clara Valley and greater South Bay, are advancing a climate resilience model grounded in land return, cultural stewardship, and Indigenous knowledge systems. In the face of accelerating climate change, habitat loss, and restricted access to ancestral lands, the Nation's recent land acquisition and related stewardship efforts demonstrate how Indigenous-led land ownership and management can strengthen ecological resilience, cultural continuity, and regional climate solutions.

CLIMATE IMPACTS ON CULTURAL PRACTICES AND ECOSYSTEMS

Climate change is already altering the timing, availability, and health of culturally important plants, animals, and marine resources within Tamien ancestral territory. Tribal citizens report increasing uncertainty in seasonal harvesting and fishing practices, as climate-driven changes disrupt long-held ecological knowledge about when and where resources are available. Storms have reshaped landscapes and habitats, affecting species distribution, and access to shellfish and other coastal resources. In response, the Tribe must continually monitor ecological conditions, adapt gathering practices, and seek new locations for cultural activities. This is an ongoing challenge that underscores the vulnerability of both ecosystems and living cultural traditions.

HISTORIC LAND RETURN AND TRIBAL OWNERSHIP

In 2025, the Tamien Nation achieved a historic milestone with the acquisition of 235 acres of ancestral homeland in East San José through a $6 million grant from the California Governor's Office Tribal Nature-Based Solutions Program. This marks the first return of land to full Tribal ownership in the South Bay in more than 200 years. The land is 100% owned, governed, and protected by the Tamien Nation in perpetuity, not as an easement or co-management agreement, but with full Tribal sovereignty over land stewardship.

The property includes culturally significant sites and ecologically valuable landscapes adjacent to existing protected lands, supporting wildlife corridors and regional biodiversity. The Nation is undertaking restoration efforts informed by Traditional Ecological Knowledge (TEK), with the goal of revitalizing springs, habitats, and native species while reconnecting Tribal citizens to place-based practices and teachings.

FIRE STEWARDSHIP AND WORKFORCE DEVELOPMENT

The Tamien Nation is also building climate resilience through Indigenous fire stewardship. Beginning with a partnership with the Central Coast Prescribed Burn Association, the Tribe trained approximately 20 Tribal citizens as Type II wildland firefighters. Since then, the Nation has established its own fire crew under the leadership of a former CAL FIRE professional and is working toward developing certified burn bosses within the community.

Through cultural burning and prescribed fire, the Tribe aims to reduce wildfire risk, restore ecosystem health, and support the regeneration of culturally important species. These efforts are

designed to be reciprocal—benefiting both the land and the Tribe—while also creating pathways for economic development through service partnerships with public agencies, land conservancies, and private landowners.

PARTNERSHIPS, EDUCATION, AND REGIONAL BENEFITS

Looking ahead, the Tamien Nation envisions expanding land access across diverse ecosystems within its ancestral territory, including Santa Clara valley floor, coastal, and redwood forest landscapes. The Tribe is exploring additional land acquisitions and partnerships that could support cultural centers, Indigenous agriculture, and public education on land stewardship and climate resilience.

The Nation's work highlights the broader regional benefits of Indigenous-led climate solutions: maintaining wildlife corridors, promoting native and drought-resilient species, reducing wildfire risk, and sharing sustainable land management practices with surrounding communities. By demonstrating that even non–federally recognized Tribes can successfully lead large-scale climate and conservation projects when provided with appropriate funding and support, the Tamien Nation's experience offers a powerful model for equitable and effective climate action in the San Francisco Bay Area.

Case Study II: Communities United for Restorative Youth Justice: Youth-Led Research for Community Resilience

Since 2011, Communities United for Restorative Youth Justice (CURYJ) has advanced youth justice and community resilience in Oakland's Fruitvale neighborhood. Founded to end youth criminalization and mass incarceration, CURYJ builds leadership among systems-impacted youth through ethnic studies, restorative justice, culturally rooted healing practices, and hands-on organizing and policy advocacy.

Though not traditionally defined as a climate organization, CURYJ treats climate resilience as inseparable from struggles against incarceration, policing, poverty, and environmental racism. Youth and families impacted by incarceration, foster care, and immigration often face unsafe housing, high pollution exposure, extreme heat, and limited access to green spaces—conditions shaped by long histories of disinvestment and inequitable planning.

CURYJ's programs link climate change directly to community safety and healing. Its Dream Beyond Bars Fellowship trains formerly incarcerated youth as researchers and organizers. Fellows have led community surveys on extreme heat and local park conditions, often working with violence interrupters to safely gather information. These projects highlight how environmental stressors like heat intensify community violence, underscoring CURYJ's belief that social networks and cultural identity are vital adaptation strategies. Initiatives such as "Town Nights in the Fruitvale" show how community-building events can strengthen both resilience and community safety.

Youth leadership is central to CURYJ's climate justice work. Through the Oakland Youth Advancing Climate Action (OYACA) project, young people at CURYJ, Frontline Catalysts and East Bay Academy for Young Scientists engaged in participatory research and creative projects—collecting data and

producing digital stories about the local impacts of climate change and their visions for climate solutions. CURYJ also reconnects youth to land through its community garden, outings to regional parks, and Indigenous-rooted healing practices.

Currently, CURYJ leads HEATED (Homegrown Experts Aiming to Transform Emergencies and Disasters), a youth-driven effort to survey Fruitvale and West Oakland residents about where they access services, resources and support during heat waves. Findings will inform Oakland's Local Hazard Mitigation Plan and support the development of a Fruitvale community resilience hub. By centering youth leadership and an abolitionist framework, CURYJ demonstrates how climate adaptation can advance equity, enhance community safety, and repair relationships among people, land, and community.

Resources

- CURYJ: Engaging youth to strengthen community resilience to extreme heat events
- CURYJ Annual Report 2022
- Dream Beyond Bars Program
- CURYJ Forgotten Voices: A Youth Vision for Oakland

Case Study III: Climate Resilient Communities: Tackling Extreme Heat Through Participatory Design

ISSUE OVERVIEW

North Fair Oaks (NFO), an unincorporated area in San Mateo County, faces a disproportionate threat from extreme heat due to limited green infrastructure, high concentrations of impervious surfaces, and a significant number of residents with pre-existing health conditions. The impacts of extreme heat are most acutely felt by lower-income households, renters, older adults, and those with chronic illnesses - communities historically underserved by climate adaptation initiatives.

PROJECT DESCRIPTION

In the summer of 2024, Climate Ready North Fair Oaks (CRNFO) - a local neighborhood group composed of residents, faith leaders, academic institutions, government agencies and nonprofit groups who live, work or play in North Fair Oaks, requested support identifying extreme heat adaptation strategies at the community level. Climate Resilient Communities (CRC), the North Fair Oaks Community Alliance (NFOCA), El Concilio of San Mateo County, and City Systems launched the Mobile Air Conditioning Kit (MACK) pilot project as a response to community leadership priorities. The aim was to provide a practical, community-centered solution for at-risk households needing relief from dangerous temperatures.



Figure A1: *Derek Ouyang, of City Systems, presenting to CRNFO and receiving consensus on prototype design.*

IMPLEMENTATION

- The pilot originated from a CRC Community Climate Change Team (CCCT) in North Fair Oaks called Climate Ready North Fair Oaks (CRNFO)'s, and received funding from the University of Michigan in a co-application from the project partners led by CRC.
- Local leaders and volunteers assembled and tested easily-movable air condition kits that could be quickly deployed into residents' homes, designed by City Systems.
- The kits were designed with input from residents and piloted through a collaborative effort, including door-to-door outreach and educational pop ups.
- The project prioritized multilingual text communication and inclusive feedback to ensure equitable access to the resources.

APPROACH TO EQUITY AND INCLUSION:

The CRNFO team featured strong leadership from North Fair Oaks community members - reflecting the neighborhood's ethnic and linguistic diversity. This group ensured that pilot recipients represented those most vulnerable to heat, including older adults and families with health risks. Transparent community and trust-building were ongoing priorities throughout implementation.

OUTCOMES:

- Several households benefitted from cooler indoor environmental during heat waves, reporting improved comfort and reduced health-related stress
- The project strengthened local relationships among partners and increased general awareness about extreme heat risks and available solutions.

LESSONS LEARNED & BROADER APPLICATIONS

The MACK addressed an urgent climate adaptation need and demonstrated the effectiveness of participatory, community-driven interventions. Providing physical relief from heat empowered residents while building trust with organizations leading climate resilience efforts at the grassroots level.

Project partners better understand the needs of residents seeking a place of refuge during extreme heat and how critical it is to have extreme heat adaptation resources at the household level. From the process of going into peoples' homes to share the MACK and asking residents to invite their neighbors, it became apparent that each home needs an air conditioning unit, not just one for the entire neighborhood to use for the four to six hours the community experiences extreme heat. Installing more units in the community would lead to expanded household-level resilience.

ADDITIONAL RESOURCES

- Climate Resilient Communities, North Fair Oaks Community Alliance
- Project Overview Video on YouTube
- Analysis of heat in North Fair Oaks (Stanford Future Bay Initiative)
- Health impacts of extreme heat
- Research on clean air shelters

Case Study IV: Bay Area Youth Climate Summit: Youth Leadership for Climate Resilience

The Bay Area Youth Climate Summit (BAYCS) is a youth-led nonprofit dedicated to building community and amplifying youth leadership in climate action. Since its founding, BAYCS has hosted six annual summits that bring together 200–250 young people for workshops, keynote speakers, and hands-on climate action planning. The organization also organizes monthly workshops and is partnering with San Francisco's Department of the Environment to host a Green Career Fair in November 2025.

BAYCS is rooted in the belief that climate solutions must be by youth, for youth. As Padma, a BAYCS leader, explained: "I grew up always knowing that climate change existed and that my future would be impacted by it. For a long time, I didn't think I had any power to make a difference—but I found an overwhelming sense of community through BAYCS. Being in a space where other young people are committed to action fuels my determination to keep going."

For many, BAYCS provides not just education but also agency. Emily shared: "Before BAYCS, I didn't have much climate knowledge, let alone the term environmental justice. Being part of BAYCS transformed my understanding of climate change from a science issue to an intersectional, multi-dimensional issue that truly impacts everything we do."

Both Emily and Padma emphasized the urgency and innovation youth bring to climate action. "Older people sometimes tell us we're too idealistic," Padma noted. "But the reality is, we see the gravity of the situation and have that sense of urgency as we get closer to tipping points." Emily added: "Young people know how to organize, bring fresh perspectives, and retain open mindsets. When youth are given a platform to vocalize their input on climate policy, we can create more inclusive, sustainable solutions."

BAYCS also highlights the barriers youth face. Policymakers often expect young people to advocate, but as Padma stressed, "Policy makers need to reach out to underserved youth who don't have time to be advocates. Their input is valuable, and they are among the most vulnerable to the climate crisis."

By fostering community, resilience, and leadership, BAYCS demonstrates how empowering youth is essential to shaping a just and sustainable climate future for California.

Case Study V: Disability and Climate Risk: Land Use, Disproportionate Wildfire Risk, and Inclusive Wildfire Resilience Planning

ISSUE OVERVIEW

Wildfires are intensifying across California, disproportionately endangering people with disabilities (PWDs) and more broadly speaking, groups with Access and Functional Needs (AFN), a loose category that includes seniors, people with disabilities, families with children, and people with little or no English proficiency. These groups face compounding challenges: inaccessible evacuation infrastructure, limited housing options, and systemic economic disadvantages that push them into fire-prone areas. As Alex Ghenis, disability activist noted, societal discrimination and inaccessibility create and amplify disability, and climate-related threats are magnified by those inequities.

PROJECT DESCRIPTION

Alex Ghenis's work emerged from over a decade of research and advocacy at the intersection of disability, climate change, and disaster planning. It began with the New Earth Disability newsletter in 2014, which evolved into the World Institute on Disability's formal climate justice initiative. New Earth Disability looked at the connection between climate and disability and aimed to uncover how people with disabilities are harmed by climate consequences and how policies can amplify or reduce disproportionate climate risk. In 2020, Alex founded the Accessible Climate Strategies consultancy and in 2024 started *DisabilitYIMBY*, a second newsletter project. *DisabilitYIMBY* examines how land-use and housing policies affect people with disabilities, and how they can amplify or reduce other inequities ranging from economic well-being to climate risks.

Using data analysis, the *DisabilitYIMBY* project took Los Angeles's 2025 wildfire evacuations as a starting point to evaluate the overlap between land use policies, residential concentrations of PWDs and seniors, and wildfires in California. In order to do that, Alex broke down the rate of disability and the combined rate of seniors and PWDs (i.e., all PWDs age 0-64, plus all seniors) at the census tract level in California, and compared that to California's documented wildfire perimeters.

Findings revealed that: "Seniors and PWDs are usually over-represented in California's wildfire danger zones," driven there in large part by a lack of affordable, accessible housing in more fire-safe areas. The project showed that land-use policies at both the state and local level in California, including restrictive zoning and excessive veto points on new development, have significantly limited construction of multifamily housing that tends to be more affordable and accessible than single-family homes. Meanwhile, housing shortages in high demand areas of the state have priced out many seniors and PWDs into more affordable but riskier rural areas and the Wildland-Urban Interface (WUI). Finally, California's home insurance policies have artificially underpriced the risk of wildfire, encouraging risky development and providing artificially affordable housing alternatives to seniors and PWDs—alternatives that put them in harm's way.

EQUITY AND INCLUSION

Equity and inclusion are central pillars of *DisabilitYIMBY*. The project calls for:

- **Accessible communications:** Communications that use plain language, have good captioning, include ASL, and have multiple types of disaster warnings for people with different sensory abilities.
- **Housing reform:** Increaseaccessible, multifamily housing in climate-resilient urban areas through improved zoning and permitting policies plus increased funding for affordable, accessible housing. Ultimately, California needs more dense, urban, transit-friendly environments that are far from climate risks and allow residents to live more safely and sustainably. DisabilitYIMBY states that "California's mistakes show how misguided policies can push Californians, and especially seniors and PWDs, into wildfire danger zones. Hopefully we can fix our policies to transform where and how we live, thus saving lives."
- **Intersectional planning in the face of climate change:** The information and data presented by this case study emphasizes the need for planning that recognizes that disability often overlaps with race, income, and age. For example, PWDs are highly exposed to climate-driven economic crises and resulting austerity, and African Americans with disabilities are especially at risk. As Alex put it in an interview, "People with disabilities are traditionally last to be hired and first to be fired, and we disproportionately utilize government services ranging from public transit to healthcare. If climate change leads to a shrinking economy, our unemployment spikes more than able-bodied folks, while the budget cuts of climate austerity threaten our independence, health, and even survival. And all of this is with the context that there are different rates of disability by age, income, and race, so some of us are affected more than others."

The project also emphasized *train-the-trainer* approaches and capacity-building among community members, not just top-down interventions. It repeats the disability justice mantra, *nothing about us without us*, in calling for active inclusion of the disability community in land use and climate decisions.

LESSONS LEARNED & BROADER APPLICATIONS

This case study highlights how disproportionate climate risk isn't just about geography or emergency planning; it's also about public policy and economic inequity. California's exclusionary zoning and insurance systems, combined with systemic inequities around ability and age, have "pushed Californians, and especially seniors and PWDs, into wildfire danger zones," where evacuation is often difficult or infeasible for those seniors and PWDs.

Importantly, even the best emergency response systems "can't guarantee they can reach or save everyone," especially during fast-moving wildfires. Comprehensive, forward-looking climate policy should include risk reduction through inclusive urban planning, not just reactive emergency management.

This work provides a model for integrating disability into climate adaptation, something often still missing from most regional plans. "The blinds are being drawn," Alex explained. "There hasn't historically been comprehensive work on it, but we are finally seeing some progress."

ADDITIONAL RESOURCES

- Urban Form, Age/Disability, and Wildfire Evacuations in California Read the whole piece that goes more in depth to the information discussed in this case study.
- Resources | Sustain Our Abilities is a resource list Alexi Ghenis put together while working at Sustain Our Abilities. The section on climate consequences has some good resources that could be helpful for California.
- Transportation Accessibility Resources - World Institute on Disability is TRACS, the transportation study Alex worked on in the Bay Area.
- How Berkeley's NIMBYism Betrayed the Disability Rights Movement: Part 1 is also relevant just for looking at the impacts of housing policies on the disability community. Part 2 is coming soon.

Case Study VI: Cultural Burning and Indigenous Collaboration at 'Ootchimin 'Ooyakma (Jasper Ridge Nature Preserve)

ISSUE OVERVIEW

The growing frequency and severity of wildfires in California threatens ecosystems, cultural heritage, and surrounding communities. 'Ootchamin 'Ooyakma (Jasper Ridge Biological Preserve), a preserve on the Stanford University campus, located in ancestral Muwekma Ohlone territory, faced overgrowth and high fire risk, particularly at the wildland-urban interface. The people at risk include neighboring communities, local ecosystems, and Indigenous communities whose cultural practices and homelands have been historically disrupted.

PROJECT DESCRIPTION

The Muwekma Ohlone Tribe of the San Francisco Bay Area and Stanford University have been cultivating a partnership over the last several decades, which has resulted in several on-the-ground climate resilience projects and plans for future collaboration and partnership.

This relationship began with the important step of returning ancestral remains of 550 human beings from Stanford's archaeological collections. University Archaeologist Laura Jones, then a graduate student, spearheaded this effort in 1989, when she drove a truck bearing the Muwekma Ohlone's ancestral remains back to the Tribal council, who were able to lay the remains to rest as they saw fit. With this first step, Dr. Jones helped sow the seeds of a decades-long partnership between Stanford and the Muwekma Ohlone Tribe, and set the stage for future trust-building.

Building on this foundation, the Muwekma Ohlone Tribe and Stanford have partnered on several land-based projects in recent years. The Tribe helped shape the Four Directions Garden, co-developed with agroecologist Patrick Archie, Director of Stanford's Educational Farm, which includes culturally important species with signage with both English and Chochenyo plant names. The Tribal members informed the species chosen and the shape of the garden, highlighting plants essential to the Muwekma Ohlone, further deepening the partnership with the university. Established in 2022, the garden is a living space for growing native plants such as miriyan or sage (*Salvia apiana*), apio or blue elderberry (Sambucus nigra ssp. caerulea), and many more, co-managed with Muwekma Ohlone Tribal members. It serves as a space for cultural reconnection, learning, and harvesting, as well as a space for sharing their traditional ecological knowledge. This effort is further reinforced by the Muwekma native plants garden near the Stanford Dish, where anthropologist and Stanford instructor Michael Wilcox teaches a class where students learn about the Muwekma Ohlone Tribal culture and traditions.

More recently, the Tribe has also been collaborating around returning good fire to the university's biological preserve, Jasper Ridge. Through this collaboration, the preserve was given an Indigenous name by the Muwekma Ohlone Tribe, 'Ootchamin 'Ooyakma, meaning "red ridge" in Chochenyo. This new collaboration, coordinated by the preserve's Faculty Director, Professor Tadashi Fukami, aims to revitalize the Muwekma Ohlone's Indigenous knowledge for land stewardship, including cultural burning practices. This effort also involves Chairman Ron Goode of the North Fork Mono Tribe, who has generously agreed to share their extensive experience with Muwekma members. The Stanford community seeks the Tribe's guidance and collaboration to reframe ecological management through both Indigenous and Western science. At the same time, opportunities like this to access their homeland are essential to the Muwekma Ohlone Tribe, a Tribe that does not have a landbase of their own due to bureaucratic issues and obstruction around their federal recognition status.

In 2024, Jasper Ridge Biological Preserve conducted pile burning over several acres as part of the university's wildfire management plan. Ahead of the burn, the Tribal members offered a song and prayer, grounding the work in cultural respect. Tribal members, including Chairwoman Charlene Nijmeh, Tribal Cultural Bearer Joey Torres, and other adult and youth members, returned multiple times to observe post-burn ecological responses. The pile burning also provided an opportunity for Indigenous researchers, students, and faculty to co-develop studies and experiences under real land management conditions and contribute to a better understanding of effective wildfire resilience. As a result of the pile burns, a previously dormant native species endemic to the San Francisco Bay Area, western bewildering bushmallow (*Malacothamnus arcuatus var. arcuatus*), reemerged and is seen as a symbolic reawakening of both land and culture. The project also includes efforts such as Tribal youth camps, co-application for CAL FIRE's Tribal Wildfire Resilience Grant Program, and the planning of a Tribal Stewards Program for ongoing access to the preserve. A broader effort includes planning a collaborative research and education agreement to allow safe and sovereign access for ceremony and stewardship.

Building wildfire resilience is ongoing. While mechanical clearing remains necessary in certain areas, leaders emphasize that cultural fire brings a deeper philosophy of "reciprocal restoration," as described by Robin Wall Kimmerer, an approach that heals both land and people in a synergistic manner.

This collaborative work has inspired institutional change. In 2025, Stanford's Doerr School of Sustainability selected a proposal to hire a new faculty member specializing in Traditional Ecological Knowledge (TEK), affirming growing academic recognition of Indigenous science. The proposal was co-written by a team of about a dozen faculty members across the campus. This faculty group has been informed by students, many of whom are Indigenous, who have participated in and learned from these land-based projects. The search committee held a meeting with the Tribal leadership to seek input on what an ideal candidate looks like to them.

The collaboration emphasizes equity through co-creation: Tribal members co-lead planning, participate in restoration, and guide training development.

LESSONS LEARNED & BROADER APPLICATIONS

This collaborative effort, while still in its infancy, has been founded on the premise that Indigenous knowledge is not only culturally vital, but ecologically effective and essential to help ecosystems stay resilient to shifting climate and fire regimes. By centering traditional ecological knowledge (TEK) in climate adaptation strategies, land management becomes more holistic, just, and sustainable. Below are the lessons learned:

- Trust-building over decades, like repatriation facilitated by Stanford archaeologist Laura Jones, laid the foundation for current collaboration.
- Listening to Indigenous leadership respectfully leads to more meaningful outcomes.
- Restoration must be relational, as healing land is inseparable from healing relationships with Indigenous peoples and knowledge.

This model can be replicated across California by forming long-term partnerships with Tribal Nations, embracing TEK, and reshaping university or agency-led restoration to be community-led and place-based.

RESOURCES

Other articles about the collaboration:

- Fire at Jasper Ridge honors the past, present, and future
- Prescribed burns at Jasper Ridge awaken a rare plant
- 'Ootchamin 'Ooyakma, what does it mean to all of us?
- Muwekma youth campout, how it came about and why
- Witnessing the return of a rare native plant

Muwekma Ohlone Tribe

- Before Stanford: The Muwekma Ohlone people

TEK Stories podcast by Stanford undergraduate students

Case Study VII: A Living Model of Adaptation: Teaching, Healing, and Restoring with Suscol Intertribal Council

The Suscol Intertribal Council is advancing climate adaptation and resilience through hands-on ecological restoration, cultural education, and community training. On their 20-acre site in Chiles Pope Valley, northeastern Napa, they are restoring riparian habitat along a waterway with gabions, native perennials, and careful understory clearing across 16 acres. Soil remediation with mycelium and mushrooms complements their efforts to improve ecological health, while medicinal plants such as manzanita are being cultivated and harvested.

Their work also centers on workforce training and cultural knowledge sharing. Through federal Administration for Native Americans (ANA) support, they have trained over 35 people—including youth groups from the Hoopa Valley Tribe—to build with cob and strawbale, reviving sustainable construction practices. Participants come from as far as New York and Malaysia, reflecting the global relevance of their methods.

A hallmark of their program is the use of bokashi balls—beneficial microbes mixed with wheat bran, molasses, and clay—to restore waterways by breaking down toxins and algae. Approved in studies by Massachusetts Institute of Technology and the US Environmental Protection Agency, this practice has been taught to children and community members, sparking both ecological and emotional healing. By combining traditional ecological knowledge, innovative science, and education, Suscol Intertribal Council is creating a living model of resilience for Tribes and communities everywhere.

*Suscol Intertribal Council is a community-based, 501(c)(3) organization, seeking to bring healing between the existing population and the people who historically inhabited Napa Valley and nearby counties.

Case Study VIII: The Canal Community Resilience Planning Project

WHAT CLIMATE ISSUE DOES THIS PROJECT ADDRESS?

In the last century in San Rafael, wetlands and mudflats were filled in to make way for development, making parts of the city now lower than the bay. This area lacks a formal flood control system, so while sea levels continue to rise and the land also sinks, the flood risks are increasing significantly. Along the Canal's edge, informal, unstable, and disconnected barriers built by property owners are currently the only protection against coastal flooding, putting people and property at serious risk.

WHO IS THE MOST AFFECTED?

The Canal neighborhood faces the highest sea level rise risk in Marin County and is the most racially segregated district in the Bay Area. Over 90% of Canal residents are Latino/Hispanic—mostly immigrants and low-income families. More than 6,000 people already live below today's high tide line, and over 15,000 are projected to be below the king tide levels by 2055. There are many vulnerable multi-family buildings, placing renters on the front lines of climate impacts. Critical facilities—including the Community Center, health centers, highways and railroads, a fire station, and many others —are all at risk, with limited evacuation routes for residents.

OVERVIEW OF THE PROJECT

The adaptation planning project is a collaboration with many project partners, including Canal Alliance, the County of Marin, the Multicultural Center of Marin, the City of San Rafael, and the University of California Berkeley. They are all working together to understand the hazards facing our community, prioritize actions, build capacity, and provide STEM educational opportunities to students. The project is studying sea level rise adaptation options through inclusive and culturally relevant engagement.

HOW WAS IT IMPLEMENTED?

A collaborative planning model elevates community voices and partners with local organizations to shape future policy and resilience strategies. The study is evaluating the implications of the feasibility of adaptation alternatives from a technical standpoint, but more importantly in terms of their implications for the community. To do this project, partners have been engaging residents of all ages to build long-term adaptive capacity.

HOW DO YOU APPROACH EQUITY AND INCLUSION IN YOUR WORK?

Recognizing that sea level rise impacts are unevenly distributed, the project centers local voices through early participatory planning in culturally relevant formats.

- The formation of a **Steering Committee** with community residents, has become a strong capacity-building vehicle. Members received training, shared insights, and gained a deeper understanding of sea level rise and its connection to other community issues (e.g., housing, transportation, mental health, emergency preparedness)
- **A Technical Advisory Committee** of experts and local sector representatives (e.g., housing, public health) advises the consultant team.
- **Resources in Spanish** and visual materials to ensure participation and promoting community involvement (focus groups, radio, video)
- **Community fairs**, tours, field trips and bringing climate adaptation materials to different spaces where people are gathering including classrooms.

WHAT WERE THE OUTCOMES?

- Equity goals were embedded in resilience planning and the project engaged more than 3,000 people in person and conservatively more than 200,000 via media outreach.
- The **Steering Committee** evolved into the San Rafael Canal Sea Level Rise Working Group; they will be partnering with the Consejo de Residentes to sustain advocacy and participation in decision-making spaces to achieve community resilience.
- The project includes community voices to create **guiding principles** for the feasibility study; they have been used to design meaningful engagement strategies.
- **Policy recommendations** are designed to focus on environmental justice to prevent displacement, prioritize investments in infrastructure resilience, expand affordable housing in high-risk areas and strengthen emergency preparedness
- The project is building capacity and partnerships across organizations including universities, museums, non-profits and others who haven't traditionally been involved in climate work.

LESSONS LEARNED & BROADER APPLICATIONS

- The project links sea level rise to broader challenges—housing, health, emergency management, and mental health—emphasizing that effective climate resilience planning addresses these connections.
- True engagement requires trust, empowered community leaders, and lasting spaces for inclusive, sustainable participation.
- The collaborative brings together partners from nonprofits (Y-Plan, Canal Arts, Exploratorium, and more), universities, students, volunteers, students (Laurel Dell School), community members and groups to build local capacity. The events were embedded where the community is rather than just at standalone workshops.
- Complex adaptation needs stronger public-private collaboration, housing solutions, and diverse funding.

HOW CAN THIS PROJECT INFORM SIMILAR EFFORTS?

San Rafael's Sea Level Rise Collaborative shows that community-led planning and partnerships yield meaningful, replicable results—especially in vulnerable coastal areas—while also underscoring the deeply interconnected challenges of accessible, affordable housing and climate adaptation.



Figure A2: *San Rafael steering committee leaders tour the shoreline discussing sea level rise and ways to prepare.*

- A **co-created Steering Committee**, prioritizing renters and marginalized residents.
- **Policy briefs** on community priorities, emergency preparedness, anti-displacement, build and rebuild safer and climate justice
- Alignment with **regional plans** to ensure consistent standards and access to funding.

Case Study IX: Bay Area Resilience Hotpots: A Blueprint for Community-driven Adaptation Action

WHAT CLIMATE ISSUE DOES THIS PROJECT ADDRESS?

This project addresses climate hazards of sea level rise and flooding, wildfire, and extreme heat in the San Francisco Bay Area. Through a mixed-methods approach, the project highlights social vulnerabilities and works with local communities to tackle those intersectional vulnerabilities head-on.

WHO IS THE MOST AFFECTED?

This initiative highlights locations around the San Francisco Bay Area where climate hazards intersect with opportunities for nature-based resilience and areas of high social vulnerability. The 18 Hotspots locations reflect climate-vulnerable communities with the least resources to adapt, yet some of the greatest need and opportunity for near-term adaptation and resilience measures.

OVERVIEW OF THE PROJECT

The Bay Area Resilience Hotspots initiative is a blueprint for protecting communities that stand to lose the most in the face of climate change in ways that co-benefit local economies, habitats, open spaces, biodiversity, public health, and more.

Greenbelt Alliance compiled regional spatial data through a robust spatial analysis process to identify opportunities for nature-based solutions that can address climate risks. This work incorporated data layers that reflect physical features of a place, like climate and sprawl risk, as well as socioeconomic factors that can make some populations more vulnerable to climate hazards. The Hotspots Initiative seeks to balance climate hazards, social vulnerability factors, and conservation priorities into actionable map outputs paired with partner work, research, and local priorities necessary to advance on-the-ground projects. This data and spatial analysis process was informed by a diverse group of technical advisors who reviewed the data and methodology and provided feedback on best practices.

Through this process, Greenbelt Alliance identified 18 Resilience Hotpots. The project team then further engaged five priority communities to develop the narrative of climate risk based on local lived experiences, lift up local leaders, and co-create priorities for action. The result of this process was the creation of five Community Resilience Profiles, co-produced with local Community Based Organizations (CBOs) in Southwest Santa Rosa, Gilroy, North Richmond, Suisun, and Newark. These profiles serve as user-friendly information hubs showcasing climate risks, demographic and social data, local stories, and joint priorities for action.

Ultimately, the goal of the Resilience Hotspots initiative is to build local resilience through on-the-ground partnerships, recognizing that local organizations and CBOs, and government partners are critical in moving this work forward.

HOW WAS IT IMPLEMENTED?

The Resilience Hotspots initiative was officially launched in 2023 with the publication of the interactive map and website hosting the five community profiles. In the subsequent year, Greenbelt Alliance prioritized ongoing work in these five communities by advancing joint priorities identified in the Community Profiles. This was done through close partnership and a combination of additional research, ongoing outreach, and pursuit of joint funding opportunities.



Figure A3: *Participants of the Resilient Roots Climate Leadership Network learning hands-on about data and sea level rise. Credit: Essex Cook*

WHAT WERE THE OUTCOMES?

Greenbelt Alliance continues to advance the Resilience Hotspots Initiative through ongoing work in the five focus locations as well as expansion of work into the remaining 13 Hotspots locations. As of Spring 2025, key outcomes include:

- Successful awards of over $3 million in grant funding to support project implementation and capacity-building in five priority Hotspots, including significant pass-through funding to CBO

partners. Projects range in scope from planning for a Resilience Hub to piloting a climate leadership program to sub-regional planning for sea-level rise.

- Ongoing collaboration among local elected officials, government staff, CBOs, and technical experts to advance priorities, including ongoing participation in collaboratives and roundtables.
- Bilingual community outreach and engagement in five priority Hotspots to gain further input on action plan, communicate about climate risks, and work collaboratively to shape ongoing resilience efforts. Events have included multiple shoreline community clean-ups in Newark, hosting a community visioning event series in Gilroy, and leading youth-oriented community learning sessions on sea-level rise, among many others.
- Advancing on the ground research like "Be Prepared Gilroy: A Community Disaster Preparedness Toolkit" and advocating for policies that impact climate-vulnerable communities through planning processes and local advocacy efforts.

LESSONS LEARNED & BROADER APPLICATIONS

The Resilience Hotspots Initiative showcases a powerful model for combining research and partnership to advance on-the-ground climate action. In particular, this project reaffirmed the importance of local capacity building and the role of regional organizations like Greenbelt Alliance in leveraging administrative and technical capabilities to expand funding opportunities for local CBOs and governments.

RESOURCES

- Bay Area Resilience Hotspots
- Resilience Playbook
- Be Prepared Gilroy: A Community Disaster Preparedness Toolkit

Case Study X: Scaling Urban Resilience: San Francisco Heat and Air Quality Resilience Project (HAQR)

ISSUE OVERVIEW

In San Francisco, climate change-fueled extreme heat events and wildfire smoke events are emergent threats. While San Francisco's temperatures do not get as hot as other parts of the state or country, San Franciscans are uniquely vulnerable to the health impacts of extreme heat and wildfire smoke events because the city's buildings and infrastructure were not designed for extreme temperatures and wildfire smoke. The city has one of the lowest rates of air conditioning anywhere in the country, and access to cooled spaces is inequitable. While emergency preparedness and response actions have worked to address the short-term health impacts of these events, there has not been a continuous effort to supplement these actions with the medium-to-long-term strategies necessary for San Francisco to become more resilient year to year. The process to develop these strategies includes participation of community, public, private, and academic partners who:

- Represent, engage, or work closely with communities most vulnerable to the impacts.

- Plan or execute emergency preparedness and response activities.
- Provide healthcare or other community services.
- Build, regulate, or maintain housing and other facilities.
- Plan or manage open space, green infrastructure or other public works that can reduce urban heat islands.
- Deliver and maintain the services that sustain San Francisco's workforce and economy.

PROJECT DESCRIPTION

Co-managed by the San Francisco Department of Public Health and Office of Resilience and Capital Planning, the Heat and Air Quality Resilience Project (HAQR) is an interdepartmental and cross-sectoral initiative to coordinate the design, implementation, and evaluation of strategies to adapt San Francisco's communities, buildings, infrastructure, programs and services to be more resilient to extreme temperatures and air quality impacts. The Heat and Air Quality Resilience Project was developed to accomplish two goals:

- Centralize extreme heat and air quality resilience planning to foster increased interdepartmental coordination and align objectives, share research, and engage partners.
- Facilitate the technical implementation and evaluation of specific extreme heat and air quality-related strategies.

HAQR centralizes heat and air quality through quarterly all-hands meetings. The purpose of these meetings are to increase situational awareness, share best practices, amplify funding opportunities, and build relationships with partners. These meetings are open to public, community, academic, and private partners.

In 2023, HAQR released the city's first Heat and Air Quality Resilience Plan. The Plan lists 33 heat and air quality adaptation strategies, divided into the following objectives: (1) San Francisco's buildings are adapted to reduce heat and poor air quality, (2) San Francisco's exterior built and natural environments are adapted to reduce exposure to extreme heat and poor air quality, (3) San Francisco is resilient to extreme heat and wildfire smoke through equitable emergency preparedness, response, and resilience actions, and (4) San Francisco is made more resilient to current and future events through city services that can predict and adapt to climate-related stressors. The strategies were identified in collaboration with nine community-based organizations, 14 city departments, and other subject matter experts.

Since 2023, the city has worked to implement the Plan. Some example actions have included: (1) Collaboration between HAQR and the Department Public Works to use health data and urban heat island data to prioritize neighborhoods for green infrastructure, (2) increased monitoring of indoor temperatures in public-facing facilities, and (3) support of community-based organizations to maintain continuity of operations during extreme heat and wildfire smoke events.

LESSONS LEARNED AND BROADER APPLICATIONS

The Heat and Air Quality Resilience Project is the first comprehensive extreme heat and wildfire smoke resilience project in San Francisco, an important tool to build consensus and design and improve strategies. Participants believe that HAQR all-hands meetings are especially useful to build and maintain relationships with partners, increase situational awareness of current and planned actions, and to expose members to local and national best practices. For other jurisdictions that do not have established heat or wildfire smoke programs, leaning heavily into cross-sectoral coordination and planning is an important first step to building the capacity to implement strategies to reduce health impacts.

Case Study XI: Empowering the Next Generation: San Francisco Youth Commission

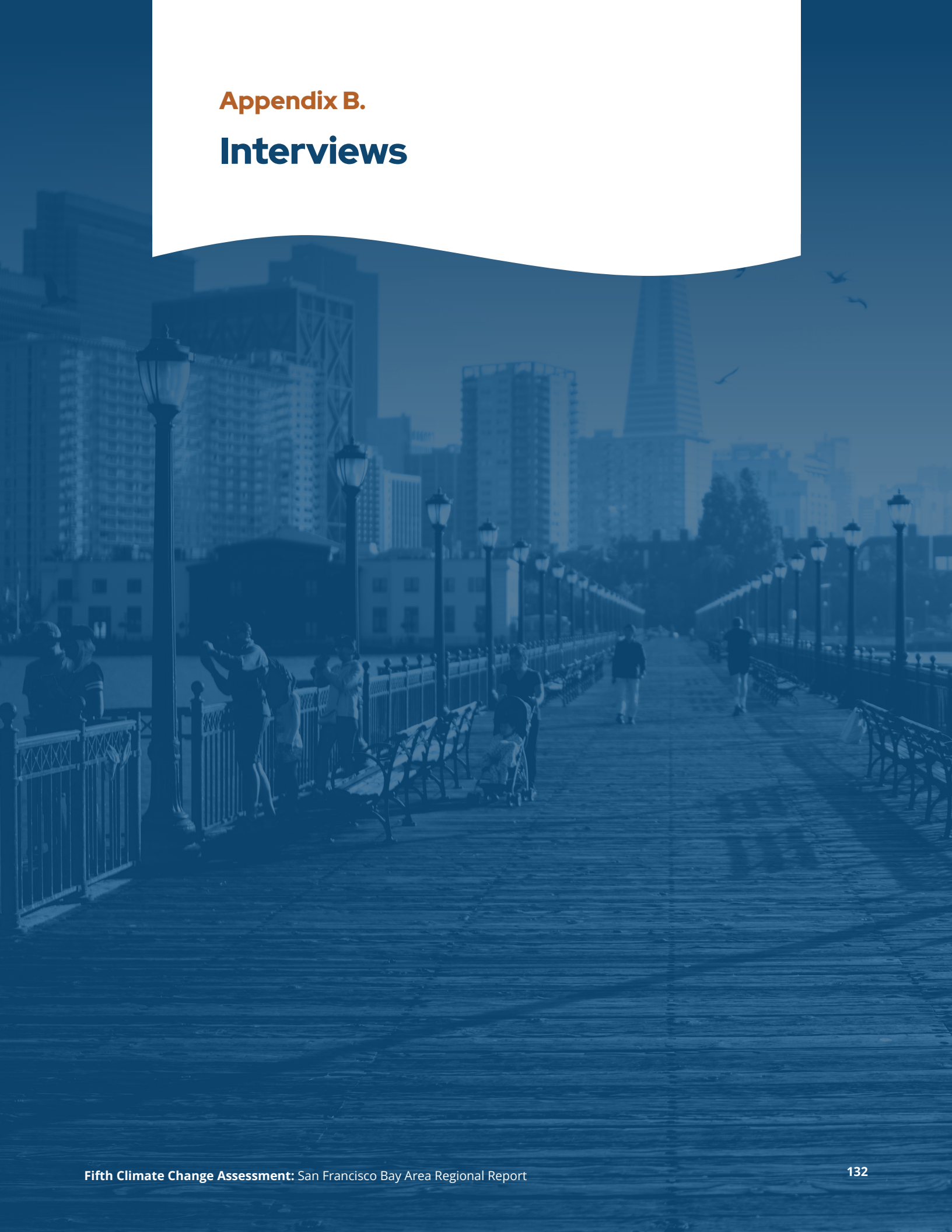
The San Francisco Youth Commission is a body of 17 youth between the ages of 12 and 23, representing the 113,000 youth of San Francisco. Created by the voters under a 1995 amendment to the City Charter, the commission is responsible for advising the Board of Supervisors and the Mayor on policies and laws related to young people, including providing comment and recommendations before the Board takes final action. Some notable accomplishments include successfully advocating for Free Muni For All Youth and closure of the county jail at 850 Bryant, 2 as well as placing Vote16 on the ballot twice.

Annually, the Youth Commission thoroughly researches and gathers youth input to produce a Budget Policy Priorities Report (BPPs), outlining key recommendations for San Francisco's budget, which is then presented to the San Francisco Budget and Appropriations Committee. In Fiscal Year (FY) 2024-2025, the Youth Commission passed a BPP report on climate change. Some key recommendations include scaling up EV charging; developing respite center networks; assessing sea level rise impacts on youth; supporting garden maintenance and teacher and student climate fellowships; and urging SFUSD to dedicate a district-wide climate action day. The Youth Commission also passed legislation on Bayview Hunters Point Toxic Soil Contamination and EV charging.

Youth leadership is fundamental in climate planning and policy because young people will live through the consequences of today's policy decisions. By the end of the century – when children born in 2025 will be 75 years old – they will experience 8-27 more extreme heat days and 3- 6 feet of sea level rise [in SF]. Youth bring new perspectives, lived experiences, and urgency to make policies more inclusive. Looking ahead, the Youth Commission hopes to continue working on climate legislation by expanding our partnerships with more government agencies, and youth groups and commissions.

Appendix B.

Interviews



Shy Walker, Ninth Root: Creating Sanctuaries for People and Nature in Oakland

CAN YOU TELL US ABOUT NINTH ROOT AND YOUR ROLE THERE?

I am the founder and director of Ninth Root, a community-based organization focused on climate and community healing, and restoration of natural lands. Ninth Root was founded as a response to my 2021 Sacred Spaces project, which envisioned a sanctuary park on the shoreline for healing and outdoor education. After widespread support and interest coming from the community and my fiscal sponsors, I officially founded Ninth Root in February 2023. The name reflects both personal history, I grew up on 9th Street in Oakland, and the deeper roots we're trying to nurture in our community.

WHAT ARE THE CLIMATE IMPACTS THAT YOU FACE IN YOUR WORK AND HOW ARE YOU ADDRESSING THEM?

We face threats from sea level rise, heat, and flooding, which lead to recreational area and ecosystem loss. For example, storms wash trash and pollutants into waterways, flooding roads and shorelines, which makes shorelines unusable to recreational users. I've seen entire chunks of marshland disappear during high tides. The city's response often involves hard infrastructure which further contributes to land and ecosystem loss. At Ninth Root, we focus on community-led, nature-based solutions like removing invasive species, restoring native plants, and exploring ways to slow erosion and protect places like Damon Marsh. Through education and hands-on activities, we bring people, especially from underrepresented communities, out to the shoreline, to connect with the land and with each other. We gather feedback to inform our restoration and adaptation efforts. For example, when the community expressed a desire for beaches, we explored how to incorporate that in a way that also buffers waves and wind. Our work aims to integrate adaptation and resilience measures with healing for the community.

WHAT HAVE YOU LEARNED ABOUT CLIMATE AND COMMUNITY RESILIENCE?

Climate resilience is inseparable from community resilience. Urban microclimates, neglected infrastructure, and lack of access to green spaces all increase vulnerability. I've learned how much root systems and species like oysters matter in protecting the land, and how closely environmental health ties into the community's well-being. When people see their environment being cared for, they respond. There has to be a deliberate effort to make things accessible to people and our work helps do that.

HOW DO YOU APPROACH EQUITY AND INCLUSION IN YOUR WORK?

It is about listening. It is about being open to everyone but intentionally reaching out to neighborhoods that are statistically left out from societal processes, usually those impacted by poverty, first, and making sure they have an opportunity to engage first. Really making connections is how I make sure to have that equity part. Other than that, we focus on language access, mobility, and partnering with groups doing similar work. We aim to be broad, inclusive, and responsive to community strengths and needs, always building from the ground up.

WHAT ARE SOME PROJECTS THAT STAND OUT TO YOU FROM YOUR WORK?

Moments when I get to talk to people really mean a lot. Recently, we had a table at Futures Fest with the prompt "What is sacred to you?" and we got all kinds of responses, from "Cheetos" to "the animals near my home," which sparked real conversations. I want to get to know people not just so I can tell them about sea level rise but because I really want to know them. Then I want to tie that into knowing about the ecosystem, the environment, and the spiritual connections to the land. Those moments of openness, silliness, and vulnerability are where healing and learning happen.

WHAT IS SACRED TO YOU?

Time and existence. They're the foundation of connection, growth, and presence. Without them, none of this work would be possible.

Lil Milagro Henriquez, Youth Mycelium Network: Building Resilience with Youth and Imagination

CAN YOU TELL US A LITTLE BIT ABOUT THE MYCELIUM YOUTH NETWORK AND YOUR ROLE THERE?

I'm the Founder and Executive Director of Mycelium Youth Network, which I started in 2017 in response to a need I saw while working in schools in East Oakland. The shift into climate and environmental education came during the wildfires. I was working as the Director of Organizing at an elementary and middle school, and I saw fifth graders experiencing headaches and nosebleeds. One student said, "the wildfires were really bad but the adults aren't talking to us so that is making it so much worse," and that stuck with me. Our young people were already living with climate impacts and being left out of the conversation. This led me to really consider, how am I in conversation *with* youth?

My own background is as a detribalized Nahuat Pipil from Cuzcatlán (now known as El Salvador) and my father is from the Caribbean Coast of Nicaragua. In both of these cultures, we do things intergenerationally and in community and we are very respectful of our plant and animal relatives. Mycelium has these values at its heart and works toward preparing youth for the realities of climate change while creating solutions with them, not for them. Mycelium has always been imagined as a mycelial network that is connecting local action to the national landscape so we can support and feed one another and be able to grow.

WHAT ARE THE CLIMATE IMPACTS THAT YOU ARE FACING IN YOUR WORK AND HOW ARE YOU BUILDING RESILIENCE?

We are an organization that is based in East Oakland and we also do work in San Francisco. We face wildfire, sea level rise, drought, and extreme storms. We experience what most of California does and the reason why I want to highlight that is because I want people to know that our young people are facing the same impacts as all of California's young people. When we create solutions that work on a hyperlocal level, they can also be utilized as best practices for other areas in California.

In order to build resilience, we focus on education and leadership. First, we meet youth where they are. For example, we ask: What does wildfire mean at the home level? What can you do now? We teach practical tools like how to build DIY air filters, grow food indoors, or create defensible space. Through this, we focus on workforce development. The next generation will be responsible for climate adaptation and recovery, yet they're not being trained for it. Our work builds that capacity. Additionally, we invest deeply in youth leadership. We ask: *What future do you want? How do you see yourself in it—and what can you do now?* We back this with real support, including youth stipends (6.8% of our total budget) and co-creating success models with students based on what they want to see in their schools and neighborhoods.

WHAT HAVE YOU LEARNED ABOUT COMMUNITY RESILIENCE?

What we've learned is that we're not waiting on policy shifts. Our communities have always done the work and will continue to. Regardless of who's in power, we move forward because young people are ready and committed. The question is no longer if we act, it's how we show up together to build the future.

COULD YOU TELL US A LITTLE BIT ABOUT THE PROGRAMS OFFERED BY THE MYCELIUM YOUTH NETWORK?

Our flagship Climate Resilient Schools program brings K-12-aligned climate adaptation curriculum into classrooms. Youth Leadership Council supports students in transforming their schools into resilience hubs, working alongside climate experts. Gaming for Justice is our environmental justice Dungeons & Dragons program, where youth imagine climate futures and build community through play. Our Data Warriors program helps youth define what success looks like in their work and supports intergenerational evaluation. And the regional Estuary Youth Council which we work on, alongside other organizations in the Bay Area, brings together youth to focus on Bay Area estuary issues.

CAN YOU TELL US A LITTLE BIT ABOUT THE ROLE OF FANTASY AND IMAGINATION IN A CLIMATE RESILIENT FUTURE AND HOW YOU INCORPORATE IT INTO YOUR PROGRAMMING?

We believe imagination is central to resilience. If youth can't envision a different world, how can they build it? Fantasy and play, especially through storytelling and gaming, open the door to possibility. We bring this into every program, from Dungeons and Dragons campaigns based on Bay Area climate futures to shoreline restoration projects with youth-led Live Action Roleplaying adventures. This helps shift young people from climate anxiety to climate agency, while supporting their social-emotional well-being.

WHAT ARE SOME OF THE BIGGEST BARRIERS OR CHALLENGES YOU FACE IN YOUR WORK?

Our barriers aren't scientific, they're systemic. Adultism, underfunding, and lack of youth power-sharing are major issues. Climate change is often excluded from school curriculums, creating a disconnect between what youth are experiencing and what they're being taught. Policies often overlook youth voices, or include them superficially. We aim to change that.

HOW DO YOU APPROACH EQUITY AND INCLUSION IN YOUR WORK?

How do we not? Equity is at the core of everything we do. Our work in East Oakland and San Francisco benefits all of California, because when we prepare our youth, especially those most impacted, we're preparing the workforce of tomorrow. Equity to us means centering race, class, ability, gender, and power in every conversation. We believe in power-sharing, and we create space for youth to show up fully as themselves, because real climate resilience includes everyone.

Keta Price, Hood Planning: Helping Communities Reimagine their Built Environment

CAN YOU TELL US A LITTLE BIT ABOUT HOOD PLANNING GROUP AND YOUR ROLE THERE?

Hood Planning Group is a for-profit, community-centered consulting firm focused on engaging and hiring local contractors for climate-related planning and project management. We help communities reimagine their built environment. I'm the founder, owner, and principal planner. My background is in urban and environmental planning, with a strong focus on economic and workforce development. I entered the climate space not intentionally, but because I saw a lack of representation in who leads, implements, and benefits from climate work, especially in BIPOC communities like mine in East Oakland.

WHAT ARE THE CLIMATE IMPACTS THAT YOU ARE FACING IN YOUR WORK?

In East Oakland, we face heat island effects, wildfire hazards from dense vegetation and power lines, and we don't have enough formal arborists to maintain the tree canopy in the community. We also have significant issues with stormwater and groundwater flooding because East Oakland lacks proper infrastructure to manage the stormwater which turns heavy rains into public health risks. Living and working in East Oakland, these issues impact our day to day life.

WHAT ARE YOU DOING TO BUILD CLIMATE AND COMMUNITY RESILIENCE?

Creating Hood Planning Group was my response to wanting to do more than just be an informed and angry resident, I wanted to create change. I created Hood Planning Group to model how people from the community can do the work AND get paid for it. I also serve as co-chair of the Oakland-Alameda Adaptation Committee and sit on advisory groups like the San Francisco Bay Restoration Authority (SFBRA), pushing for more equitable grant funding and policy change.

WHAT HAVE YOU LEARNED ABOUT CLIMATE AND COMMUNITY RESILIENCE?

I have learned a lot, initially I didn't see myself as a climate leader, I just followed the issues impacting my neighborhood. I would be at the shoreline, I use public transportation, I breathe in air, so naturally my attention went toward environmental justice. I learned that many in our communities are already doing climate work, even if they don't use the jargon. We need to speak in community language and make this work accessible.

Focusing on economic and workforce development, I've seen how BIPOC communities often lack the capacity and resources to implement climate solutions, despite being on the frontlines. There's a huge gap, and opportunity, in preparing our communities for green, clean jobs. For example, during an EV push, it became clear we weren't equipping Black and Latino auto shop owners for EV repairs. Now, through community-driven planning, we're working to build local infrastructure, empowering community developers and contractors to lead on shoreline adaptation, trails, tree maintenance, and more.

WHAT ARE SOME PROJECTS THAT STAND OUT TO YOU FROM YOUR WORK?

The Green Stormwater Infrastructure (GSI) projects by and for communities is near and dear to me because it is one of the first projects I got to lead from start to finish. We're working with residents in the Columbia Gardens neighborhood to educate them about GSI and how we can use it as a tool to reduce the contaminants and flooding in the area. We are getting to work with the community to create this plan and we have money for implementation which is really cool. It has been very rewarding to build trust with the community and see them get excited and more involved, working on other climate-related projects. We've also partnered with students at Castlemont High to redesign an outdoor courtyard into a green learning space using rain gardens, permeable pavement, and catchment systems. I am not concerned with just checking the box of the benefits of installing a project but I also want to think about how it is installed, what is learned, and who installed it. I always want to take that opportunity to think about how to maximize the social, economic, education, and environmental benefits. Thinking about the multi-beneficial aspect is often the best way to go.

WHAT ARE SOME OF THE BIGGEST BARRIERS OR CHALLENGES YOU FACE IN YOUR WORK?

The reimbursement model for contracts is tough; I'm a small, woman-owned, queer business without capital to front expenses. Grants often don't fund things like hot meals, which is important because culturally we break bread, sitting at a proper meal is a way of bonding together. They also don't fund childcare, which is vital to meaningful engagement. Policy language often sounds equitable but gets overridden by budget constraints. And it's always a challenge reaching folks who have a million other priorities; making the urgency of climate change feel real to them means finding the right connection point, whether it's through kids, health, or economics.

HOW DO YOU APPROACH EQUITY AND INCLUSION IN YOUR WORK?

By remembering my "why." I meet people where they are, whether it's in classrooms or at the basketball court, and always with a trauma-informed, humility-driven mindset. I won't automatically connect with people just because I am from the hood so being flexible and responding to people and changing my delivery if I need to. My goal is to support people being part of the process at whatever level, and help increase capacity for community-driven planning and development.

Aaron Burnett, Canal Alliance: Community Engagement is Capacity Building

CAN YOU TELL US A LITTLE BIT ABOUT YOUR ROLE AT CANAL ALLIANCE?

I am the Director of Policy and Civic Engagement. At Canal Alliance, we do a lot of policy and civic engagement but beyond that, we're deeply involved in community development in the Canal neighborhood, one of the most vulnerable areas in the Bay Area to sea level rise. Whether it's infrastructure for housing or early childhood education, we approach it all through a climate resilience lens.

WHAT ARE THE CLIMATE IMPACTS THAT YOU ARE FACING IN YOUR WORK?

We're seeing rising risks from extreme heat, and there's no resilient housing or cooling infrastructure in the Canal. Sea level rise is always front and center (for the Canal Neighborhood in Marin County), because the canal is shaped like a bowl and built on bay fill and is sinking at the quickest rate in the entire Bay much of the land is high tide and it is being held back by a hodge podge of public and private solutions ranging from levees (none which are FEMA certified) to plywood pieces in between walkways. On the other hand the city does have a system where stormwater and sewer water are separated. Stormwater and groundwater are then pumped back into the Bay but these systems are not built to pump saltwater. Currently, at high tide, there is seepage of saltwater into the pumps which is damaging and corroding them. No significant flooding event yet but if they were to fail, there would be a significant health and safety risk for the community.

WHAT ARE YOU DOING TO BUILD CLIMATE AND COMMUNITY RESILIENCE?

We prioritize resident-led planning and build strong partnerships with the City of San Rafael, County of Marin, and local agencies. We're currently wrapping up a three-year grant with the City of San Rafael to explore methods of sea level rise adaptation. We have worked really hard to build those relationships and partnerships.

WHAT HAVE YOU LEARNED ABOUT CLIMATE AND COMMUNITY RESILIENCE THROUGH YOUR WORK?

We have learned that generally speaking when your average Californian thinks about who will be impacted by sea level rise, they think of Stinson Beach or Caramel mansions on the bluff but communities like the Canal, predominantly renters in multifamily buildings, are on the frontlines. We have been working on elevating these facts to a broader audience because it is going to take a lot of funding and partnerships to adapt to this crisis without significant displacement of our largest historically underserved community. We've also learned that climate resilience means more than infrastructure, it's about health, safety, and emergency preparedness. During a tsunami warning last year, there was no clear evacuation plan for our community, which only has one road in and out.

WHAT ARE SOME PROJECTS THAT STAND OUT TO YOU FROM YOUR WORK?

Nuestro Canal, Nuestro Futuro, a resident-led planning effort to design a neighborhood vision plan for the canal and surrounding community, is a standout. Twenty residents have been meeting monthly for over a year, learning urban planning basics and shaping the neighborhood's future.

Our goal is for the City Council to adopt it as part of the 2040 general plan and be a guiding force for investment in the future and guardrails for outside people who want to come and invest in the community to make sure they do it in a way that benefits the residents of the Canal. We're also pushing for a resilience hub with solar, health services, and emergency functions. While we haven't secured funding yet, we're building a "hub and spoke" model with broad community input.

WHAT ARE SOME OF THE BIGGEST BARRIERS OR CHALLENGES YOU FACE IN YOUR WORK?

Funding with intentionality. It's rare to find support for real capacity building. We're not just engaging the community, we're training residents as co-planners. That takes time and resources, and it's not always reflected in state or local funding structures. We need to redefine what community engagement looks like and budget for it properly. There is definitely an onus on local governments to be the backbone of support. It doesn't cost a lot of money to start this quasi planning group. My goal is to show the County of Marin that there is value in this planning commission so we can get funding for this capacity building work.

HOW DO YOU APPROACH EQUITY AND INCLUSION IN YOUR WORK?

There is a community engagement tool called The Spectrum of Community Engagement to Ownership, and I think in the past equity was a checked box approach. We aim for planning to be at least resident-led. That is what we are showing is not only possible but also successful with Nuestro Canal, Nuestro Futuro Initiative. We are supporting residents in telling us what their community should look like.

RESOURCE:

- Nuestro Canal Nuestro Future

Juanita Croft, Belle Haven Community Development Fund, Pam D Jones and Marlene Santoyo from Belle Haven Empowered, and Cecilia Taylor from Belle Haven Action: Climate and Civic Leadership in Belle Haven

CAN YOU TELL ME A LITTLE BIT ABOUT EACH OF YOUR ORGANIZATIONS AND YOUR ROLES THERE?

I am **Juanita Croft**, the Advisory Board Chair from Belle Haven Community Development Fund (BH CDF). BH CDF has been active since 2013, starting with the city's mini-grant program. Over the last few years, we've expanded into environmental justice and safety, increasingly engaging in climate resilience work.

I am **Pam D. Jones**, the Program Manager at Belle Haven Empowered (BHE).

Belle Haven Empowered launched four years ago to help residents understand and engage with government systems so that they can participate and voice their concerns. We are not about one

specific issue or about one side or the other, we are about having all voices heard. We also have monthly meetings which we use to support other organizations by bringing information to the community, reducing meeting fatigue and making sure community members are updated on how their answers to surveys are being put into action.

I am **Cecilia Taylor**, the founder and executive director of Belle Haven Action (BHA). BHA started in 2017 to give Belle Haven residents representation and support. Our mission is to partner with residents to amplify the voices of community leaders. We advocate for inclusion, equitable distribution of shared resources, and acknowledgement of the diversity that makes our neighborhood unique. We work in sectors such as environmental justice, housing, food access, displacement, and access to healthcare resources.

I am **Marlene Santoyo**, I am a community organizer and I have worked with all three organizations supporting civic engagement, environmental justice, and community education efforts.

CAN YOU TALK ABOUT HOW YOUR COLLABORATION CAME ABOUT?

PDJ: It started out of necessity, community-based organizations (CBOs) like ours are underfunded, and we realized we could do more together. Now, we share office space, staff, and resources. It's allowed us to support job creation, build leadership, and avoid duplicating efforts. We're a multigenerational team, which helps inform our advocacy and community outreach.

JC: Collaborating helps us provide real job experience for residents, especially youth, and pay them a fairer wage. We're also building capacity through partnerships with BayCAN, Bay Area Urban Areas Security Initiative (BA UASI) and others.

PDJ: We are like a basket weaving in and out to create a container for the community, it shows how deeply committed we are to our community as long-term residents

WHAT ARE THE CLIMATE IMPACTS THAT YOU ARE FACING IN YOUR WORK?

CT: Whatever the existing conditions are, that impacts us too, whether it is weather conditions or bad air quality.

PDJ: I can think of three, one is that the community pays for flood insurance even though we have never needed it. Even people who have been living in the community for over 70 years have not needed it. We are currently looking at projects that would help us get out of the flood zone, as designated by FEMA. The second is that due to small property size, we have a hard time planting trees in residential areas. Recently Canopy was able to plant fruit trees which was not allowed up until a year ago. The final one is displacement. We have been struggling with displacement since 2008, and we just need basic things that will improve our lives.

JC: We're focusing on disaster preparedness through Thrive's Communities Organizations Active in Disasters (COAD) network and developing a multimodal emergency communication plan for residents, many of whom aren't online or lack consistent access.

MS: Sea level rise and nearby contaminated sites are serious concerns. Through the Peninsula Accountability Contamination Team, we're helping gather data and raise awareness.

WHAT ARE YOU DOING TO BUILD CLIMATE AND COMMUNITY RESILIENCE?

JC: Ever since we participated in the Environmental Justice and Safety update for Menlo Park, all our work centers around climate and community resilience. We are starting to look not only at mitigation but adaptation too. Many of our residents live in very old homes and we are evaluating what they need to adapt to our current conditions. We're looking into establishing a local resilience hub and exploring grant options.

PDJ: As Juanita mentioned, we are in the process of creating a communication plan to reach every household in an emergency. We're also distributing battery packs, alongside Climate Change Community Teams, to help residents charge phones during blackouts or emergencies. Our community was hit hard during the four-day PG&E outage. Another major concern is that residents often don't know their neighbors due to turnover. We're looking at how to rebuild those connections, since neighbors will be the first to help in an emergency.

CT: BHA is distributing heat kits and working to launch a farmer's market and mobile health clinic. We also continue advocating for reliable community WiFi and stronger emergency infrastructure.

PDJ: Another important point is the impact of air quality. Even though major corporations in our area have downsized, we're still surrounded on three sides by highways, so pollution just sits here. When winds shift, the pollution hits our neighborhood even harder but how do you measure the impact of that? We've been gathering self-reported health stories, not in strict categories, but in open-ended conversations. We have found patterns like asthma across multiple generations that was never formally diagnosed and therefore doesn't show up in the data.

JC: On that point about data that Pam made, being under-resourced means, we often lack data in our communities which is why we take every grant opportunity we can to collect community data. When we do collect data, whether it's about asthma, air quality, or displacement, it confirms what the community already knows, but the community knows at least someone will hear it if there is data.

WHAT ARE SOME PROJECTS THAT STAND OUT TO YOU FROM YOUR WORK?

JC: We're currently implementing a project funded by the BA UASI grant focused on emergency management. One of the biggest gaps we've identified is communication during crises, so this grant is allowing us to conduct a door-to-door outreach campaign to reach all 1,500 households in Belle Haven. It includes health checks and assessments of residents' needs, like mobility, disability status, and language access. We're building a real map of who lives in the neighborhood and what support they may need.

PDJ: A key part of that BA UASI project is understanding which residents are most vulnerable during emergencies like those who would need help evacuating or accessing resources. Another facet is social cohesion. When it comes to building community cohesion, we have to be intentional about language and outreach. For example, at National Night Out, we met people who had lived here for 3–5 years and were attending their very first community event. Some who engaged during door-to-door campaigns are now staying involved. We're working hard to maintain the strength of the core, long-term community, especially homeowners, while welcoming and including everyone else.

CT: Belle Haven Action continues to support other organizations in the neighborhood, and right now we're waiting to hear back about funding for a farmer's market and mobile healthcare services that would provide basic screenings like blood pressure checks and glucose testing. The work I did when I was on the Menlo Park City Council, advocating for environmental justice, also stands out to me. We gave a presentation to the Bay Area Air Quality Management District and they responded by donating 80 air purifiers for Belle Haven seniors. Now, BHA comes back each year to replace the filters and conduct wellness checks.

MS: A project that really stood out this year was our voter education center pilot. It ran for six weeks and was located in the same spot as the local voting station. We also did a major door-to-door outreach campaign, which was the first time we'd done something at that scale. It was incredibly effective in connecting with residents and helping them understand the voting process. We're hoping to establish this as a regular feature during elections and are working toward securing a permanent location.

WHAT ARE SOME OF THE BIGGEST BARRIERS OR CHALLENGES YOU FACE IN YOUR WORK?

CT: For Belle Haven Action, the two biggest challenges are funding and capacity. None of our staff are full-time, even though they should be. Another significant issue is health disparities; our community's life expectancy is eight years shorter than the rest of Menlo Park, largely due to lack of access to healthcare and social determinants of health. These challenges are compounded for our Black and Latino residents, and are rarely addressed in broader policy conversations.

JC: A major issue is that community-based organizations (CBOs) like ours are often excluded from larger grant opportunities. We're doing work on par with bigger nonprofits, but we typically only qualify for smaller grants, $20,000 or so, which is far too little given the scope of what we do. Most large grants have narrow topical or regional requirements but because our work touches many different community needs, it's difficult to fit into those boxes. And this is all layered on top of decades of systemic disinvestment and redlining in our neighborhood. The laws may have changed, but the circumstances have not.

PDJ: Another barrier is short-term funding cycles. We usually receive two-year grants which are helpful, but what we really need are multi-year (3–5 year) funding commitments. It's difficult to build long-term programs or hire and retain staff when funding is unstable. Longer grants would also give us time to collect deeper, more meaningful data to show the value of the work that we are doing.

JC: We also face language access barriers. While we do fairly well with English and Spanish, our capacity to serve other linguistic groups, particularly Pacific Islanders (Samoan and Tongan) and the growing Chinese population needs improvement.

PDJ: To add on to that point, through our voter outreach and community engagement efforts, we recently discovered that there are also Hindi speakers in the neighborhood. As we continue door-to-door campaigns and emergency preparedness work through COAD, we expect to identify even more linguistic groups. A big part of the challenge is creating a communication system that truly reaches everyone. We're also trying to bridge the gap with newer residents, many of whom are extremely wealthy and don't interact with the broader community. These residents need to understand that they share the same risks in a disaster, and we all need to be in this together.

HOW DO YOU APPROACH EQUITY AND INCLUSION IN YOUR WORK?

CT: We do not ask for any information. You don't have to qualify for any of our services, all you have to do is live in the neighborhood.

JC: For the fund, it is pretty much the same. If we are taking applications, anyone from Belle Haven can participate, though we do target communications to make sure we get the word out to core and legacy populations which are hard to reach through regular communication systems.

PDJ: The inclusion is natural when it comes to BHE. We are looking to reach and include people who live in Belle Haven neighborhoods because when it comes to civic engagement, we do have our unique issues but we do collaborate with members from East Palo Alto and North Fair Oaks because we all have very similar issues.

Jennifer Lopez and Juliana Gonzalez, The Watershed Project: Connecting Communities to a Love for Nature and Solutions

CAN YOU TELL US A LITTLE BIT ABOUT THE WATERSHED PROJECT AND YOUR ROLE THERE?

Juliana Gonzalez (JG): I'm the Executive Director of The Watershed Project. I've been with the organization for over 18 years. I started as a biologist and moved into environmental policy. I'm passionate about building climate-resilient communities through participatory projects. I was looking for something where I could see change happening in the community so I felt that the watershed scale was perfect for moving things along. Our work combines environmental education, green infrastructure, and climate adaptation, especially in communities facing injustice and environmental risk.

Jennifer Lopez (JL): I manage the Green Collar Corps, our youth employment and development program. My background is in urban planning and I was always very passionate about quality of life. Later in my education, I started to realize how connected quality of life is to climate change because I want people to live well and claim their right to a healthy environment. This brought me to The Watershed Project where I focus on creating career pathways for youth, especially from communities that are disproportionately affected by climate change. My goal is to connect people to meaningful work that improves quality of life and the environment.

WHAT ARE THE CLIMATE IMPACTS THAT YOU ARE FACING IN YOUR WORK AND HOW ARE YOU ADDRESSING THEM?

JG: We work mostly in West Contra Costa County and surrounding Bay Area communities. We're seeing more flooding from atmospheric rivers, ongoing droughts, and pollution from both visible (trash) and invisible (toxins) sources. We focus on nature-based solutions like bioswales, rain gardens, and urban greening to address these issues at a watershed level. Extreme heat is also a big issue, especially on school campuses that are mostly concrete. We've worked to transform these spaces with shade trees and green infrastructure to make them healthier for kids. We also help residents and youth engage directly in shoreline restoration, green infrastructure, and

environmental education. In low-income neighborhoods, we run pilot projects that bring green solutions where they're needed most.

JL: Youth in the Green Collar Corps are part of all this. They plant trees, monitor water quality, install irrigation systems, and engage with the public on climate resilience projects. We train them not only in technical skills but also in understanding why their work matters, connecting everyday tasks to real environmental impacts like flooding, sea level rise, and carbon sequestration through oyster beds. We are not only investing in the infrastructure for mitigating climate change but also in the people. We are carrying out multi-benefit projects that improve people's lives TODAY.

HOW ARE YOU BUILDING CLIMATE AND COMMUNITY RESILIENCE?

JL: The first thing is establishing a connection to the watershed, and all of the flora, fauna, and people that are in it. Once they become connected, it is natural to become invested in the well-being of all of these places, people, animals, and plants. This is a key part of our programs with youth. We train young people for climate jobs that are urgently needed. But it's more than just job training, it's about empowerment. We want young people to know that whatever skills or background they bring, whether they're artists or engineers, they can contribute to climate solutions. We create an environment where youth can discover a purpose, build skills, and feel hopeful. When they work on big projects, they see immediate impacts and start to believe change is possible.

JG: Everything starts with love for nature and ends with hope. Our community work involves deep collaboration, from dreaming up solutions, to designing, building, and maintaining green infrastructure. A good example is our shoreline work in North Richmond, where the community helped plan and design projects like parks and flood protection systems. We helped facilitate, fundraise, and bring agencies on board, but the vision came from residents. We're now community engagement partners for Contra Costa County's sea level rise adaptation plan, ensuring frontline communities have a voice. We train residents to understand the issues and co-create solutions. That kind of involvement leads to projects that people truly care about.

Another big piece, especially for community resilience is connection to other people. If we are going to have to face a climate that is more unpredictable and riskier, resiliency is also about human connection. In a climate disaster it will be necessary to be able to call your neighbor and ask for or offer help. We are very intentional about the connections we create for interns and leadership teams, providing a lot of opportunities for people to co-create, and get muddy.

WHAT ARE SOME PROJECTS THAT STAND OUT TO YOU?

JG: Rheem Creek Flood Reduction Project

Located in the Rollingwood neighborhood, this long-term project tackled chronic flooding caused by a neglected creek running through private backyards and between jurisdictions. The Watershed Project facilitated community mapping, led engagement with multiple municipalities, and worked with interns and residents to implement nature-based solutions. Today, the creek no longer floods for the first time in 20 years. The project has also produced educational materials, community videos, and even a children's book to celebrate the restoration.

Wildcat Creek Revitalization

This project addresses sediment buildup and flood risks while restoring potential salmon habitat. The work is transforming the watershed into a more accessible, living public space, with new trails, pocket parks, and community stewardship groups. Much of the progress has been driven by grassroots advocacy and years of partnership with local councils.

JL: Green Climate Corps

The program I lead is what stands out to me, particularly the impact that the pathways model and career exploration models have on the interns. At the end of the year, we had a symposium where interns got to recap their experience. One kid said the following: "When I got here I was just interested in graffiti and now I am thinking about studying entomology because I had such a positive experience surveying bugs during the internship." We have had many interns go into environmental careers after this program.

WHAT ARE SOME OF THE BIGGEST CHALLENGES YOU FACE?

JG: The biggest challenge is funding. We had a large climate grant that was taken away. It is discouraging and concerning to see how this is going to evolve. It has been difficult to navigate and decide what framework will work best in the future, I think that climate work will need to be folded into skills and workforce development and jobs. Funding will be more difficult and we will have to rely on individuals and foundations. My biggest fear is that this work will start to slow down and people will start to forget about the progress we have made.

HOW DO YOU APPROACH EQUITY AND INCLUSION?

JG: Equity is foundational to all aspects of The Watershed Project's work, from hiring practices to program design. We see lived experience as expertise; we actively recruit from high-risk zip codes, Title I schools, and underrepresented groups. We try to provide services to facilitate people's participation such as childcare, carpooling, transportation where needed, free transportation for the school. We also make sure to provide the chaperones and teachers that can facilitate the programs since often, we are the only natural science education the kids will get.

JL: The Green Collar Corps is specifically for youth that are underrepresented in the environmental world such as low income, identify as LGBTQIA+, have disabilities. Our goal is to offer these kids opportunities. You also don't need any experience to be part of the Green Collar Corps; we will even teach you how to use email if you show interest and passion for the work. We are trying to eliminate as many barriers for entry as possible.

WHAT IS YOUR PHILOSOPHY AROUND CAPACITY BUILDING?

JG: The Watershed Project was founded as a capacity-building organization, initially focused on training educators and community leaders. While the approach has since shifted to more direct service, the long-term goal remains: to scale from pilot programs to systemic change. We continue to create toolkits, demonstration sites, and train-the-trainer models, and envision a future where community members lead climate solutions from design to implementation.

JL: For me, it all starts by helping people build meaningful connections to the land, the place, and each other.

Julio Garcia, Rise South City: A Blueprint for Community-Led Resilience

CAN YOU TELL US A LITTLE BIT ABOUT RISE SOUTH CITY AND YOUR ROLE THERE?

Rise South City is a community-based organization (CBO) focused on climate change and environmental justice in low-income communities, specifically in South San Francisco. Our mission is to center and uplift the voices of residents most impacted by environmental and systemic injustices.

My name is Julio Garcia, and I'm the Executive Director. We founded Rise South City about three years ago to fill a major gap: the lack of representation and advocacy for our community. In South San Francisco, we only have about five or six nonprofits, compared to over 60 in East Palo Alto, and that disparity directly affects the services and support our residents receive. It's difficult to talk about equity in a city where some workers make over $500,000 and others, like kitchen staff, barely make $40,000–$45,000. We have a big inequality between the people who live and work in our community.

HOW DID YOU GET INTO CLIMATE WORK?

I got started through my work with Nuestra Casa in East Palo Alto, where we addressed water quality issues. We began hearing from promotoras that the well water was poor, so we conducted assessments and started working on improvements. After this, I created an environmental justice curriculum for kids and parents so we understand what is happening.

WHAT ARE THE CLIMATE IMPACTS THAT YOU ARE FACING IN YOUR WORK?

The biggest issue is air quality. South San Francisco is surrounded by freeways (101, 280, and 380) and located near San Francisco International Airport. Despite that, we had almost no data on air pollution until we installed monitors ourselves. But the community already knew: kids were getting asthma, residents had respiratory issues.

Another issue is the lack of tree canopy. South San Francisco has one of the lowest tree canopies in San Mateo County, and that contributes to higher temperatures and poorer air quality. We are trying to help community members solve these issues and get more involved. We are trying to educate them on these issues and bring them to the table and foster leadership. It takes a few years for people to be comfortable talking about this topic especially if you don't talk about it every day.

The language that people, government, scientists, academia use is so different from the community. That is one of the roles CBOs need to take as intermediaries between government agencies and community members in order to interpret the information in simple language.

WHAT ARE YOU DOING TO BUILD CLIMATE AND COMMUNITY RESILIENCE?

We're doing community training on air quality and sharing real-time data from our monitors. We also worked with Climate Resilient Communities in San Bruno to launch Climate Change Community Teams, and now we're working to establish one in South San Francisco too.

We consult with residents to decide where to install air monitors and involve them in interpreting the data. We are also planting trees. Since there isn't much public space left, we're working directly with homeowners and residents to plant trees on private property with the help of the community.

WHAT HAVE YOU LEARNED ABOUT CLIMATE AND COMMUNITY RESILIENCE?

The biggest lesson is that change takes time. The community needs time to understand and get involved; you cannot expect a community member to understand tomorrow, we need to take small steps and manage our expectations.

WHAT ARE SOME PROJECTS THAT STAND OUT TO YOU FROM YOUR WORK?

The first one that comes to mind is our air quality monitoring project. We've created a network of monitors in South City and made the data publicly accessible on our website. The goal is for the data to be easily understood by the community, and actionable. Another one is the planting trees initiative. We have been planting trees in our community which provides a direct response to heat and poor air quality for the community. Trees are especially impactful because they will be there for generations and you can be proud of participating and making our city more beautiful. Finally, we have a team of 11 promotoras, five of whom live in the community and have children in the schools. They are the heartbeat of Rise South City. They go door-to-door, share air quality information, invite neighbors to meetings, and build relationships. Our promotoras are modeled after Latin America's "promotoras de la salud," but we've expanded their role. They're trained not just in health but also in environmental justice, migrant justice, and climate change.

WHAT ARE SOME OF THE BIGGEST BARRIERS OR CHALLENGES YOU FACE IN YOUR WORK?

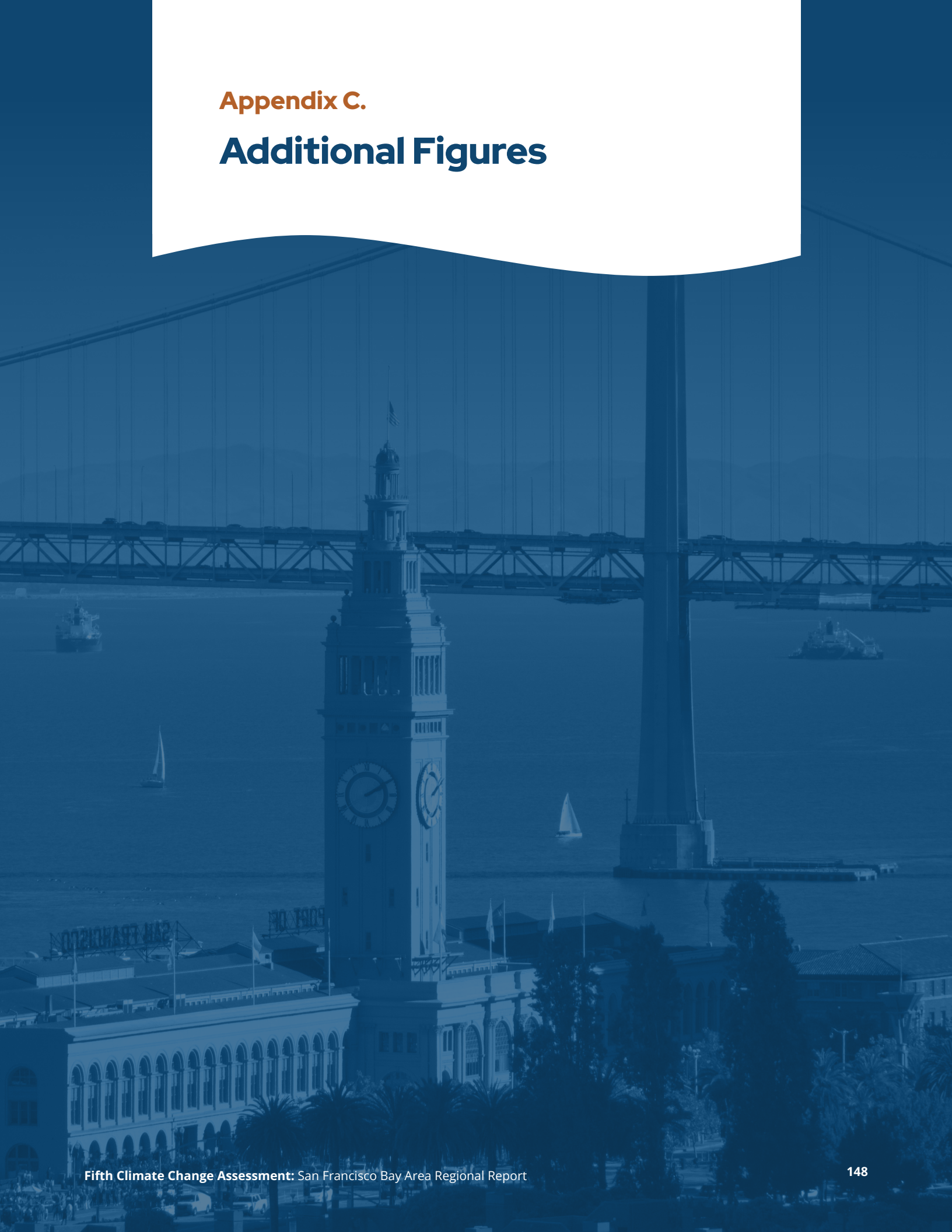
The fear of immigration enforcement is the most significant barrier right now. With recent reports of immigration agents in the city, people are scared to attend meetings or even answer the phone. We're facing the possibility of losing 4-5 years of progress due to fear, and it is a justified fear. Even legal residents and citizens are increasingly hesitant to engage. The undocumented immigrant community is the one with the biggest needs, those were the voices we were trying to lift at the forefront. Even though we represent the community, we are not the actual voices of the communities.

HOW DO YOU APPROACH EQUITY AND INCLUSION IN YOUR WORK?

Equity and inclusion must be foundational. They're not just boxes to check, they have to live in your vision, mission, and daily practice. If you're serving frontline communities, then your work should focus on uplifting their voices, not speaking for them. Our job is to give people the tools, training, and support they need so they can advocate for themselves.

Appendix C.

Additional Figures



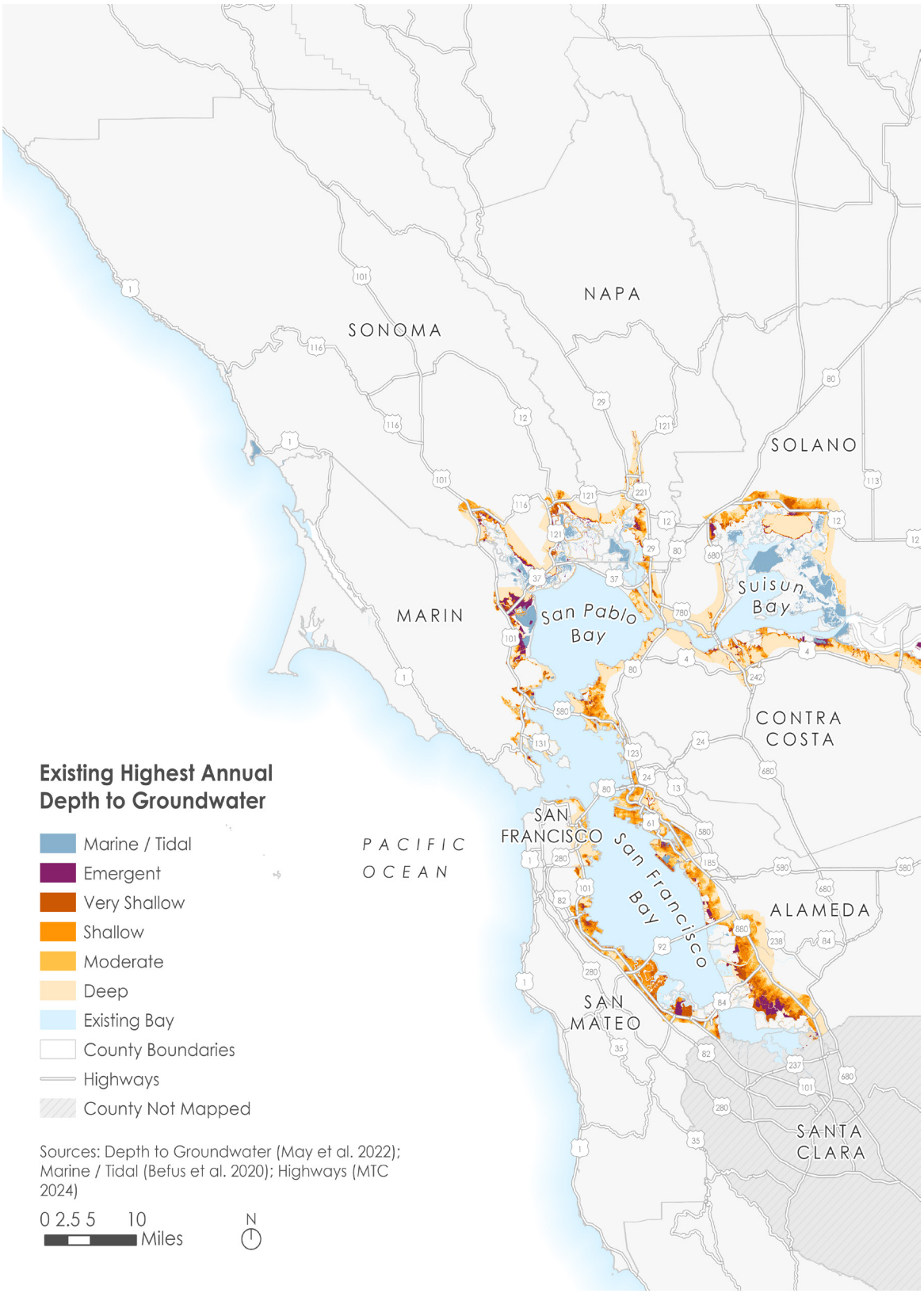


Figure A4: *Existing Highest Annual Depth to Groundwater (May et al. 2022).*

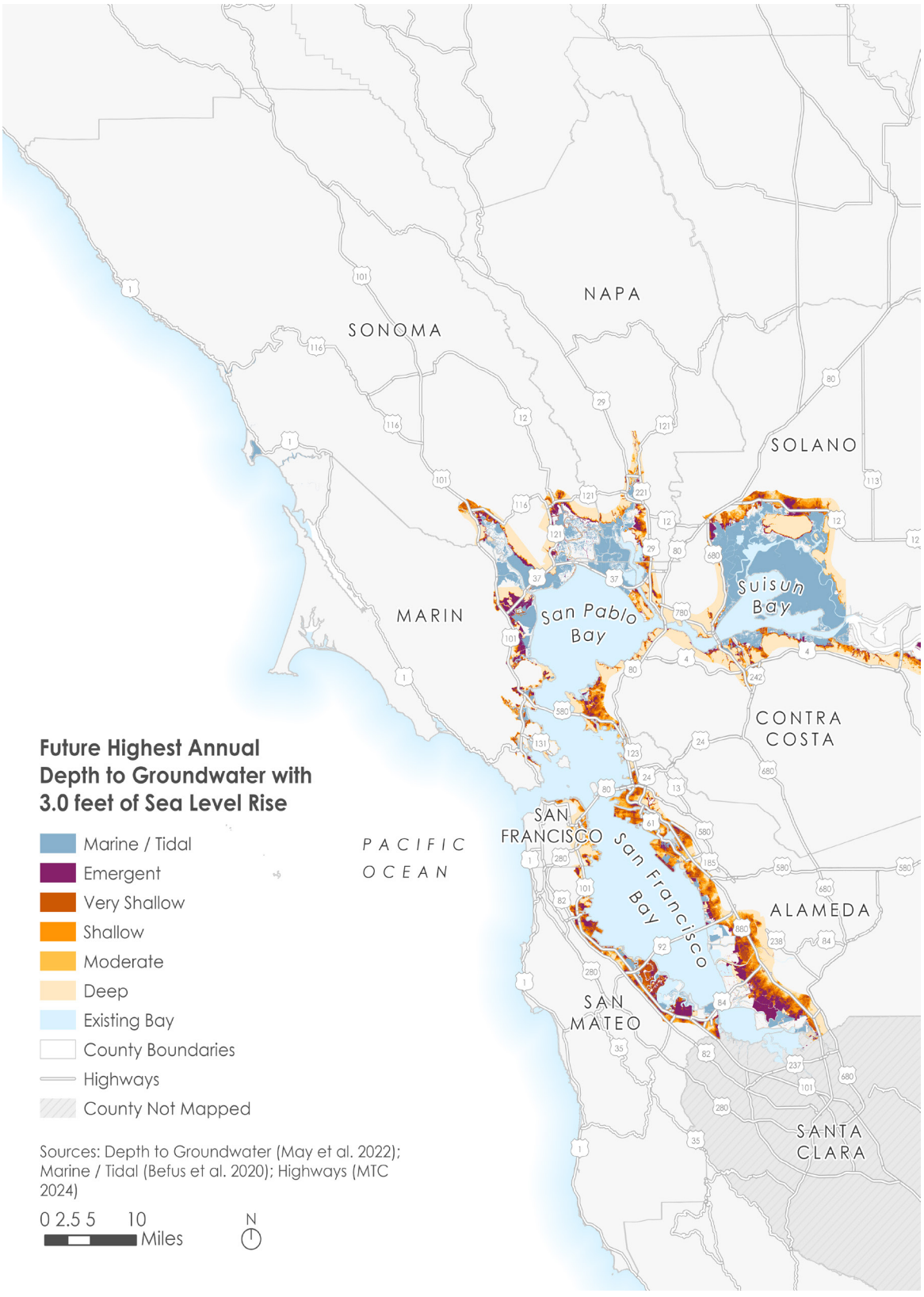


Figure A5: *Future Highest Annual Depth to Groundwater with 3 feet (~1 m) of Sea Level Rise (May et al. 2022).*

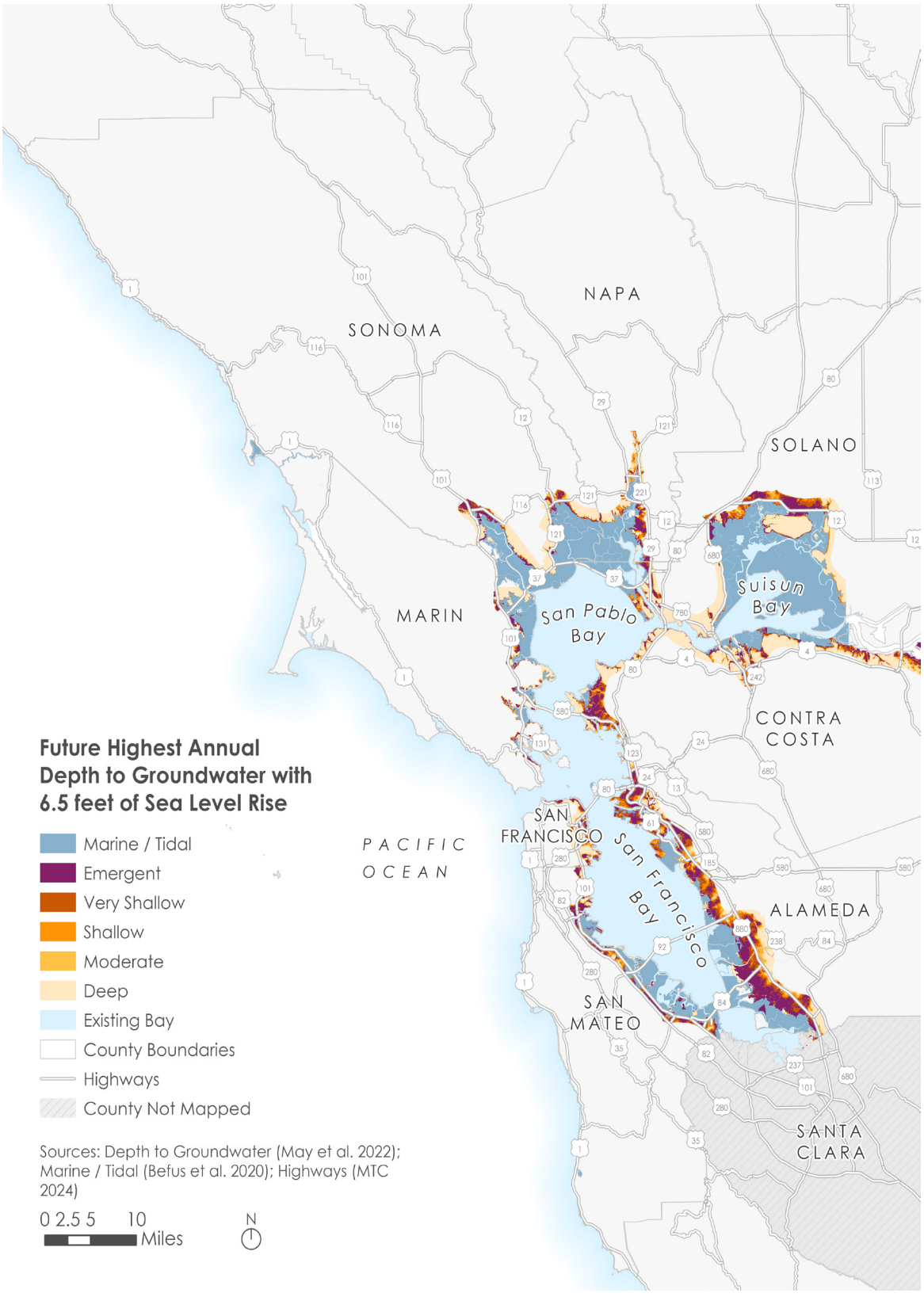


Figure A6: *Future Highest Annual Depth to Groundwater with 6.5 feet (~2 m)of Sea Level Rise (May et al. 2022).*

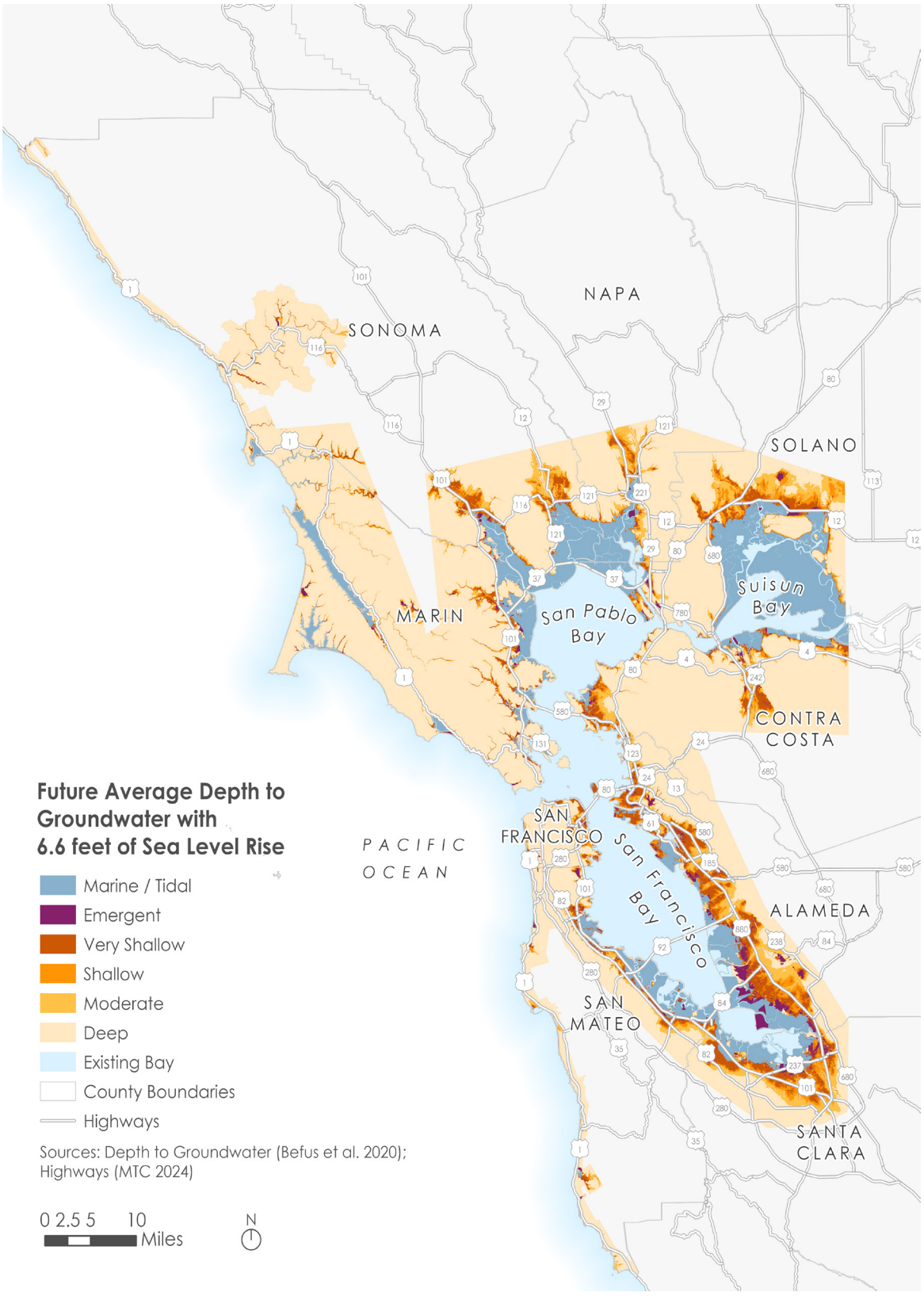


Figure A7: *Future Average Depth to Groundwater with 6.6 feet (2 m) of Sea Level Rise (Befus et al. 2020).*



CALIFORNIA'S FIFTH
CLIMATE CHANGE
ASSESSMENT